EEPSEA
2014-RR6

Economic Analysis of Flood Adaptation Options in the Sta. Cruz River Watershed, Laguna, Philippines

Jaimie Kim Bayani Arias, Vicente G. Ballaran, Jr., Ma. Emilinda T. Mendoza, Rowena A. Dorado, and Bessie M. Burgos

WorldFish

Published by the Economy and Environment Program for Southeast Asia (EEPSEA)
EEPSEA Philippines Office, WorldFish Philippines Country Office, SEARCA bldg., College, Los Baños, Laguna
4031 Philippines; Tel: +63 49 536 2290 loc. 196; Fax: +63 49 501 7493; Email: admin@eepsea.net

EEPSEA Research Reports are the outputs of research projects supported by the Economy and Environment Program for Southeast Asia. All have been peer reviewed and edited. In some cases, longer versions may be obtained from the author(s). The key findings of most *EEPSEA Research Reports* are condensed into *EEPSEA Policy Briefs*, which are available for download at www.eepsea.net. EEPSEA also publishes the *EEPSEA Practitioners Series*, case books, special papers that focus on research methodology, and issue papers.

ISBN: 978-971-9994-45-9

Front cover photo: Laguna flood by Bill Sta. Clara, courtesy of the International Rice Research Institute

Economic Analysis of Flood Adaptation Options in the Sta. Cruz River Watershed, Laguna, Philippines

Jaimie Kim Bayani Arias
Vicente G. Ballaran, Jr.
Ma. Emilinda T. Mendoza
Rowena A. Dorado
Bessie M. Burgos

March, 2014

Comments should be sent to:
Prof. Jaimie Kim Bayani Arias, Department of Economics, College of Economics and Management, University of the Philippines Los Baños, College, Los Baños, Laguna, Philippines
Tel: +63 49 536 2505
Email: jkbayani@gmail.com, jbarias@up.edu.ph

The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics. Its goal is to strengthen local capacity in the economic analysis of environmental issues so that researchers can provide sound advice to policymakers.

To do this, EEPSEA builds environmental economics (EE) research capacity, encourages regional collaboration, and promotes EE relevance in its member countries (i.e., Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines, Thailand, and Vietnam). It provides: a) research grants; b) increased access to useful knowledge and information through regionally-known resource persons and up-to-date literature; c) opportunities to attend relevant learning and knowledge events; and d) opportunities for publication.

EEPSEA was founded by the International Development Research Centre (IDRC) with co-funding from the Swedish International Development Cooperation Agency (Sida) and the Canadian International Development Agency (CIDA). In November 2012, EEPSEA moved to WorldFish, a member of the Consultative Group on International Agricultural Research (CGIAR) Consortium. The Program now has two offices – one in the WorldFish headquarters in Penang, Malaysia and another in the WorldFish Philippine Country Office in Los Baños, Philippines.

EEPSEA's structure consists of a Sponsors Group comprising its donors (now consisting of IDRC and Sida) and host organization, an Advisory Committee, and its secretariat.

EEPSEA publications are available online at http://www.eepsea.org.

ACKNOWLEDGEMENTS

This study was made possible through the generous funding of the International Development Research Centre-Climate Change and Water Program (IDRC-CCW) and the Economy and Environment Program for Southeast Asia (EEPSEA).

The authors would like to extend their gratitude to the people who provided support and guidance throughout the implementation of the project: to Dr. Herminia A. Francisco, EEPSEA Director; Dr. Carrie Mitchell and Dr. Bhim Adhikari of CCW; Dr. Gil Saguiguit, Jr., SEARCA Director; Dr. Bessie Burgos, SEARCA Research and Development Division (RDD) Manager; and Dr. Bui Dung The, Overall Project Coordinator.

Sincere thanks to our partners from the government and academe for their technical assistance: the Laguna Provincial Planning and Development Office (PPDO); the Provincial Environment and Natural Resources Office (PENRO); the Department of Environment and Natural Resources Region (DENR) IV, the Laguna Lake Development Authority (LLDA); and professors from the University of the Philippines Los Baños (UPLB). Also to our research assistants: Ms. Hazel Maligaya; Ms. Pamela Rocamora; and Mr. Leo Viado, and the SEARCA RDD staff.

Lastly, we would like to thank the local government and the people of Los Baños, Bay, Victoria, Pila, Nagcarlan, Liliw, Rizal, Pagsanjan, Sta. Cruz, Majayjay, Calauan, and Magdalena for their invaluable contributions to the project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ECONOMIC ANALYSIS OF FLOOD ADAPTATION OPTIONS IN THE STA. CRUZ RIVER WATERSHED, LAGUNA, PHILIPPINES[1]

Jaimie Kim Bayani Arias
Vicente G. Ballaran, Jr.
Ma. Emilinda T. Mendoza
Rowena A. Dorado
Bessie M. Burgos

EXECUTIVE SUMMARY

This research report covers the second phase of a three-year project, which was conducted from January 2011 to December 2013. The first part of the study focused on vulnerability assessment. This second phase of the study focuses on the economic analysis of flood adaptation options. The overarching frameworks the research team adhered to while conducting the project were the participatory framework and the watershed approach. These were the principles that guided the selection of adaptation options and aided the narrowing down of the study sites. Our study site covered three lakeshore municipalities belonging to the Sta. Cruz River Watershed: Pila, Victoria, and Sta. Cruz. Three sub-studies were also undertaken: (1) Direct Damage Cost Estimation for Floods; (2) Benefit-Cost Analysis of a Technology-Based Early Warning System, and (3) Cost-Effectiveness Analysis of Relocation vis-à-vis Evacuation and Building Modification.

Direct damage cost estimates from floods can be used in future studies that look into the feasibility of flood mitigation projects, such as dredging lakes or building road dike systems. We estimated the typical damage cost per hectare for two types of land-use given different flood depths. For built-up land, the typical direct damage cost per hectare is about PhP 410,000, PhP 215,000 and PhP 85,000 for neck-level, waist-level and knee-levelfloods, respectively. Farming land (rice), on the other hand, incurred a damage cost of PhP 29,600/ha for a flood level of 2.5ft and above.

Flood inundation was also predicted for the study site for floods with varying return periods: 1 in 2 years; 1 in 15 years; 1 in 25 years; and 1 in 50 years. We found that about 146.8 to 506.4 ha of built-up lands and about 673.9 to 2,565 ha of farming rice lands are at risk of flooding. The corresponding damage cost resulting from this ranges from PhP 13.7 million to PhP 88.8 million for built-up lands and PhP 19.9 million to 75.9 million for farming rice lands.

We also found that the respondents in the study site have a positive willingness-to-pay for a technology-based early warning system. The estimated mean willingness-to-pay is between PhP 127 and PhP 152/household per month. Gender seems to play a significant role in predicting mean willingness-to-pay. Male respondents were found to have a higher likelihood of voting 'yes' for willingness-to-pay. The analysis also shows that the proposed project produces large social net benefits, with a Benefit Cost Ratio (BCR) reaching as much as 33. Hence, we recommend the implementation of this project.

One of our sites, the municipality of Sta. Cruz, is exposed to long-term floods which can last as long as six months. Hence, we conducted a case study comparing the cost-effectiveness of three options suitable for such types of flooding: relocation, the use of evacuation centers, and building modification. Risk analysis was also undertaken to test the robustness of our results using Monte Carlo Simulation. The results suggest that building modification is the most cost-effective option among the three, followed by evacuation centers.

[1] This study is part of a research project funded by the International Development Research Centre-Climate change and Water Program (IDRC-CCW), and the Economy and Environment Program for Southeast Asia (EEPSEA), administered by the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA).

1.0 INTRODUCTION

1.1 Background to the Study

Climate change and its expected adverse impacts on natural and human systems continue to receive great attention from various stakeholders across the global community. The vulnerability of human ecosystems in the light of changing climatic patterns and extreme weather events continues to be of primary research and development concern. In developing countries such vulnerability is characterized by fragile geographic characteristics coupled with the socio-economic conditions of various sectors, many of which have limited resources and capacity to adapt to the impact of climate change.

The Philippine government continues to pay attention to and respond to the challenges and risks posed by climate change. The Philippine Climate Change Act of 2009 (Republic Act 9729), which was signed into law on 23 October, 2009, has been instrumental in establishing the Philippine Climate Change Commission (PCCC), which actively participates in global climate change fora and bodies. The Commission also provides direction for policy and on-the-ground implementation of climate change adaptation and mitigation. In addition, the signing into law of the Philippine Disaster Risk Reduction and Management Act of 2010 (Republic Act 10121) has created and mandated the National Disaster Risk Reduction and Management Council (NDRRMC) to coordinate the efforts of various government agencies in preparing and responding to disasters, including those that are brought about by climate change-related hazards.

At the local level, the Province of Laguna continues to initiate programs and policies to address climate change and disaster risk reduction. However, as mentioned in previous project reports, physical, financial and institutional constraints continue to hinder efforts to develop appropriate and effective location-specific adaptation strategies, especially in areas that are most vulnerable to climate change. This is not to mention the weakness in mainstreaming relevant research results in the formulation of development strategies. Evidence-based or science-based policy support is needed to guide and pin down the most appropriate and effective climate change adaptation measures, considering that financial resources are a constantly limiting factor. Therefore research activity which focuses on the economic analysis of adaptation options is necessary.

Economics provides a framework by which one can assess the feasibility of a project considering the whole of a society's point of view. It is different from financial analysis where the only concern is whether the project is profitable from the perspective of an investor or even from fiscal analysis where the central consideration is the impact of the project on the budget of the government. Economics can give a broader picture, which can enable transparent decision making. A project is deemed worthwhile only if it promotes the welfare of the society as a whole. If a project is found to improve welfare then the implementation of the project ensures the efficient allocation of resources. With limited financial and human resources to implement climate change adaptation measures, there is a need to increase the capacities of local government units (LGU) to incorporate the most appropriate, cost-effective and socially acceptable climate change adaptation measures in development planning and implementation.

In this research, benefit-cost and cost-effectiveness analyses of selected adaptation projects were undertaken. The selection of adaptation options was done in a participatory manner through consultations with various levels of local government, as well as with academic experts.

It is intended that the output of this research will be used to assist local government in crafting an adaptation project proposal for submission to various funding agencies. This ensures that the findings of this scientific research will be utilized for policymaking. Hence this research is relevant, not only because of its contribution to an exsisting body of knowledge but due to its direct impact on communities.

For this study we narrowed our focus to flooding hazards. Flooding imposes the highest risk in terms of severity and extent of impacts on our study site. Our study site covers the Sta. Cruz River watershed, the watershed that was found to have the highest vulnerability as well as the highest estimated peak run-off based on our GIS model. Three sets of analysis were undertaken, which were independent of each other. The first analysis is concerned with direct flood damage cost estimation for the whole Sta. Cruz River watershed, covering the municipalities of Victoria, Pila, Sta. Cruz, Calauan and Pagsanjan. The second analysis looks into a technology-based early warning system that could be implemented in the lakeshore municipalities of the

Sta. Cruz River watershed, namely Victoria, Pila and Sta. Cruz. This early warning system was considered for benefit-cost analysis. The third analysis is a case study focusing on selected lakeshore barangays of the municipality of Sta. Cruz, which experiences long-term inundation. Cost-effectiveness analysis was undertaken to assess the following options in these locations: relocation, evacuation and building modification.

1.2 Research Objectives

The general objective of the study was to identify suitable adaptation projects that meet the criterion of economic efficiency to cope with flooding along the lakeshore municipalities of the Sta. Cruz River watershed. The specific objectives were to:

1. Generate flood inundation maps for the Sta. Cruz River watershed;
2. Estimate the typical direct flood damage cost for the Sta. Cruz River watershed;
3. Identify feasible adaptation options that can address the problem of flooding in the lakeshore municipalities of the Sta. Cruz River watershed;
4. Identify, quantify and monetize, wherever possible, the benefits and costs of the identified flood adaptation projects; and
5. Make recommendations as to which projects are suitable for the study site.

1.3 Research Questions

1. Which areas along the Sta. Cruz River watershed are expected to flood in the future?
2. What is the value of flood damages along the lakeshore municipalities of the Sta. Cruz River watershed?
3. Using the Contingent Valuation Method (CVM), what is the estimated maximum willingness to pay of households along the lakeshore municipalities of the Sta. Cruz River watershed for a technology-based early warning system?
4. What are the costs associated with the implementation of a technology-based early warning system?
5. Is the technology-based early warning system a good project?
6. Which among the following options are the most cost-effective: relocation, evacuation, or building modification?

2.0 METHODOLOGY AND DATA

2.1 Identification of Adaptation Options for Economic Analysis

Figure 1 summarizes the process undertaken in order to come up with the adaptation options for economic analysis. Evident in the process is the participatory framework considered as a cross-cutting theme in the project.

The first round of consultations were undertaken during a training-workshop on the economic analysis of adaptation options, which involved our stakeholders, the municipal planning officers of the 12 municipalities of Laguna, and representatives from the Department of Environment and Natural Resources (DENR). During this consultation a long list of options was identified (Table 1). In order to narrow down the list, the participants were asked to identify sets of criteria by which to judge the various options. The evaluation of the options was done through a simple scoring system and those that garnered the highest scores were considered for the second round of consultations. The criteria used are indicated in Table 2.

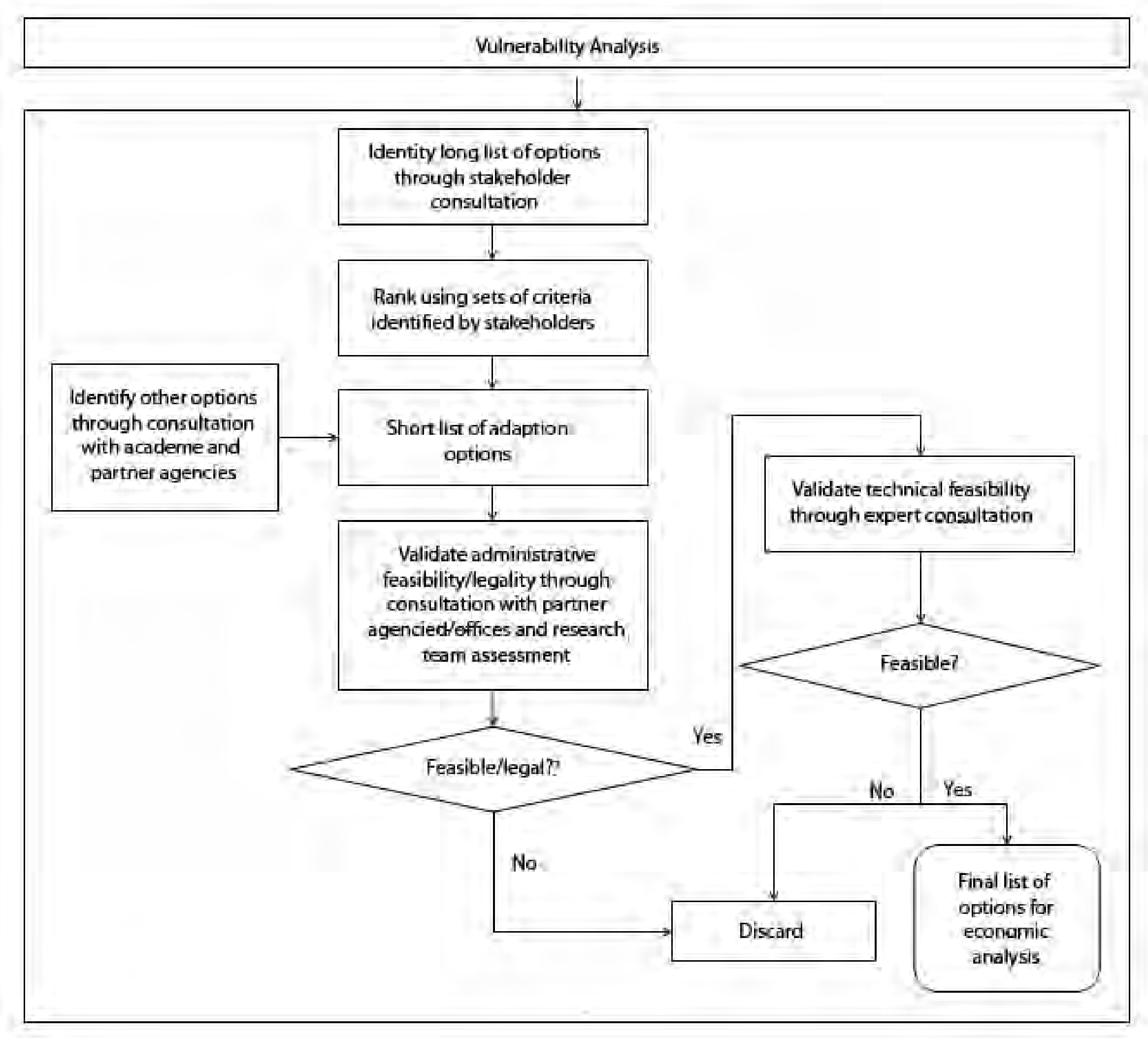


Figure 1.Process used in identifying the list of adaptation options for economic analysis

Table 1. Initial list of adaptation options identified during the stakeholder workshop

Category	Option
Technology	• Planting of submersible rice variety • Sloping agricultural land technologies • Organic farming
Infrastructure	• Coordination with the Manila Metropolitan Development Authority (MMDA) and the Laguna Lake Development Authority (LLDA) regarding the Napindan Channel Operation • Construction of road dike sea wall along the perimeter of the Laguna de Bay • Dredging of drainage canal, esteros and waterways
Regulation	• Strict implementation of 'no development' zoning within 12.5 m of lakeshore • Relocation of informal settlers
Information and aid	• Massive Information and Education Campaign (IEC) • Installation of early warning system
Environmental Management	• Waste management • Floating toilets and elevated artesian well • Planting of putat trees and bamboo along the lakeshore • Tree planting/reforestation • Green architecture
Livelihood assistance	• Charcoal briquetting

Table 2. Criteria used in screening the adaptation options for economic analysis

Criteria	Description
Effectiveness	• Will the option meet the objectives? • Will it increase/ensure climate change resiliency? • Does it increase the potential for increased climate resilience and environmental conservation/protection/preservation? • Will it address targets of intervention?
Multiple goals/benefits	• Will it generate other benefits? • Can it achieve multiple goals? • Does it have the potential to conserve/preserve the environment? • Can it decrease carbon emissions/energy consumption? • Does it promote socio-economic efficiency? • Will it minimize illegal logging activity? • Will it promote solid waste management? • Will it promote sustainable organic food production? • Does it have the potential to reduce health hazards? • Will it increase land productivity? • Will it reduce soil erosion/siltation of rivers and lakes?
Social acceptability/legitimacy	• Is the option politically, culturally and socially acceptable?
Practicality/low barriers	• Is it feasible? • Can the option be implemented on relevant timescales? • Is it sustainable?
Scalability/replicability	• Can it be scaled up or replicated to larger areas? • Will its effect "ripple" to neighboring towns and provinces? • Can it be mainstreamed to larger markets?
Equity	• Will the option benefit vulnerable groups and communities? • Will it promote participation of other entities? • Will it promote participation of households?
Urgency	• How soon does the option need to be implemented? • Will the intervention target a high-priority area? • Does it have a huge, urgent impact on climate change adaptation?

In the second round of consultations, the shortlisted options were presented to our partner agencies, which include the Laguna Provincial Planning Development Office (PPDO), the Laguna Lake Development Authority (LLDA) and the Provincial Environment and Natural Resources Office (PENRO). They assessed the legal and administrative feasibility of the shortlisted options and at the same time contributed by identifying other options that did not come up during the first consultation.

In order to validate the technical feasibility of the options, a last round of consultation was undertaken involving experts from academia. The experts provided insights on the availability of technologies that could be used to implement the proposed adaptation projects, as well as suggested other options that could be applicable to the study site. Field/on-site visits were undertaken to validate these insights.

Using this rigorous process, and taking into considering the output of the vulnerability assessment done in the first phase of this project[2] (not covered in this report), the following options were considered for analysis: a technology-based early warning system for the whole of the Sta. Cruz River watershed; and relocation, evacuation and building modification illustrated via a case study undertaken in selected lakeshore barangays.

[2] The first phase of the project is discussed in the EEPSEA Research Report "Household Vulnerability to Climate Change in Selected Municipalities in Laguna, Philippines" (2014-RR1).

2.2 The Study Site Selection

Since the project utilizes a watershed approach to design the adaptation strategies, one of the critical sets of activities that was conducted was the analysis of GIS topographical maps and a review of the results of the vulnerability assessment done in phase one of this study, which was conducted between January and December 2011. Computational modelling was carried out to guide the selection of the study site for the economic analysis.

A rational method was applied in the computational modelling in order to estimate peak runoffs that contribute to flooding. This method is a function of the study site's watershed characteristics, together with rainfall intensity for various return periods. The result yielded the highest runoff estimates in the Sta. Cruz River watershed. This matched the results of the vulnerability index study conducted in the first phase of this study, where the two most vulnerable barangays in terms of overall vulnerability and the three most vulnerable barangays in terms of agricultural vulnerability were located within this particular watershed. Thus, while the Year 1 vulnerability assessment was originally conducted with the study site comprised of three sub-watersheds – Mabacan, Sta. Cruz and Balanac – the team decided to narrow down the the study site for the second phase of the project (Year 2) to the Sta. Cruz watershed. Municipalities belonging to the Sta. Cruz watershed with the highest vulnerability index were selected – Sta. Cruz, Victoria and Pila.

2.3 Data Collection Method

A household survey was conducted to collect data on household profiles and characteristics, impacts and damages from flooding, and willingness to pay for an early warning system. Respondents were chosen using a two-stage stratified random sampling procedure. First, the population of households was stratified by municipality (i.e., Sta. Cruz, Pila and Victoria) and second by the household location (i.e., rural high-vulnerability index, rural low-vulnerability index, urban high-vulnerability index or urban low-vulnerability index barangay). A stratified random sample of 500 households was then obtained using proportionate sampling (i.e., the size of each stratum in the sample is proportionate to the size of the stratum in the population). The households making up the sample were selected from a list of households provided by the LGUs and the Barangay Integrated Development Approach for Nutrition Improvement of the University of the Philippines (BIDANI-UPLB). Whenever a household included in the sample could not be located or refused to participate, a replacement household was selected randomly from the same stratum.

Focus group discussions (FGD), key informant interviews (KII), and secondary data collection were also undertaken for the study. Through the FGD, the Contingent Valuation Scenario was identified. From KIIs, we were able to gather information about the experiences of selected barangays of long-term floods as well as their responses during flooding. Secondary information collected included the municipal comprehensive land use plans, municipal profiles, Laguna Lake profile, typhoon damage data, evacuation data, and building construction cost standards. Our informants included:

- Laguna Provincial Planning and Development Office
- Sta. Cruz Municipal Mayor
- Sta. Cruz Municipal Planning and Development Coordinator
- Sta. Cruz Municipal Social Work and Development Office
- Sta. Cruz Municipal Health Office
- Sta. Cruz Municipal Engineering Office
- Laguna Lake Development Office
- Victoria Municipal Planning and Development Coordinator
- Pila Municipal Planning and Development Coordinator
- Barangay Officials of San Pablo Norte, Santissima and Poblacion 4, Sta. Cruz.

2.4 Flood Inundation Model and Damage Estimation

Market-based valuation was applied to monetize the property and asset losses from flooding. There are five categories of land use in our study site, based on collected maps: a) built-up/residential use, b) farming (rice), c) sugar and cereals, d) coconut production, and e) industrial use.

Since our site-validation showed that there is no sugar production in the area, the sugar and cereal category was also considered to be rice farming land. Due to an absence of data, we were not able to establish the typical damage cost for industrial land. It is assumed that the damage cost for coconut land is zero since the crop is relatively resilient to flooding.

When collecting the property damage data, we adopted a synthesis of approaches: the real damage approach; the absolute damage approach; and the relative damage approach. In the real damage approach a social survey was done to get real damage data. In the absolute damage approach, damage per square meter of floor space was estimated, usually using information from insurance claims. The relative damage approach estimated damage as a percentage of the market value of the property (Messner and Meyer 2005).

We collected data on damage costs per household through a household survey and utilized this information to estimate the typical damage cost per hectare based on varying flood depths. Specifically, we looked at the typical household appliances, furniture, and vehicles that are damaged during a typhoon event, and used the average repair costs (*RC*) for these assets. There are three ways to value damages: a) repair cost; b) replacement cost; and c) depreciated value. In this study, the repair cost was used. The replacement cost was deemed to be inappropriate because replacement also entails improvements, that is, old goods damaged by the flood are replaced by new goods, which are more productive and efficient (Penning-Roswell et al. 2003). On the other hand, depreciated costs are difficult to estimate as information is needed on the average age of assets.

To get the typical damage cost per household of flood depth *i,* the repair cost for asset *j* multiplied by the probability of incurring the damages are summed.

$$D_i = \sum (P_{ij} * RC_j)$$

where:
D_i isthe typical damage cost per household exposed to flood depth i
P_{ij} is the probability of damage on asset j, for flood depth i
RC_j is the repair cost for asset j
i: 4 ft and above, 2.5-3.9 ft, 2-2.4 ft, less than 2 ft

P_{ij} is computed using the formula:

$$P_{ij} = \frac{n_{ij}}{N_i}$$

where:
P_{ij} is the probability of damage on asset j, for flood depth i
n_{ij} is the number of households exposed to flood depth i, that reported damage on asset j
N_i is the total number of households exposed to flood depth i

To get the per hectare flood damage cost, *D* is multiplied to the household density per hectare. The household density per hectare for built-up areas in the study site is 50. It must be noted, that the per hectare damage cost estimates are lower bound as the study did not undertake a survey of businesses. Hence, flood impacts on businesses and commercial establishments were not included.

For rice farming land, the lost producer's surplus, approximated by the lost net income per hectare of a typical rice farm, was used to value the flood damages. The threshold level of flood which can destroy standing crops is 2.5 ft. In the estimation, rice production cost data was sourced from existing literature (Philippine Department of Agriculture 2012), while rice yield and market price was based on information obtained via the household survey.

2.5 Contingent Valuation Method

To evaluate the benefit of the technology-based early warning system project, the Contingent Valuation Method (CVM) was used. CVM is a survey-based valuation technique which directly asks individuals or households about their willingness to pay for a good or service. It is a direct method that measures the values of non-marketed goods or services. It is survey-based, wherein a hypothetical market is presented to the respondents in a realistic and structured way before eliciting the value of their willingness-to-pay (WTP), rather than inferring from an observed behavior (Carson 2000). Leary (1999) defined WTP as the amount paid by a person that would have an equivalent effect on the person's welfare, as would the policy. It is referred to as "contingent" because valuation is dependent on the information provided to the respondent during the survey.

2.5.1 Review of literature

The concept of using public opinion as an instrument to value public good was first proposed by Bowen (1943) and Ciriacy-Wantrup (1947). However, it was Davis (1963) who was able to implement the first contingent valuation survey in his attempt to value recreation in the Maine woods. Pioneering studies on CVM can be credited to the U.S. National Parks and Forests Service when they used this methodology in the 1950s and 1960s to obtain people's preferences and WTP for public goods. The U.S. Army Corps of Engineers also used this valuation method to conduct benefit-cost analysis of water projects such as dams and levees.

The technique's ability to estimate values of non-market goods made it a useful tool in estimating environmental benefits and costs. In 1986, the U.S. Department of Interior recognized CVM as a preferred method for measuring benefits and damages under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. After the Exxon Valdez spill the National Oceanic and Atmospheric Administration (NOAA) established a panel of experts to assess the reliability of CVM estimates of natural resource damage. The Nobel Prize-awarded Kenneth Arrow and Robert Solow co-chaired the NOAA Blue Ribbon Panel. Leary (1999, as cited by Cardoso and Benhin 2011) defined WTP as the amount paid by a person that would have an equivalent effect on the person's welfare, as would the policy.

Since then this technique has become one of the most widely used methods for valuation of non-market goods. This is the only methodology that can estimate both the use and non-use value in welfare changes (Hanneman 1994; Mitchell and Carson 1989; Bateman et al. 2002). This technique is flexible; it allows valuation of a wider variety of non-market goods and services. Nevertheless, CVM is also subject to biases such as information, design and compliance, which can overestimate or underestimate the real value of a good in question. However, the effect of such biases can be minimized upon careful application of the technique and via the design of the survey (Akhter 2010). Furthermore Lipton et al. (1998) confirmed that CV can be regarded as the best method to estimate the economic value of anything.

According to Hanemann (1994) CVM is extensively used by governments and the World Bank for appraising a variety of investments, such as transportation, sanitation, health, literature, education, and the environment. It has also become a prominent method for policy analysis and academic research (Awad and Hollander 2010). In the United Kingdom, the Department of Environment has recommended the use of CVM for project and policy appraisal (UK DOE 1991).

CVM has also become a useful methodology for climate change mitigation and adaptation studies. Layton and Brown (2000) and Brouwer et al. (2008) used WTP on tree plantations for carbon sequestration, and Akhter (2010) used it to estimate the economic value of campus carbon offsets. Akhter and Bennet (2009) did a WTP survey to support a carbon pollution reduction scheme proposed by the Australian government; this study did a web-based survey of 600 respondents using a single bounded dichotomous choice elicitation format and results show a positive demand for climate change mitigation action. Markantonis and Bithas (2010) did a CVM survey to estimate climate change adaptation and mitigation policies in Greece. Cardoso and Benhin (2011) used CVM to estimate the market and non-market benefits of protecting the Columbian Caribbean Coast from sea level rise.

Various studies confirm that the dominant share of the potential impact of climate change will take the form of non-market impacts. In addition, the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report states that between 30-80% of the total existing estimates of climate change costs are non-market costs (Rothman et al. 2003). Thus, excluding non-market impacts of climate change is an underestimation.

2.5.2 Theoretical framework

The theoretical framework of CVM described below was borrowed from Bateman et al. 2002.

Basic utility theory suggests that individuals (or households) maximize their utility subject to their budget constraint. Following standard economic theory, an indirect utility function, *V*, can be defined which shows the maximum amount of utility that a household can derive from their income *Y*, given prices of goods *P* and the level of provision of a non-marketed good *Q* (which in this case is the early warning system). It is also assumed that the household's utility depends upon their socio-demographic characteristics *S*. Hence,

$$V(Y,P,S,Q)$$

It is expected that the higher the income or the lower the prices, the higher the utility level. Also, an increase in provision of the non-marketed good, let's say from Q^0 to Q^1, will increase the household's utility, such that:

$$V(Y,P,S,Q^0) < V(Y,P,S,Q^1)$$

When households are answering a CV question, they are essentially comparing their utility at Q^0 vis-à-vis Q^1. At Q^1, they are experiencing higher levels of utility; hence it is reasonable to assume that they would be willing to pay an amount to get Q^1. However, as they increase their payment to get higher provision of *Q*, their utility diminishes. Hence, the maximum amount that they would be willing to pay is defined where:

$$V(Y,P,S,Q^0) = (V(Y - C,P,S,Q^1)$$

and the position wherein is provided but it has to pay for the provision of the non-market good. That is, when the household yields the same level of utility from his situation when the non-marketed good is not provided, and from his situation when the non-marketed good is provided but he has to pay for its provision. If payment exceeds *C*, then the household is better off at Q^0. In the equation, *C* is the compensating variation measure of a change in welfare or the household's maximum WTP to achieve the increase in provision of the non-market good.

From the previous equation, a bid function *C( )* can be defined as a function of the other parameters in the model. It is also assumed that maximum WTP is equal to *C* and should be less than income *Y*.

$$C = C(Q0,Q1,Y,P,S) = WTP \leq Y$$

2.5.3 Parametric estimation of willingness-to-pay

In the binary choice format, households just state whether they are willing to pay a certain amount (*B*), or not. In response to the CV question, they can either answer:

No if $C_i < B$ or
Yes if $C_i \geq B$

The probability that the household is willing to pay can be estimated using Hanemann's binary logit model, wherein the dichotomous choice WTP responses are regressed on bid values and a vector of socio-economic and awareness/attitudinal variables (X_i).

$$Pr(Yes) = E\left(Y = \frac{1}{X_i}\right) = 1/(1 + e\text{-}[\beta_0 + \beta_1 X_i])$$

The mean WTP is then estimated using the formula:

$$WTP = -\alpha/\beta_1$$

Where:

α: the sum of the constant term and the coefficients of all explanatory variables multiplied with the mean values of explanatory variables (except the variable bid price).

β_1: coefficient of the bid price.

2.5.4 Empirical model

The dependent variable takes on the value of 1 if the household is willing to pay the bid amount, and takes on the value of 0 if not. The explanatory variables used in the analysis are summarized in Table 3.

Table 3. Explanatory variables used in logit regression

Explanatory variable	Notation	Description	Expected sign	Rationale
Bid	BID	Takes on the values of PhP 25, PhP 50, PhP 100, PhP 200, PhP 300	-	As the price of the good increases, the likelihood of paying will diminish
Household income per capita	INC	Monthly household income divided by the household size	+	As the income increases, the greater the likelihood of paying
Exposure	EXP	Number of floods inundating the house in the last 10 years	+	As exposure to flooding becomes greater, the greater the likelihood of paying
Knowledge about early warning system	KNOW	Dummy, if self-rating on knowledge is above 2, the variable takes on the value of 1; 0 if below 3	+	The more aware and knowledgeable a household is about the early warning system, the greater the likelihood of paying
Autonomous adaptation	RISK	Dummy, if household has undertaken any form of autonomous adaptation, the variable takes on the value of 1; 0 if otherwise	+	Autonomous adaptation may be indicative of risk aversion. Risk-averse households will be more likely to be willing to pay
Control variables reflecting respondent characteristics				
Respondent's sex	RSEX	Dummy, if male the variable takes on the value of 1; 0 if female		
Respondent's education	REDUC	Number of years of schooling		
Respondent's age	RAGE	Age as of last birthday		
Control variables reflecting geographical location				
Pila	PILA	Dummy, if household is located in Pila, the variable takes on the value of 1; 0 if otherwise		
Sta. Cruz	SCRUZ	Dummy, if household is located in Pila, the variable takes on the value of 1; 0 if otherwise		

2.5.5 Non-parametric estimation

To get a non-parametric estimate, the lower bound Turnbull mean WTP equation was used (Haab and McConnell 2002). The Turnbull estimator is a distribution-free estimator relying on asymptotic properties. The proportion of 'no' responses is higher as the bid price increases, while the survival function is decreasing in bid. The mean is given by:

$$E_{LB}(B) = \sum_{j=0}^{M} B_j\left(F_{j+1} - F_j\right)$$

With variance:

$$V\left(E_{LB}(B)\right) = \sum_{j=1}^{M} F_j(1 - F_j)(B_j - B_{j-1})^2/T_j$$

where:
M: is the number of bids
B: bid level
T_j: number of respondents offered the bid price β_j
F_j: proportion of 'no' responses to the bid price β_j

2.5.6 The contingent valuation survey design

To get reliable estimates of maximum WTP, the CVM survey was carefully designed, from the drafting of the questionnaire, to the sampling process, and the survey implementation. The following are the key features of the CV survey and questionnaire:

- The survey took the form of face-to-face interviews, as recommended by Arrow et al. (1993).

- A probabilistic sampling technique was applied. The population from which the sample was drawn was households within Pila, Victoria and Sta. Cruz. Specifically, the researchers conducted multi-stage stratified random sampling.

- A total of 497 completed household questionnaires were used in the analysis, 147 of which were replacement households. Of the total non-response, 67 households were not located, 37 had moved, 32 refused/could not be interviewed, while 7 did not have electricity. The total population of households in the study site is 41,869.

- Most of the content of the questionnaire used in the survey was written in Tagalog, the local dialect, except for some terms that do not have a direct translation in the vernacular. The questionnaire was 22-pages long and featured an introduction/screener page and six modules on the following areas:
  Module 1: Experience and Perceptions about Flooding Risk
  Module 2: Knowledge and Perceptions about Early Warning Systems
  Module 3: CV Scenario and Willingness-to-Pay
  Module 4: Household Profile and Characteristics
  Module 5: Livelihood Characteristics
  Module 6: Flood Damage Experience and Adaptation Activities

- As an input to the drafting of the CV scenario, FGDs were undertaken to obtain information on the possible range of WTP bids, payment vehicles, and local experiences of floods and early warning systems (EWS). Also, a technical expert was consulted to provide a description of the EWS technology.

- Before finalizing the questionnaire, a pre-test was conducted in Los Baños, a lakeshore municipality in Laguna near our study site. The pre-test site was selected because of its similar socio-economic characteristics and also because of its similar exposure to floods.

- Training was given to the enumerators prior to the field work.

- The Tailored Design Method (Dillman 2000) was adopted in the survey. The aim was to encourage respondents to participate in the survey by establishing trust and lowering the perceived costs, while increasing the perceived rewards of joining the survey. First, the purpose of the study and the institutions involved were explained to the respondent. The strict confidentiality of participant responses was assured. Respondents were informed that they would be given a short report if they wished to receive an update of the study. Also, a token (a fabric reusable shopping bag) was given to all the respondents. The token was carefully thought out, so as not to encourage biased responses. The token was simple and inexpensive, yet useful. It also bears the name of the project and the name of the institutions undertaking the project to re-enforce the legitimacy of the survey. Visual aids were also used to help respondents in the cognitive task of understanding the good that they are being asked to value.

- A good CV questionnaire features an easily understood scenario, and we provided a clear description of the proposed project (a technology-based flood EWS for installation along the Sta. Cruz River watershed). To help to explain the project, a pre-tested brochure was used. The proposed EWS technology utilizes an Automated Weather System and a Water Level Monitoring System. This equipment can collect weather and water data at regular intervals and send it automatically to a remote server that can be accessed through the internet. This information can then be used as a basis for issuing flood warnings. The flood warning would be sent via text message to households that subscribe to the service. The lead time is between two and four hours, and the information sent would include details about areas that will be flooded and areas that need to be evacuated immediately. The institution responsible for this project is the local government of the three municipalities. The lifetime of the project is 10 years, which is lifespan of the equipment (2014–2023).

- The payment vehicle used is mandatory through an additional charge in the electricity bill. This will be collected on a monthly basis for a period of 10 years (the duration of the project). Since EWS has a public good nature, mandatory payment is deemed incentive compatible. During the FGD we found that people were less inclined to pay additional taxes. Also, a water bill surcharge was not suitable because a significant proportion of households are not connected to the water supply. Instead, they source their water from private wells. An additional surcharge to the electric bill was deemed acceptable.

- The choice of benefit measure is WTP, noting that we are eliciting the household's valuation of the good. Hence, the target respondents are the heads of families. When the head of a family was unavailable, the spouse, or a working son or daughter of at least 21 years of age was asked to answer the questionnaire.

- The elicitation technique used is single-bounded dichotomous choice. Although there are other elicitation techniques (e.g., open-ended, bidding game, payment card and double-bounded dichotomous choice), the single-bounded dichotomous choice was chosen for its simplicity and incentive compatibility. The bid levels used were PhP 25, 50, 100, 200, 300 per month, to be paid for 10 years.

- To minimize strategic bias, a provision point was stated: it was explained that the project would be pushed through only if more than 50% of the respondents vote 'yes' in the barangay referendum. To discourage yea-saying and minimize warm glow effect, a cheap talk script was included. Specifically, the respondents were reminded of their income constraints as well as of the existence of alternative projects.

- A scope test was not included in the survey due to the limited size of the sample. However, the scope and limits of the project were explained in the scenario.

- Debriefing questions were included to identify invalid and protest votes. Table 4 categorizes the responses according to valid or invalid answers. If 'yes' answers are invalid, they should be converted to 'no' votes. If 'no' votes are protest votes, these could be dropped from the observation or retained. In this study, the protest 'no' votes were retained.

Table 4. Classification of answers to the willingness-to-pay debriefing question

	Valid answers	Invalid (bias or protest)
Reasons why respondents are willing to pay	• My household will benefit from the project • I have confidence in the effectiveness of the technology that will be used • I have confidence in the government's ability to execute this project	• We will not really be made to pay • We are happy that we are able to help
Reasons why respondents are not willing to pay	• We cannot afford to pay any amount • Our electricity bill is already too high • There are other more important problems that should be given priority • Early warning systems are not beneficial • The lead time is not sufficient • The local government gives ample warning • No one in my household owns a cellphone	• The government should be made to pay • Only the rich should be made to pay • I don't have confidence in the ability of the government to implement this project • I don't have confidence in the technology

- A certainty question was included to further verify the validity of yea-answers. In the survey, the respondents were asked about how certain they were that they would vote in the same way if they were asked in a real barangay referendum. With 1 being the lowest score (not sure) and 5 the highest (very sure), those that answered 3 or better were considered legitimate 'yes' votes. Those that answered 2 or below were further classified based on their reasons for being uncertain. If the reason for their high uncertainty was because they wanted to know first the responses of the majority, then these were considered valid 'yes' votes, as their attitude just reflected aversion to free-riding. However, if their reason was because they wanted to consult first with their spouses or because they are unsure about their income in the future, these were converted into 'no' votes. Thirty-one (31) 'yes' responses were converted into 'no' votes.

2.6 Benefit-Cost Analysis

As mentioned, Benefit-Cost Analysis (BCA) was applied to evaluate the EWS project. BCA is a method by which the impacts of a project are systematically identified, quantified and monetized to determine the net benefit of the project vis-à-vis the status quo. Its main purpose is to determine whether a project is worthwhile doing based on its economic efficiency. A project is considered good if the net present value (NPV) is positive. The generic steps for conducting a BCA are as follows (Boardman et al. 2010):

1. Specifying the alternative projects;
2. Identifying whose benefits and costs count;
3. Cataloguing the impacts (benefits and costs) and selecting measurement indicators;
4. Predicting the impacts over the life of the project;
5. Monetizing impacts;
6. Discounting net benefits to obtain present values;
7. Computing the NPV of each alternative;
8. Performing sensitivity analysis;
9. Making a recommendation

Since the stream of costs and benefits of adaptation are realized at different points in time, discounting should be undertaken to obtain present values. The present value of a benefit (*B*) or cost (*C*) at year *t* can be computed by dividing it by $(1 + s)^t$; where *s* is the social discount rate and *t* is the year. The discount rate used in the study is 15%, which is the discount rate used by the Philippine National Economic and Development Authority (NEDA) to evaluate local projects. To get the NPV, one simply obtains the difference between the present value of benefits and the present value of costs:

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+s)^t} - \sum_{t=0}^{n} \frac{c_t}{(1+s)^t}$$

Since only one option was subjected to BCA, the Benefit Cost Ratio (BCR) was also calculated. A project is considered good, if it has a BCR of greater than 1. The BCR is estimated by dividing the present value of benefits by the present value of the costs:

$$BCR = \frac{PV(B)}{PV(C)}$$

To address uncertainties, sensitivity analysis must also be undertaken. It is good practice to look at the sensitivity of NPV estimates to varying levels of discount rates (Margulis et al. 2008). However, since the estimated BCR for the project is large, the Internal Rate of Return (IRR) was estimated instead. The IRR shows the discount rate where the NPV of the project equals zero.

2.7 Cost-Effectiveness Analysis

For the case study looking at adaptation options to long-term flooding, Cost-Effectiveness Analysis (CEA) was employed. This method was chosen because it is difficult to monetize or even directly attribute the benefits of the relocation option and the evacuation option. The decision criterion of CEA is to choose the option that can achieve the objective at the least cost. We used the following equation to obtain the Cost-Effectiveness (CE) ratio:

$$CE_i = \frac{\sum_{t=0}^{T} C_{it}/(1+r)^t}{E_i}$$

Where C_{it} is the adaptation cost component at time *t,* and *r* is the discount rate. The discount rate used was 15%.

The CE ratio can be interpreted as the average cost per unit of effectiveness. In other words, the most cost-effective adaptation option has the lowest average cost per unit of effectiveness.

To account for uncertainty and risk, risk analysis using Monte Carlo simulation was undertaken. Risk analysis is a quantitative method that seeks to determine the outcomes of a decision situation as a probability distribution. In the simulation, about 10,000 pairs of values of cost and beneficiary households were drawn from their respective normal distributions. For each cost and effectiveness pair, the cost-effectiveness ratio was then computed.

3.0 RESULTS AND DISCUSSIONS

3.1 Study Site Description

Sta. Cruz is the capital of the province of Laguna and has a land area of 3,860 ha, comprising of 29 barangays[3]. The topography is level or nearly level with slopes ranging from 0 to 2.5%. In 2010, the estimated population was about 127,320, which is around 26,150 households. Although Sta. Cruz serves as the commercial and service hub of eastern Laguna, the municipality is still dependent on agriculture, with rice, coconuts and vegetables as the main crops. All of Sta. Cruz is considered urban.

Pila is similar in size and topography to Sta. Cruz. The total land area covers 3,120 ha, with 17 barangays. The majority (67%) of the population is considered rural. The estimated population in 2010 was 51,300, which is around 10,260 households. The municipality is considered to be agriculture-based. Major crops include rice, coconuts and fruit trees.

The municipality of Victoria has a total land area of 2,235 ha, covering nine barangays. The population as of 2010 was estimated to be 34,600, which is around 6,900 households. Out of the nine barangays, only two are considered to be urban. The major contributor to the economy is agriculture. The municipality is well known for duck-raising.

Three types of flood occur in these lakeshore municipalities: a) rapid-onset, which is characterized by a quick rise in water levels but flood waters also dissipate quickly; b) slow-onset, which involves a gradual increase in the water level but the inundation lasts for a long period; and c) flash floods, which occur within minutes or hours of a typhoon or of heavy rainfall. These floods bring about huge economic losses in terms of damage to property, income loss, morbidity and mortality.

Flood water in the area comes from upland run-offs. However, the major flood contributor in the area is Laguna de Bay (Laguna Lake). Laguna de Bay is the largest lake in the Philippines with a surface area of 900 km^2. More than 100 streams feed into the lake but it has only one outlet, the Pasig River, which drains out to Manila de Bay. It serves as the catch basin for the provinces of Laguna, Rizal, Batangas, Cavite, Quezon, and some parts of the National Capital Region. However, its water holding capacity has been declining over the years due to siltation. According to the Laguna Lake Development Authority (LLDA), its depth now only averages about 2.5 m, a substantial decline from its maximum observed depth of 10 m. Figure 2 shows the study site in relation to Laguna de Bay.

[3] The 'barangay' (or village) is the smallest administrative unit in the Philippines.

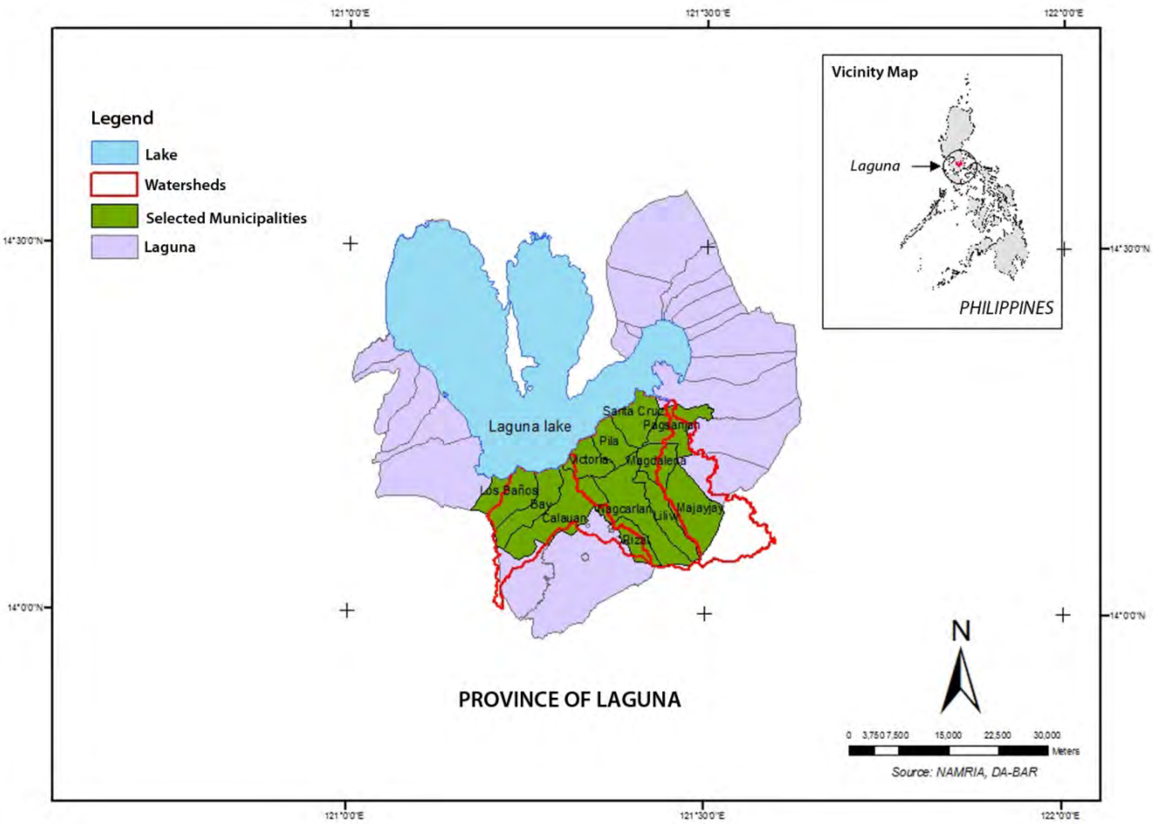


Figure 2. Locale of the study in relation to Laguna Lake

3.2 Household Survey Respondents' Profile

The composition of respondents according to sex, position in the family, marital status and primary occupation are summarized in Table 5. About 64% are female and the majority (76%) is married. In terms of occupation, about 28% are housewives, 21% are small business owners, and 17% are laborers or unskilled workers. Eighty-seven percent (87%) are the heads of the family or their spouses.

Table 5. Respondents composition based on sex, civil status, position in the family, and primary occupation

Indicator		Frequency	%
Sex	Male	180	36
	Female	320	64
Civil Status	Single	27	5
	Married	379	76
	Widowed	61	12
	Divorced/separated	13	3
	Common law	14	3
	Unknown	6	1
Position in family	Head	236	47
	Wife/spouse	198	40
	Son/daughter	27	5
	Son-in-law/daughter-in-law	11	2
	Grandson/granddaughter	1	0
	Father/mother	8	2
	Other	19	4

Table 5 continued

Indicator		Frequency	%
Primary occupation	Housewife	141	28
	Small business owner	105	21
	Unskilled labor, vendor, pedicab driver	85	17
	Skilled laborer	34	7
	Farmer	13	3
	Animal/livestock raiser	13	3
	Government employee, LGU	14	3
	Pensioner	14	3
	Farm worker/laborer	12	2
	Fisherman/fishpenfish pen owner	6	1
	OFW	3	1
	Student	3	1
	Professional	4	1
	Office staff	2	0
	Unknown/others	51	10

The majority (60%) of the households source their livelihood mainly from employment in the services sector. Twenty-seven percent (27%) are engaged in small non-agriculture-related business, while 12% have agriculture-based livelihoods (Table 6).

The mean age of the respondents is 48, while the mean years of schooling is nine. The average individual income is PhP 5,125/month, while the mean monthly income of the whole household is PhP 17,000. The average household size is five (Table 7). Female respondents have a significantly lower mean individual income compared to male respondents. The difference is as much as PhP 5,000 per month. For the whole household, the mean income is also lower for female respondents by as much as PhP 2,000.

Table 6. Composition of respondents based on main source of livelihood

Main sources of household income	Frequency	%
Services sector	301	60
Small business	135	27
Farming	36	7
Livestock/poultry	26	5

Table 7. Summary of respondents' characteristics

Indicator	All	Male	Female
Mean age	48	50	46
Mean years of schooling	9	8.99	9.37
Mean income	5,125	8,356	3,308
Mean HH income	17,000	18,321	16,263
Mean HH size	5	5	5

Thirty-six percent (36%) of the respondents have lived in the same house since birth, with average residency of about 28 years, while the rest (64%) are transferees/migrants (Table 8). About 3% of respondents claimed that the reason they transferred to their current house was flooding in their previous residence. About 3% of respondents expressed their intent to transfer to another house in the future because of flooding in their current home (Table 9).

Table 8. Composition of households based on previous residence

Previous residence	Frequency	%
Same house	180	36
Same barangay	145	29
Another barangay	64	12.8
Another municipality	38	7.6
Another province	58	11.6
Others	15	3
Total	**500**	**100**

Table 9. Incidence of flood-related migration

Indicator	Frequency	%
Moved because of flood	14	2.8
Plan to move because of flood	15	3

The average size of the ground floor of an average house is 80 m^2 (Table 10). Most houses are built as single-level detached structures so high floods pose a threat to the safety of the occupants. The majority of the houses are well-built, comprising of permanent roofing and walls. The majority of respondents (77%) own their houses, 5% rent, while 13% occupy the house with the owner's consent (Table 11).

Table 10. Selected housing indicators

	Mean	Standard deviation
Years in residence	28	20
Size of ground floor	80	9

Table 11. Composition of households based on selected housing indicators

	Indicator	Frequency	%
Ownership	Owned	385	77
	Rented	26	5
	Occupied with consent	65	13
	Occupied without consent	4	1
	Others	18	4
House type	Single-detached	453	91
	Duplex	43	9
	Others	3	1
Number of floors	One floor	374	75
	Two floors	122	24
	Three floors	2	0
	Four floors	1	0
Type of roofing	Permanent materials	369	74
	Light materials	34	7
	Mixed but predominantly permanent	73	15
	Mixed but predominantly light	24	5
Type of walls	Permanent materials	324	65
	Light materials	54	11
	Mixed but predominantly permanent	92	18
	Mixed but predominantly light	28	6

In terms of flood exposure, the mean number of flood events respondents experienced over the last 10 years was five. An average of three flood events inundated their homes over the same period. The mean highest flood height was 1 ft, while the mean longest duration of the flood was 16 days (Table 12). Fifteen percent (15%) experienced knee-deep flooding (about 1-2 ft), 9% waist-deep flooding (3 ft), 5% neck-deep flooding (4 ft) and 6% experienced flooding that reached above the head (5 ft and above) (Table 13). In terms of duration, 21% reported experiencing long-term flooding, which corresponds to at least a month of inundation (Table 14).

Table 12. Flood exposure indicators

Flood exposure	Mean	S.D.
Frequency of floods in the last 10 years	5	13
Frequency of floods inside house in the last 10 years	3	9
Highest flood height, in feet	1	2
Longest duration of flood, in days	16	34

Table 13. Composition of households based on reported maximum flood height inside their home

Flood height	Frequency	%
0	250	50
1 ft	42	8
2 ft	34	7
3 ft	43	9
4 ft	27	5
5 ft	15	3
6 ft	8	2
>6 ft	6	1
Total	**250**	**50**

Table 14. Composition of households based on reported longest duration of flood inside their home

Duration	Frequency	%
<1 day	246	49
1 day	108	22
1 week	39	8
1 month	24	5
2 months	29	6
3 months	41	8
4 months	7	1
5 months	3	1

In order to gauge the respondents' perceptions of flooding risk and impacts, several attitudinal questions were asked. To determine their perceived risk of flooding, they were asked how frequently they thought they would experience flooding in the future. A majority (47%) believe that they face a risk of flooding once every five years, while 36% believe that they face no risk at all. About 4% of respondents think that they face a very small risk of flooding, which corresponds to a flood that occurs once every 50 to 100 years, while 7% feel that they are exposed to flooding once every 10 to 25 years (Table 15).

In terms of risk acceptability, the majority (77%) believe that some degree of flood risk is acceptable because floods cannot be avoided, while 23% believe that no amount of flooding is acceptable (Table 16). The distribution is the same regardless of whether the respondent is male or female. Attitudes toward risk acceptability can provide insights to the type of interventions that would be acceptable to the respondents. For those who do not want to accept any flood risk, it might be appropriate to recommend options that totally mitigate flooding, or even propose the option of relocation. But since the majority of respondents think that some degree of flood risk is acceptable, then the EWS and the fixed evacuation center options may be deemed sufficient.

Table 15. Composition of households based on perceived risk of flooding

Perceived risk of flooding	Male	%	Female	%	Total	%
Once every 5 years	92	51	144	45	236	47
Once every 10 years	8	4	16	5	24	5
Once every 20 years	2	1	3	1	5	1
Once every 25 years	2	1	2	1	4	1
Once every 50 years	1	1	0	-	1	0
Once every 100 years	7	4	14	4	21	4
Never	56	31	122	38	178	36
Don't know	12	7	19	6	31	6
Total	**180**		**320**		**500**	

Table 16. Composition of households based on perceived risk acceptability

Risk acceptability	Male	%	Female	%	Total	%
Any type of flooding is unacceptable	41	23	74	23	115	23
Floods are unavoidable, we just have to learn to live with them	134	77	244	77	378	77

The consequences of flooding on the emotional and mental well-being of affected households are seldom included in the valuation of flood impacts – mainly because this is difficult to monetize. However, these impacts should not be disregarded as they may prove to be significant. In order to get a small glimpse of the psychological impacts of flooding, respondents who have experienced flood inundation in the past were asked to rate the severity of their worry about future floods and how they think they would be affected emotionally by this hazard. It is apparent that the psychological stress caused by flooding is significant: the majority of respondents (76%) rated their worry as 5, the highest rate in the scale. It was also observed that a slightly higher percentage of male, as opposed to female respondents, rated their worry as 5. As for perceived impact on emotional well-being, about 70% of those who were asked gave a rating of 4 to 5. This proportion was about the same for both male and female respondents (Table 17).

Table 17. Composition of households based on perceived severity of impacts and worry about floods

Indicator/rate	Male	%	Female	%	Total	%
Worry about flooding						
1 (lowest)	0	-	5	3	5	2
2	2	2	7	4	9	3
3	10	8	19	10	29	9
4	12	10	20	10	32	10
5 (highest)	94	80	144	74	238	76
Total	**118**		**195**		**313**	
Perceived impact of future floods on emotional well-being						
1 (lowest)	9	8	12	6	21	7
2	8	7	22	11	30	10
3	22	19	26	13	48	15
4	21	18	39	20	60	19
5 (highest)	58	49	96	49	154	49
Total	**118**		**195**		**313**	

3.3 Flood Inundation Simulation and Direct Flood Damage Cost Estimates

3.3.1 Flood inundation

This section discusses the results of our simulation of flood inundation in the study site for various return periods: 1 in 2 years, 1 in 15 years, 1 in 25 years and 1 in 50 years. Specifically, we predicted the total area that would be inundated by least 4 ft (neck level), 2.5-3.9 ft (waist-to-neck level), and 2-2.4 feet (knee level). In the Sta. Cruz River watershed, which covers the municipalities of Victoria, Pila, Sta. Cruz, Calauan and Pagsanjan, the total area of land classified as built-up is about 1,170 ha (excluding Pagsanjan because of the absence of data), while farmland (rice) accounts for about 7,769 ha.

Table18 shows that a flood return period of 1 in 2 years will inundate about 146.8 ha of built-up land (13% of built-up land) in the study site. A return period of 1 in 15 years will result in the inundation of about 309.5 ha (26% of built-up land). A total of 375.1 ha (32%) are flooded for a return period of 1 in 25 years, and 506.4 ha (43%) for flooding 1 in 50 years. The majority of these flooded areas are situated in the municipalities of Sta. Cruz and Victoria.

Figure 3 shows that the percentage of flooding across built-up land is highest in Victoria (53-63%), followed by Sta. Cruz (10-49%), Pila (0-16%) and Calauan (0-8%).

Table 18. Area of built-up land predicted to be inundated by flooding (ha)

Return period	Flood depth (ft)	Area of built-up land predicted to be inundated by flooding (ha)				Total
		Victoria	Pila	Sta. Cruz	Calauan	
1 in 2 years	4 and above	-	-	-	-	-
	2.5-3.9	-	-	9.2	-	9.2
	2-2.4	65.9	0.0	71.1	0.5	137.5
	All	**65.9**	**0.0**	**80.3**	**0.5**	**146.8**
1 in 15 years	4and above	-	-	9.2	-	9.2
	2.5-3.9	-	0.0	60.9	0.5	61.5
	2-2.4	69.1	3.6	162.7	3.4	238.8
	All	**69.1**	**3.6**	**232.9**	**3.9**	**309.5**
1 in 25 years	4and above	-	0.0	29.9	0.2	30.0
	2.5-3.9	1.1	1.2	94.9	1.5	98.6
	2-2.4	71.4	4.4	166.0	4.8	246.5
	All	**72.4**	**5.6**	**290.7**	**6.4**	**375.1**
1 in 50 years	4and above	-	0.0	71.1	0.5	71.6
	2.5-3.9	3.2	3.6	162.7	3.4	172.9
	2-2.4	75.8	6.1	172.5	7.5	261.9
	All	**79.1**	**9.7**	**406.2**	**11.4**	**506.4**
Total built-up area (ha)		**125.0**	**59.3**	**836.8**	**149.6**	**1,170.7**

** No data for Pagsanjan*

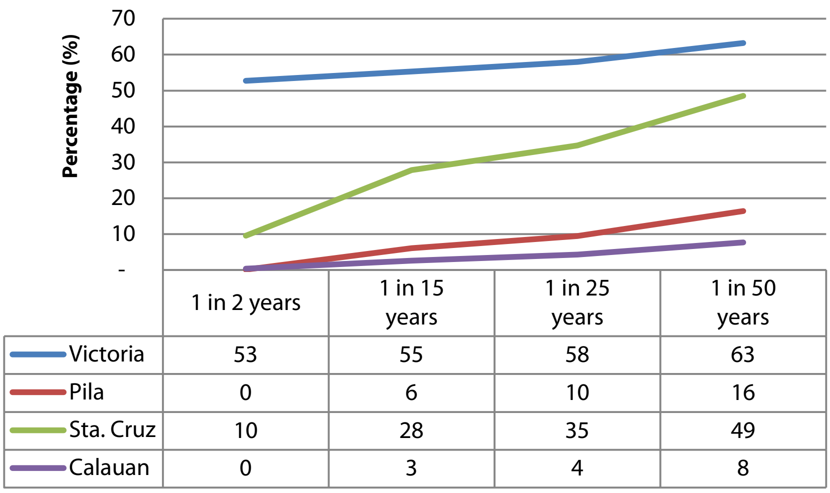


Figure 3. Percentage of built-up land predicted to be inundated by floods

For farmland, the predicted area that would be inundated is about 674 ha for floods that occur 1 in 2 years, 1,952 ha for flooding that takes place 1 in15 years, 2,157 ha for flooding 1 in 25 years, and 2,566 ha for flooding 1 in 50 years (Table 19). In terms of coverage, the highest percentage of farmland (rice) predicted to be inundated is in Sta. Cruz (11-47%), followed by Victoria (15-45%) and, lastly, by Pila (4-26%) (Figure 4).

Table 19. Area of farmland (rice) predicted to be submerged under at least 2.5 ft of water (ha)

Return period	Area of farmland (rice) predicted to be submerged under at least 2.5 ft of water (ha)			Total
	Victoria	Pila	Sta. Cruz	
1 in 2 years	338.4	89.3	246.3	673.9
1 in15 years	689.7	391.6	870.9	1,952.2
1 in 25 years	791.6	448.5	916.5	2,156.6
1 in 50 years	995.4	562.4	1,007.7	2,565.5
Total area of farmland (rice)	**2,207.4**	**2,193.3**	**2,146.3**	**6,547.0**

* No farmland is predicted to be inundated in Pagsanjan and Calauan

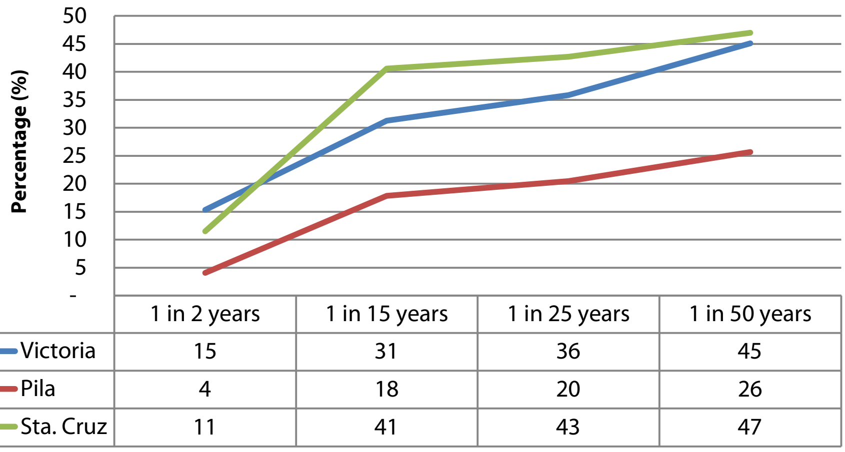


Figure 4. Percentage of farmland predicted to be submerged under at least 2.5 ft of water

3.3.2 Direct damage cost estimates

The significance of monetizing property damage impacts is that the values can be used as an estimate for the benefits of flood mitigation projects. In the Laguna Lake Basin, several flood mitigation projects are being considered. These include lake dredging, and the construction of a road-dike system that will run along the whole perimeter of the lake. The results of this research can be utilized in studies that will look into the feasibility of these projects.

Table 20 summarizes the damage cost of major flood events using the data set we collected from the survey. There were three major flood events commonly recalled by the respondents: *Habagat* (Monsoon, 2012), *Ondoy* (Ketsana, 2009), and *Santi* (Mirinae, 2009). In the study site, the damage cost was highest for *Santi*, followed by *Ondoy*, and then *Habagat*. Specifically, the mean damage cost per household was PhP 16,969 for *Santi*, PhP 9,374 for *Ondoy*, and PhP 6,511 for *Habagat*.

Table 20. Actual damage cost per household

	Damage cost per HH (PhP)				Damage cost per HH (USD)			
	Habagat 2012	Ondoy 2009	Santi 2009	All	Habagat 2012	Ondoy 2009	Santi 2009	All
Mean	6,511	9,374	16,969	10,450	163	234	424	261
Median	2,750	3,000	7,750	4,350	69	75	194	109
Mode	5,000	8,000		1,000	125	200	-	25
n	18	55	23	106	18	55	23	106

From this dataset, we also estimated the typical damage cost incurred by households from floods of varying depths (Table 21). A flood of 2-2.4 ft (about knee-high) results in a damage cost of PhP 1,700/household. This amount dramatically increases to PhP 4,300 if the flood reaches 2.5-3.9 ft (waist-to-neck-deep), while a flood depth of at least 4 ft (above the neck) results to a damage cost of PhP 8,200/household. Converting these costs into per-hectare units, for built-up residential land, the typical damage cost is estimated to be PhP 410,000/ha for a flood height of 4 ft and above, PhP 215,000 for waist-deep to neck-deep (2.5-3.9 ft) floods, and PhP 85,000 for knee-deep (2-2.4 ft) floods. Farmland, on the other hand, incurs a damage cost of PhP 29,600/hectare for a flood height of at least 2.5 ft (Table 22).

Table 21. Typical damage cost per household per flood depth

Flood depth	Damage cost per household per flood event	
	in PhP	in USD
4 ft and above	8,200	205
2.5-3.9 ft	4,300	107.5
2-2.4 ft	1,700	42.5
0-1.9 ft	0	0

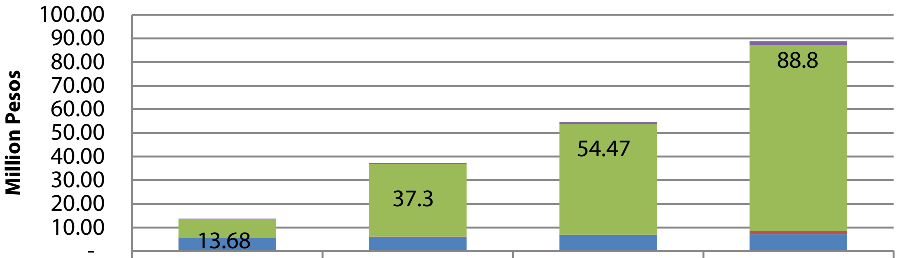
Table 22. Damage cost per hectare by flood depth

Land type	Damage cost per hectare by flood depth				
	4 ft and above	2.5 to 3.9 ft	2 to 2.4 ft	1 to 1.9 ft	0 to .9 ft
Built-up/ residential	PhP 410,000 (USD 10,250)	PhP 215,000 (USD 5,375)	PhP 85,000 (USD 2,125)	0	0
Farmland	PhP 29,600 (USD 740)	PhP 29,600 (USD 740)	PhP 29,600 (USD 740)	0	0

Note: Exchange rate: 40 PhP = 1 USD

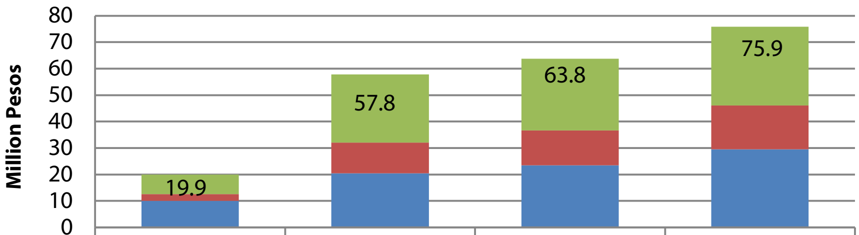
Using the per-hectare cost estimates above, we predicted that the damage cost of floods in the study site's built-up areas that occur 1 in 2 years is about PhP 13.68 million. This increases to PhP 37.3 million for floods that occur 1 in 15 years, PhP 54.47 million for flooding that takes place 1 in 25 years, and PhP 88.8 million for flooding 1 in 50 years (Figure 5).

For rice land, direct damage costs amount to PhP 19.9 million for a flood that occurs 1 in 2 years, PhP 57.8 million for a flood that takes place 1 in 15 years, PhP 63.8 million for a flood 1 in 25 years, and PhP 75.9 million for a flood 1 in 50 years flood (Figure 6).



	1 in 2 years	1 in 15 years	1 in 25 years	1 in 50 years
Calauan	0.04	0.40	0.79	1.58
Sta. Cruz	8.03	30.72	46.74	78.78
Pila	0.00	0.31	0.64	1.30
Victoria	5.60	5.88	6.30	7.14

Figure 5. Predicted direct flood damage cost estimates for built-up land



	1 in 2 years	1 in 5 years	1 in 25 years	1 in 50 years
Pagsanjan	0	0	0	0
Calauan	0	0	0	0
Sta. Cruz	7.3	25.8	27.1	29.8
Pila	2.6	11.6	13.3	16.6
Victoria	10	20.4	23.4	29.5

Figure 6. Predicted direct flood damage cost estimates for rice land

3.4 Benefit-Cost Analysis of a Technology-Based Early Warning System

The term early warning system (EWS) is defined by the United Nations International Strategy for Disaster Reduction (UNISDR) as:

> *"The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by hazards to take necessary preparedness measures and act appropriately in sufficient time to reduce the possibility of harms or losses* (unisdr.org 2013)."

All over the world, there is evidence that EWS is an effective strategy to minimize loss of life as well as damage to property (Basha and Russ 2007 and Mercy Corps Practical Action 2010). In the Philippines EWS proved its effectiveness in Bulacan, where the establishment of a community-based EWS saved the aquaculture industry from losses during typhoon Marce in 2006. In Dumangas, Iloilo, the presence of EWS kept the casualties from typhoon Frank (2008) at zero (Pagulayan 2012).

The agency at the forefront of promoting and establishing the use of EWS in the country is the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) of the Department of Science and Technology (DOST). Recognizing that flooding is becoming more prevalent, with 134 incidents from 2000-2006 (Esperanza and Paat 2007), PAGASA installed a network of fully automatic and telemetered flood EWS in at least four major river basins and reservoirs in Luzon, as well as in other parts of the country.

In addition to technical approaches, modern equipment and infrastructure, PAGASA also promotes the Community-Based Flood Early Warning System (CBFEWS). The CBFEWS, which is also referred to as the Local Flood Early Warning System (LFEWS), has the advantage of being inexpensive and timely when it comes to issuing local warnings. It is also designed according to the needs and capabilities of LGUs, as well as the physical make-up of the watershed where it is installed. The community-based approach is perceived by PAGASA to be more sustainable since it empowers the community and has an additional benefit of expanding the agency's operational hydrological services to the countryside.

Two locations served as the pilot sites for CBFEWS: Bulacan and Dumangas, Iloilo. The CBFEWS in Bulacan is located in the Lower Pampanga River basin and was completed in 2005 through the initiative and funding of the Provincial Government of Bulacan. The project, which uses Short Messaging Service (SMS) for the transmission of data, cost about PhP 1 million. The CBFEWS in Dumangas, Iloilo, commenced in 2003 and was completed in 2006. This CBFEWS was established thanks to the Municipal Government of Dumangas but was funded by the National Disaster Coordinating Council. The cost of this project was also PhP 1 million (Perez et al. 2007; Esperanza and Paat 2007).

With the success of the pilot projects, the establishment of CBFEWS at other sites soon followed, with funds coming from different international agencies. The Japan International Cooperation Agency (JICA) donated PhP 1.9 million to establish a CBFEWS in the Agno-allied River Basin in Pangasinan (Perez et al. 2007; Esperanza and Paat 2007). JICA also funded CBFEWS in Cagayan, Pampanga and Bicol, while the Korea International Cooperation Agency (KOICA) donated PhP 10 million to establish CBFEWS in Iloilo, Lanao and Aurora. The United Nations Development Programme (UNDP) and the Australian Agency for International Development (AusAID) funded CBFEWS in Ilocos Sur, Zambales, Cavite, Laguna, Northern Samar, Surigao del Norte and Surigao del Sur (Pagulayan 2012).

The establishment of a CBFEWS requires the following rigorous process: a) consultation and assessment of site and the capability of the LGU; b) identification of appropriate monitoring and communication technology to be used; c) site survey and ocular inspection; d) installation of equipment; and e) training. During the consultation stage, the feasibility of implementing an EWS in the locality is assessed. The capacity of the LGU is also evaluated in terms of existing facilities and resources.

Once the feasibility of setting up the EWS is established, the most appropriate monitoring equipment is identified, and the communication channels selected. The mode of communication can be via SMS, radio, or walkie-talkie. In remote areas of the country where these systems are non-existent or impractical, the bell and bottle method is recommended.

During the site survey and ocular inspection, the proposed site for the monitoring stations is verified and assessed for the presence of an observer, the accessibility of the site, and the availability of communication facilities.

After the site survey the appropriate monitoring facilities are installed by PAGASA personnel with staff from the LGU. A hydraulic survey is conducted to determine the water capacity of the river.

After installation, capability building is undertaken. Specifically, LGU personnel and members of the community are trained in: a) protocols for observing, recording and transmitting data to a disaster coordinating office; b) data interpretation; and c) issuing flood warning/advisories. Before the CBFEWS is turned over to the LGU a dry run is conducted to test the system and the observers (Pagulayan 2012).

3.4.1 Description of the technology-based early warning system for the study site

The proposed EWS for the study site will utilize meteorological monitoring equipment developed by the Philippine DOST's Advanced Science and Technology Institute (ASTI) and will follow the CBFEWS scheme. The technology to be used includes an Automated Weather System (AWS) and a Water Level Monitoring System (WLMS). Both types of equipment collect and send data in real-time to a central server maintained by the DOST through the cellular network. The AWS collects information on wind speed and direction, air temperature, air humidity, air pressure, and rainfall, duration and intensity, while the WLMS collects information on water levels. This information can be accessed over the internet and can be used for predicting flooding along the Sta. Cruz river watershed, which will serve as the basis for issuing warnings. The lead time for the issuance of a warning is estimated to be between two and four hours. It is proposed that the warnings be sent through SMS or via text message to registered households, providing information on areas that are expected to flood, and evacuation warnings to critical areas.

The installation of the system requires several steps, which include:

1. The acquisition and setting-up of the AWS and WLMS stations;
2. Training and capacity building of personnel;
3. Research and field validation to establish thresholds for meteorological parameters;
4. Establishment of a database containing the contact information of households; and
5. Setting up of the monitoring and communications office.

The AWS station needs to be installed in the upland area of the watershed. This upland area is under the jurisdiction of the municipalities of Nagcarlan and Liliw; hence the EWS project should also involve these two municipalities. Ideally, the equipment should be installed in a secure location, preferably in a public school compound, while the WLMS can be installed under a bridge for easy access and monitoring. The instruments will be regularly maintained and cleaned to ensure the accurate collection of data. Site validation needs to be conducted to identify the specific locations of these stations.

It is proposed that each municipality maintain its own monitoring and communications office linked to the Municipal Disaster Risk Reduction and Management Office (MDRRMO). Each office will be manned by two full-time personnel with technical capabilities. Training and capacity building will also be conducted for DRRM personnel. Computer software that maintains contact numbers, the locations of households, and manages bulk text messaging, will be acquired for the project. Households will be required to do a one-time registration to establish the database; hence information dissemination will need to be conducted. This will be channeled through the primary, secondary and tertiary school systems in the project site. To establish the thresholds as a basis for the warnings, experts will be commissioned to do research and field validation.

3.4.2 Willingness-to-pay for a technology-based early warning system

A substantial proportion of the respondents revealed that they had little knowledge about EWS prior to the survey. When asked to rate their knowledge, with 1 being the lowest and 5 the highest, 45% rated their knowledge as being below 3. This proportion is about the same regardless of whether the respondent is male or female (Table 23). A brochure we created to explain the EWS details to respondents proved to be useful in the conduct of the WTP survey

Table 23. Knowledge about early warning systems

Rate	All	%	Male	%	Female	%
Rate 1 (lowest)	152	30	53	29	99	31
2	77	15	28	16	49	15
3	132	26	47	26	85	27
4	64	13	20	11	44	14
5 (highest)	75	15	32	18	43	13

The responses to the WTP question, which have been corrected for uncertainty, are summarized in Table 24. It can be seen that the proportion of 'yes' votes decline as the bid level increases. For all bid levels, the total 'yes' votes is 252 out of 500 responses.

Table 24. Distribution of responses to willingness-to-pay question by bid level

Willingness-to-pay response	25		50		100		200		300	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Yes	64	65	67	66	54	53	37	36	31	31
No	34	34	34	33	46	46	64	63	69	68
Total	**99**	**100**	**102**	**100**	**101**	**100**	**102**	**100**	**101**	**100**

The majority of respondents who answered 'yes' stated that their primary reason for doing so is to ensure the readiness of their community during floods (73%). Ten percent (10%) stated that the fee was affordable, 4% claimed that they have confidence in the technology that will be used, while 3% stated that they are confident about the capacity of the local government to carry out the project. Ten percent (10%) claimed that they feel happy knowing that they could help others through the project (Table 25). This latter reason signals the presence of the "warm-glow" effect; therefore if this was the sole reason for voting 'yes', then these votes were converted into a 'no' response.

Table 25. Distribution of reasons for 'yes' response

Reasons	Frequency	%
To ensure the readiness of my community during floods.	173	73
I feel happy knowing that I can help others.	23	10
The fee is affordable and our area is always at risk.	23	10
I have faith in the technology that will be used.	9	4
I have faith in the ability of the local government to implement this project.	8	3

The reasons for 'no' responses were varied. The majority of respondents thought that the fee was unaffordable (39%) and that their electricity bills are already too high (22%). Eight percent (8%) thought that there are more important problems that need to be prioritized, while 6% do not think that the EWS would be useful. Some claimed that they have no confidence in the local government (3%) or in the technology that will be used in the project (2%) (Table 26).

Nineteen percent stated that they are not willing to pay because it should be the government or rich households who should shoulder the cost. This reason signals a tendency for free-riding. However, we chose to retain these observations in order to arrive at a conservative estimate of mean willingness to pay. It is important to note that our mean WTP may be an underestimation of the true willingness to pay.

Table 26. Distribution of reasons for a 'no' response

Reasons	Frequency	%
The fee is unaffordable.	105	39
Our electricity bill is already too high.	58	22
The government should pay for the project.	48	18
There are other more important problems that must be prioritized.	22	8
The early warning system is not useful.	17	6
I do not have confidence in the capability of the local government.	7	3
I do not have confidence in the technology that will be used.	5	2
Only the rich should pay for the project.	4	1
We are already being warned by our local officials.	3	1

Table 27 shows the result of the logit regression analysis. Of the 10 explanatory variables, six were found to be statistically significant, which include the bid level, income, respondent's gender and age, flood exposure and attitude towards risk. The results conform to economic theory in that the bid level was found to have a negative coefficient while income has a positive coefficient.

It was also found that male respondents are more likely to be willing to pay, while age reduces the likelihood of paying. The higher propensity of male respondents to pay may be explained by the patriarchal nature of households in the Philippines, where males usually take on the lead role of ensuring the safety and well-being of their families. The attitude towards risk where the indicator used is autonomous adaptation had a positive impact on WTP. That is, those who have undertaken some form of autonomous adaptation were found to be more likely to be willing to pay.

Table 27. Results of the logit regression analysis

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
BID***	-0.0057	0.00	-5.85	0.00	-0.01	0.00
INC*	0.0001	0.00	1.91	0.06	0.00	0.00
RSEX**	0.4865	0.21	2.36	0.02	0.08	0.89
REDUC	-0.0124	0.04	-0.35	0.72	-0.08	0.06
RAGE**	-0.0163	0.01	-2.16	0.03	-0.03	0.00
EXP**	0.0973	0.03	2.81	0.01	0.03	0.17
KNOW	0.3752	0.22	1.67	0.10	-0.07	0.82
RISK***	0.6333	0.21	3.09	0.00	0.23	1.04
PILA	0.1756	0.29	0.60	0.55	-0.40	0.75
SCRUZ	-0.2039	0.27	-0.77	0.44	-0.72	0.32
CONSTANT	0.8698	0.60	1.46	0.15	-0.30	2.04
				No. of observation		497
				Likelihood ratio		75.09
				Prob>chi2		0.00
				Pseudo R2		0.11

Note: * significant at 1%, ** significant at 5%, *** significant at 10%

Based on the logistic regression, mean WTP was estimated to be PhP 140/household per month. The confidence interval is between PhP 127 and PhP 152 at 99% confidence level. The non-parametric lower-bound mean WTP estimate falls within this limits, averaging PhP 128/household per month. The mean WTP is about 0.8% of the average household income of the respondents (Table 28).

Table 28. Parametric and non-parametric mean willingness-to-pay

	Parametric	Non-parametric
Mean WTP per HH per month	PhP 140	PhP 128
(in USD)	USD 3.5	USD 3.2
Confidence interval for mean WTP (at 99% confidence level)	[PhP 127, PhP 152]	
(in USD)	[USD 3.18, USD 3.8]	

Exchange rate: 40 PhP = 1 USD

3.4.3 Benefit-cost analysis

The estimated initial investment needed to establish the EWS is about PhP 2 million, or USD 50,000. This covers the acquisition and installation of the equipment, capacity building and training, and setting up of the monitoring and warning dissemination office. The annual operation cost is about PhP 1.7 million/year (USD 42,500/year) (Table 29).

Using the lower bound estimate of mean WTP equal to PhP 128/household per month, the estimated benefit for the first year is about PhP 65.6 million (USD 1.64 million). Projections were done to estimate the benefit for the succeeding years, considering the growth of the population. A population growth rate of 1% per year was assumed and the number of households was calculated by dividing the total population by the average household size of five. Table 30 shows the baseline number of households corresponding to the year 2012.

Using a discount rate of 15%, the NPV is estimated to be PhP 330 million (USD 82.5 million). The BCR is 33, while the estimated IRR is more than 3,000%.

To further check the validity of estimates, it is useful to compare our results to similar studies on the benefits and costs of EWS. Table 31 shows case studies which used direct damage cost avoided in estimating the benefit of EWS. Our BCR estimate seems conservative compared to these case studies, particularly those in Bangladesh (BCR of 558) and Thailand (BCR of 176). Our estimate exceeds that of Sri Lanka's with a low BCR of 0.93. The reason for this low estimate is the infrequent occurrence of floods in Sri Lanka.

Table 29. Technology-based early warning system cost items

Cost item	Amount (PhP)
Initial investment	
a. Technology installation cost	
Machine and equipment purchase	
Automated weather station	120,000
Automated water level monitoring system	260,000
Computers	360,000
Installation (20,000 @ three units)	60,000
Shipping (2000 @ three units)	6,000
Fencing, pole mask, and other civil works (30,000 per monitoring site)	90,000
b. Research to establish thresholds	200,000
c. Capacity building/training	150,000
d. Software acquisition	150,000
e. One-time registration	42,288
f. Communications expenses	72,000
g. Internet	72,000
h. Overhead costs	360,000
Operations and maintenance	
a. Personnel	1,152,000
b. One-time registration	423
c. Communications expenses	72,000
d. Internet	72,000
e. Overhead costs	360,000

Table 30. Baseline household population (2012)

Municipality	Number of households
Pila	9,331
Sta. Cruz	23,550
Victoria	8,988

Table 31. Summary of benefit cost ratio estimates from other case studies

Case study	BCR
Sri Lanka, May 2003, flood case study	0.93
Bangladesh, 2007,flood case study	558
Thailand, 2007,flood case study	176

Source: Subbiah, A.R., L. Bildan, and R. Narasimhan (2008)

3.5 Cost-Effectiveness of Relocation, Evacuation and Building Modification

Lakeshore barangays in the municipality of Sta. Cruz are at risk of long-term flooding, which lasts for several months (Figure 7). In the last five years, two long-term flood events have been reported in the area. In 2009, flooding occurred as a result of typhoon Ondoy; some houses were submerged for as long as six months. The second event took place in 2012, brought about by a strong monsoon and later extended by typhoons *Gener* (Saola) and *Ofel* (Son-Tinh). This inundation lasted for between four and six months, depending on location. Figure 8 shows the extent of the devastation inflicted by typhoon Ondoy.

These long-term floods brought severe economic loss and inconvenience to affected households. During the 2012 flood important public buildings were submerged, including the Sta. Cruz public market, two public elementary schools and several barangay halls. The public market had to be closed for more than a month and sellers conducted their trade in the plaza, while some barangay offices transferred to the municipal hall. In addition, several businesses had to close for a couple of months, resulting in income loss.

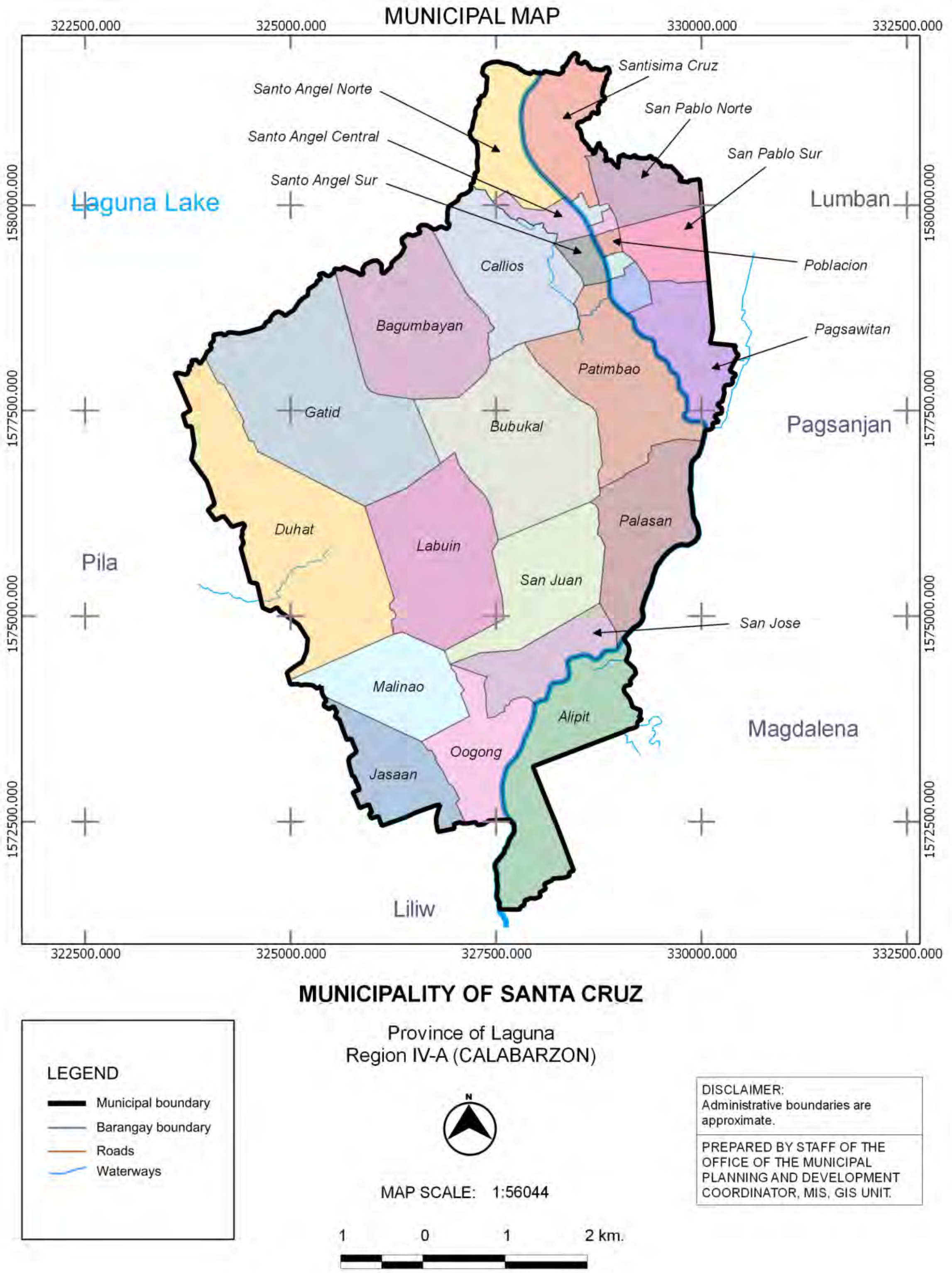


Figure 7. Municipal map of Sta. Cruz showing orientation to Laguna Lake

Figure 8. Flood impacts of typhoon Ondoy in Sta. Cruz, Laguna
Source: Sta. Cruz Municipal Planning and Development Coordinator

A total of 8,917 houses were inundated. As a result, 2,075 families (23%) moved to make-shift evacuation sites, primarily in public schools (Table 32). Other families opted to stay at home, moved in with relatives, or rented houses in unaffected areas. Those who stayed at home lived on the second floor during the flood. They used boats ferried by fishermen living in their barangay for transportation, and bamboo bridges were installed to help people cross roads.

To aid the victims, the Sta. Cruz local government provided evacuation and relief operations to households, and livelihood assistance to farmers and fishermen. But these are reactive strategies, which have short-term impacts.

Table 32. Houses inundated and families in temporary evacuation centers during Typhoon Gener

Barangay	No. of houses under water	No. of families in evacuation centers	% in evacuation centers
Santisima Cruz	3095	359	12
San Pablo Norte	2900	242	8
Santo Angel Central	550	141	26
Santo Angel Norte	600	25	4
Calios	625	148	24
Gatid	300	170	57
Poblacion V	115	98	85
Bagumbayan	250	141	56
San Pablo Sur	120	32	27
Poblacion IV	320	0	-
Pagsawitan	42	0	-
Santo Angel Central, San Pablo Norte, and Santisima Cruz	-	719	
Total	**8,917**	**2,075**	**23**

Source: Sta. Cruz Municipal Social Welfare and Development Office

Sta. Cruz has no permanent evacuation center so affected families were housed in public schools, churches, and a sports complex. Housing evacuees in temporary evacuation sites, such as schools, posed several problems:

- Barangay officials needed to get the permission of the school principal before they could utilize the building for evacuation, causing coordination problems and, sometimes, delays to the evacuation.
- Students were displaced and schools needed to reduce school hours to accommodate students and evacuees. As a consequence, the quality of education may have been compromised.
- There were concerns about the safety of students following isolated reports of harassment.
- The existing facilities of the school were not sufficient to meet health and sanitation standards, given the large number of evacuees.
- There were reports of deterioration/vandalism to school buildings and facilities.
- There were instances where schools serving as primary evacuation sites were also inundated, requiring emergency evacuation in the middle of the night. This compromised the safety of evacuees.

3.5.1 Objective of the intervention

Given the problems outlined above, the municipal local government recognized the need to implement a more long-term solution to flooding. As of 2012, it has already initiated a housing project, which benefits about 80 households. This was made possible through funding assistance from the International Organization for Migration (IOM) and the Philippine Department of Social Welfare and Development (DSWD). In addition, the construction of a multipurpose evacuation center with capacity to house 400 families is also underway. However, there are still about 1,700 households that face a high risk of flooding. The focus of this sub-study is to identify the best intervention that can provide these remaining at-risk households with a dignified temporary or permanent shelter so that they can avoid the hazards brought about by floods. Three options were subjected to CEA: evacuation centers, relocation and building modification.

Due to the nature of flooding in Sta. Cruz, which is recurrent and long-term, it is reasonable to consider relocation, building modification and the construction of a permanent/fixed evacuation site as possible interventions. For this analysis, the target beneficiaries are limited to the poor households. This limitation was set because of the administrative and legal difficulties of implementing relocation for rich households and because rich households also have the financial means to undertake autonomous adaptation.

It is important to specify from the outset that the designs of the options considered are generic and costs are merely rough estimates based on standard building and construction costs. Another limitation of the analysis is that the indirect impacts associated with the options, such as social, psychological, health and environmental costs, are not included because of the difficulties of attribution and monetization. As an example of these impacts, uprooting a family from their home may cause emotional distress and may lead to alienation and loss of social capital. It might also result in higher expenditure as households need to travel for longer to their place of work/business. Evacuation also has potential health impacts, because diseases are easily spread in crowded areas. Construction also has consequences on the environment due to emissions, water spills, waste generation, soil pollution, and resource consumption. Given these considerations, a more detailed assessment is recommended for further study.

3.5.2 Household relocation option

Relocation is a form of adaptation that involves moving populations at risk. It is defined by the World Bank as “a process whereby a community’s housing, assets, and public infrastructure are rebuilt in another location.” Several development and humanitarian agencies have already relocated a number of communities deemed to be at risk. However, most of these planned relocation projects did not work out as expected. As Scudder and Colson (1982) argues, relocation is a stressful experience. Many families are reluctant to leave their damaged home even if better housing is provided (Oliver-Smith 1991).

Davis (1977) found that after the 1963 Skopje earthquake Macedonians who were transferred to Yugoslavia experienced difficulties due to their lack of understanding of the local language, and returned to their native towns. This was also the case with Muslim and Catholic victims of the devastating 1992 earthquake and tsunami on the Island of Flores (Boen et al. 2001). Cultural and religious differences triggered the return of victims to their native villages. Gaillard (2008) states that culture and ethnicity should be incorporated into resettlement program planning, while Artur and Hillhorst (2012) includes sensitivity of the institutions in resettlement program planning.

In the Philippines, 13 relocation sites were developed for people affected by the eruption of Mt. Pinatubo in 1991. According to de Guzman (n.d.), the cost of resettlement spent on Aetas alone was PhP 349 million and PhP 1.689 billion for lowlanders. The relocation site had ample space and each family was given 94 m^2 of land with a concrete house of 27 m^2. However, due to cultural differences, poor location, and inadequate facilities, massive abandonment of these resettlement sites took place (Gaillard 2008). In contrast, the transfer of around 3,120 families from Marikina and Pasig in Metro Manila to a relocation site in Calauan, Laguna in the aftermath of Typhoon Ondoy (TS Ketsana) has been successful thanks to the provision of support services for community-building and livelihood opportunities at the relocation site (Mendoza et al. 2013).

Livelihood and the financial capacity of families should be taken into account to avoid the failure of a resettlement program. In La Union, Philippines, the government invested PhP 7.2 million in a relocation facility intended for fishermen living in areas threatened by coastal erosion. The facility, now consisting of 81 unfinished housing units, was constructed further inland. However, for the units to be inhabitable the resettlement program requires households to invest an initial outlay of PhP 140,000 for the construction of sanitary facilities and kitchens. As a result, after two years of construction only 20 units were reportedly occupied (Arias et al. 2011).

In Alaska, USA, 31 villages are in imminent danger from coastal erosion and flooding. The U.S. Army Corps of Engineers (USACE 2006) estimated that relocating the community of Kivalina will cost between USD 9-125 million, while Newtok will require USD 80-130 million, and Shishmaref will cost about USD 100-200 million. It is estimated that the villages of Kivalina, Newtok and Shishmaref will be completely eroded in 10-15 years. However, the high cost of relocation and complications in obtaining funding due to cultural, political and economic factors complicates the relocation process.

One notably successful resettlement project is the Xiaolangdi Resettlement Project in China. This project assisted the 172,487 residents of the 227 villages that are affected by the construction of Xiaolangdi Dam. The project cost USD 480 million, USD 295 million of which was spent on land, infrastructure and commercialization. Ferris (2011) stated that the success of this project has been due to political commitment, careful planning and the participation of the community in the decision-making process, and availability of sufficient financial resources.

The relocation option considered in this study provides households with core shelters made from concrete and plywood. The core shelter is 30 m^2 and each has its own toilet and sewerage facility. Land already owned by the municipal government in barangay Oogong (4.6 ha) would be used. Half of this land is already being used for an on-going housing project and about 2 ha is available for a relocation project. Oogong is about 20 minutes from the Poblacion, the municipality's center of business activity. The site is accessible via a concrete road and is situated far from the Laguna Lake, which makes the site flood-free and ideal for the relocation project. However, since the total land area needed for the project is 17 ha, an additional 15 ha needs to be acquired.

The costs associated with the relocation project include an initial capital outlay (CO), and an annual maintenance and operations cost (MOC).The CO covers the cost of acquiring the land, construction costs, transportation and hauling/moving costs, civil works for utilities, and livelihood support. The MOC consists of the land rent. The construction cost is about PhP 240,000/shelter, while the hauling/moving cost is PhP 1,800/household. The cost of civil works for electrification and sewerage is estimated at PhP 60,000/household.

As mentioned, one of the reasons why a relocation project may fail is due to the absence of economic activity or the lack of livelihood support for relocated families. This project will have a livelihood component so that beneficiaries will be able to start a business or a livelihood near their new residence.

Assistance will be given as a one-off payment of PhP 10,000/household, following the International Organization for Migration model.

Rent for existing owned land is included because using the resource for the relocation project entails an opportunity cost. This is associated with the income that could have been earned if the land was put to other productive uses, e.g. agricultural production. Hence, land rent is accounted for and is estimated to be equal to the net income per year from rice production or PhP 120,000/year.

Compared with the other options analyzed, the relocation option was deemed to be the most effective in ensuring zero casualties during disasters. However, it requires a large CO and it is difficult to implement because people can be reluctant to leave their homes.

3.5.3 Evacuation center option

The evacuation center option could also be constructed in the available 2-hectare lot owned by the municipal government in Oogong. Following international standards of 3.5 m^2/person, the three-story center would have a total area of about 29,750 m^2. The CO associated with the evacuation center option includes the building construction cost, while the MOC includes the transportation of households to and from the evacuation site, communications, maintenance, and the damage cost to properties during floods.

Since the building is intended to be multipurpose, it includes recreation and storage facilities for use when there are no evacuees. Due to this factor, only about 85% of the construction cost would be attributed to the evacuation center option. The construction cost is estimated to be about PhP 379.3 million.

Households will still shoulder some flood damage costs because their homes are still threatened by floods. The flood damage cost used in the estimation is the modal value of the reported damage cost during *Habagat* (monsoon flood), equal to PhP 5,000/household. To get the annualized flood damage cost, we multiplied this value by the probability of flood occurrence, which is once every five years. The maintenance costs cover utility bills and cleaning, and are approximately PhP 600,000/year. The transportation costs and communication costs are assumed to be PhP 10 and PhP 1 per person, respectively. The transportation and communication costs would be incurred during the evacuation operation.

The cost of providing food to the evacuation site has not been included. People would still incur costs for food even if they were not sheltered at the evacuation site so this cost item would be a transfer from private individuals to the government.

The main advantage of evacuation over other options is that it is flexible, meaning that if the hazard does not occur, the building can be used for other purposes. However, compared with relocation, evacuation may be less effective in achieving intervention and ensuring zero casualties during disasters. This is especially true if the EWS that can facilitate timely evacuation is not yet in place. Compared to building modification, evacuation has the disadvantage of being less convenient and less comfortable for the evacuees.

3.5.4 Building modification option

Building modification, or improving the resiliency of existing house structures to flooding, was also analyzed as an option. This option can be government-led, guided by regulation, and coupled with government financing. Building modification would involve diverting money from relocation or evacuation to direct assistance to households in at-risk areas. This money can be used by householders to modify or improve their houses. Although this option is usually deemed to be an autonomous type of adaptation, there might be a case for government intervention if households underinvest in adaptation activities because they are faced with liquidity constraints. The government can address this issue and provide financing to households.

Since most houses in the area are concrete, modification will entail building a second floor, rather than raising houses on stilts. The proposed size of the second floor is 20 m^2. Since ground-floor bathrooms are not usable during floods, floating toilets would also need to be provided. The toilet would be made from plastic drums and wood, while the waste treatment material would be charcoal and garden soil.

The CO associated with this option includes the building modification cost and the cost of floating toilets. The MOC includes the expense of emergency evacuation, residual property damage due to flooding, and the cost of maintaining the floating toilets. The cost of building modification is about PhP 160,000/household, while the cost of the floating toilets is about PhP 50,000/unit, with each unit serving 10 families. If this option is implemented, residual property damage is still expected to occur. The construction of the second level does not guarantee 100% protection for households. The damage cost incurred by each household is estimated to be PhP 340/year, which is the damage cost associated with a knee-deep inundation multiplied by a probability of flood occurrence once every five years.

In addition, some emergency evacuation is still expected to occur even after the implementation of building modification. This will entail an additional cost to cover communications and the transportation of affected households, which is estimated at about PhP 93,500/year.

The main advantage of this option is that households need not leave the comfort of their own homes during disasters. However, this option has the lowest effectiveness of the three options. Building modification may not be as effective in attaining our objectives compared to relocation or evacuation, especially if the flood height exceeds the height of the house's second floor. This means that houses will continue to be uninhabitable during extreme flooding, and households will still sustain full damages – and may still need to be evacuated from their homes. Also, building modification does not shield households from other hazards such as earthquake-induced liquefaction, which is one of the major hazards identified for the area by the Municipal Planning and Development Coordination Office. In addition, if the project is implemented with government funding, it may encourage households to engage in risky behavior (moral hazard), which is to settle in flood-prone areas because they are assured of financial support.

3.5.5 Comparison of the adaptation options

Table 33 summarizes the advantages and disadvantages of the adaptation options.

Table 33. Advantages and disadvantages of adaptation options

	Advantages	Disadvantages
Relocation	• Ensures the highest probability of zero casualties during disasters.	• Difficult to convince people to relocate. • Highest capital outlay. • Requires major and permanent adjustments for affected households.
Evacuation center	• Flexible; even if flood does not occur, the building can be used for other purposes.	• Inconvenience and discomfort associated with living with other people in a public environment. • May not ensure zero casualties during floods if evacuation is untimely.
Building modification	• No need to uproot people from their existing communities.	• Households not shielded from other hazards, such as earthquake-induced liquefaction. • May not ensure zero casualties during floods. • May still need to evacuate people if floods are more intense than expected. • May promote risky behavior associated with moral hazard, i.e. there is an incentive for households to settle in risky areas if the government shoulders the cost of building modification.

Table 34 summarizes the distribution of costs associated with the three options. The highest capital outlay is required for relocation (PhP 552 million), followed by evacuation (PhP 377.5 million). The cheapest option in terms of capital outlay is building modification (PhP 279.8 million). The annual operations and maintenance costs are about PhP 0.12 million for relocation, PhP 3.1 million for the evacuation center, and PhP 0.68 million for building modification.

Table 34. Capital outlay vs annual operations and maintenance cost of the three adaptation options (PhP)

Item	Relocation	Evacuation center	Building modification
Capital outlay	551,940,000	377,519,000	279,814,900
Annual operations and maintenance cost	120,000	3,101,500	685,100

3.5.6 Risk-based cost-effectiveness analysis

Although the costs of the options are designed in such a way that they meet the target of 1,700 household beneficiaries, it is recognized that the options may not yield the same level of effectiveness. Among the three options, relocation is deemed to have the highest effectiveness in attaining the primary objective of intervention, followed by evacuation, and last by building modification.

However, to determine which option is best, it is necessary to compare the Incremental Cost-Effectiveness Ratio (ICER). The results show that building modification is the most cost-effective option among the three, with an ICER of 279,342. This is followed by evacuation (ICER of 340,413), while the least cost-effective option is relocation (ICER of 447,902) (Table 35).

Table 35. Cost-effectiveness analysis of relocation, evacuation, and building modification options

Options	PV of cost*	Effectiveness	CER	ICER
Relocation	552,955,698	1,700	325,268	447,902
Evacuation	400,669,058	1,360	294,610	340,413
Building modification	284,928,589	1,020	279,342	279,342

* Used a discount rate of 15% and time frame of 25 years.

To test the robustness of the above findings, risk analysis should also be performed. Monte Carlo simulation was undertaken using the estimated mean and standard deviation of cost and effectiveness summarized in Tables 36 and 37. The standard deviation of cost is predicted to be 20% of the estimated cost, while the standard deviation of effectiveness is based on the ratings given by the research team.

Table 36. Present value and standard deviation of the estimated costs of the adaptation options

Options	Present value of cost (PhP) (15% discount rate, 25 years)	Standard deviation (PhP)
Relocation	552,955,698	110,591,140
Evacuation	400,669,058	80,133,812
Building modification	284,928,589	56,985,718

Table 37. Effectiveness measure of relocation, evacuation and building modification

Options	Effectiveness*	
	Percent	# of households
Relocation	100%	1,700
Evacuation	70% - 90%	1,190-1,530
Building modification	50% - 70%	850-1,190

* Based on ratings provided by the researchers. The researchers represent a diverse background (Engineering, Sociology/Human Ecology, and Economics).

Table 38 shows a summary of the simulation statistics. Based on the analysis, we found that building modification has the lowest expected CER (PhP 286,502), followed by evacuation (298,829) and relocation (324,973), which means that building modification seems to be the best option.

Table 38. Descriptive statistics of the results of the Monte Carlo simulation

Descriptive Statistics	Relocation	Evacuation	Building Modification
Mean CER	324,973	298,829	286,502
Median CER	324,825	293,120	277,680
S.D. of CER	65,032	72,159	78,739
Min. CER	64,899	22,303	57,643
Max. CER	550,301	739,964	953,896

In order to have a more systematic comparison, the cumulative distributions of each alternative were generated and compared. Figure 9 shows that the distribution of the evacuation option is consistently situated to the left of relocation, while Figure 10 shows that building modification is consistently to the left of the evacuation option. This means that among the alternatives the building modification option consistently offers the higher probability of achieving more desirable outcomes, i.e. lower cost-effectiveness ratio.

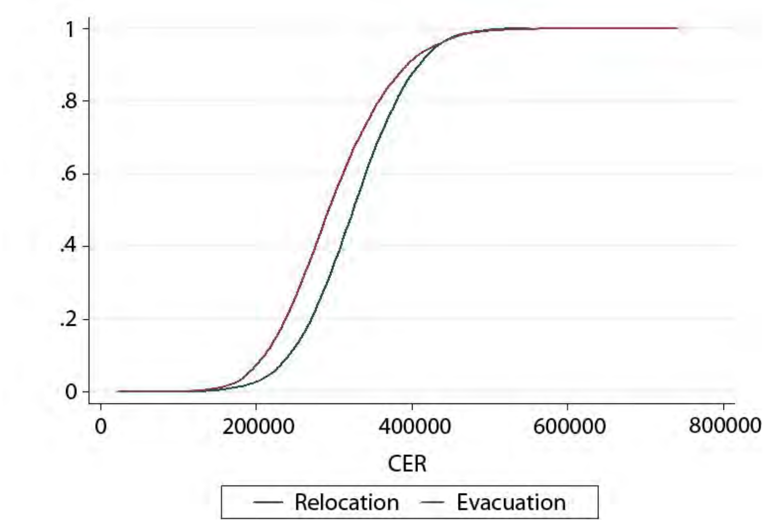


Figure 9. Cumulative distribution of the cost-effectiveness ratios of the evacuation and relocation options

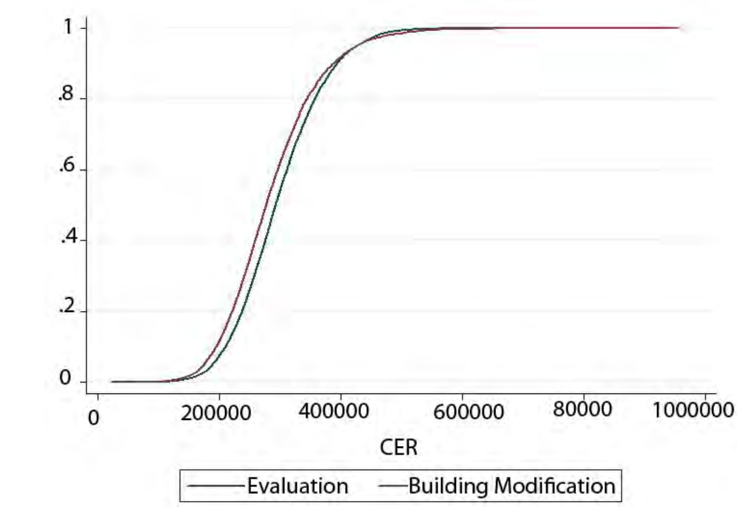


Figure 10. Cumulative distribution of the cost-effectiveness ratios of the evacuation and building modification options

4.0 SUMMARY AND CONCLUSION

Considering the results of the vulnerability assessment in the first phase of this study, combined with the run-off estimates using the rational equation, the study site was narrowed down to the municipalities belonging to the Sta. Cruz River watershed.

The project focused on the identification and economic analysis of adaptation options. Applying the participatory framework and the watershed approach, we identified technology-based early warning system for the lakeshore municipalities of the study site, and relocation, evacuation and building modification adaptation options for lakeshore barangays exposed to long-term floods in the municipality of Sta. Cruz, Laguna. The technology-based early warning system was subjected to benefit-cost analysis, while the three adaptation options for long-term floods were subjected to cost-effectiveness analysis.

We found out that the respondents in the study site have a positive willingness-to-pay for a technology-based early warning system. The estimated mean willingness-to-pay is between PhP 127 and PhP 152 per household per month. The analysis also shows that the proposed project produces large social net benefits, with a benefit cost ratio (BCR) reaching as much as 33. Hence, we recommend the implementation of this project in the study site.

Between the three adaptation options for long-term flooding, the building modification option is found to be the most cost-effective and this result is robust when risk analysis is applied. Hence, instead of the evacuation center projects already in motion, local government should instead consider the financing of building modification. However, a more in-depth study is recommended so that the indirect costs associated with all the projects can be included.

In addition, we also estimated the direct flood damage costs corresponding to various flood depths and land use. This estimate can be used as an input for studies that will look into the benefits of flood mitigation projects, such as lake dredging or road dike systems, which are currently being considered as long-term strategies for addressing flooding in the Laguna Lake basin. Our flood damage cost estimate per hectare for built-up land is about PhP 410,000, PhP 215,000 and PhP 85,000 for more than neck-high, waist-deep and knee-deep flood levels, respectively. Rice land incurs a damage cost of PhP 29,600/ha for a flood level corresponding to 2.5 ft and above.

We also conducted simulation of flood inundation in the whole Sta. Cruz River watershed. It is predicted that about 146.8 to 506.4 ha of built-up land and about 673.9 to 2,565 ha of rice land is at risk to flooding. The corresponding damage cost resulting from this ranges from PhP 13.7 million to PhP 88.8 million for built-up land and PhP 19.9 million to 75.9 million for rice land.

REFERENCES

Akhter S. 2010. Students' Willingness to Pay for Offsetting Carbon Emissions on IUB Campus: A Contingent Valuation Approach. Paper Presented at Proc. of International Conference on Environmental Aspects of Bangladesh (ICEAB10). Japan. Sept. 2010.

Akhter, S. and J. Bennet. 2009. Household perceptions of climate change and preferences for mitigation action: The case of the Carbon Pollution Reduction Scheme in Australia. Environmental Economics Research Hub Research Report.

Arias, J.K.; M.A. Dorado; and R.A. Dorado. 2011. Economic Vulnerability and Analysis of Adaptation Options to Coastal Erosion in San Fernando, La Union. Journal of Environmental Science and Management. 15(2): 35–49.

Arrow, K.; R. Solow; P. Portney; E. Leamer; R. Radner; and H. Schuman.1993. Report of the NOAA Panel on Contingent Valuation. Federal Register. 58: 4601–14.

Artur, A. and D. Hilhorst. 2012. Everyday realities of climate change adaptation in Mozambique. *Global Environmental Change.* 22: 529-536.

Awad, I. and R. Hollander. 2010. Applying Contingent Valuation Method to Measure the Total Economic Value of Domestic Water Services: A Case Study in Ramallah Governorate, Palestine. European Journal of Economics, Finance and Administrative Sciences. 76–93.

Basha, E. and D. Russ. 2007. Design of Early Warning Flood Detection Systems for Developing Countries. Manuscript submitted to Massachusetts Institute of Technology, Cambridge, MA. USA.

Bateman, I. J.; R. T. Carson; B. Day; M. Hanemann; N. Hanley; T. Hett; M. Jones-Lee; G. Loomes; S. Mourato; E. Ozdemiroglu; D.W. Pearce; R. Sugden; and J. Swanson. 2002. Economic Valuation with Stated Preference Techniques: A Manual. Edward Elgar, Ltd. Cheltenham, UK.

Boardman A.E.; D.H. Greenberg; A.R. Vining; and D.L. Weimer. 2010. Cost-Benefit Analysis: Concepts and Practice, (4th edition). Prentice Hall. NJ, USA.

Boen, T.; M. Susanto; I. Disah; Hendarto. 2001. "Post Earthquake Disaster Relocation: Indonesia's Experience", in APEC Workshop on Dissemination of Disaster Mitigation Technologies for Humanistic Concerns Phase I: Earthquake Disaster. Taipei. Taiwan. 18–21June. 22.1–22.15.

Bowen, H.R. 1943. The Interpretation of Voting in the Allocation of Economic Resources. Quarterly Journal of Economics. 58. 27–48.

Brouwer, R.; L. Brander; and P. Van Beukering. 2008. A Convenient Truth: Air Travel Passengers' Willingness To Pay Offset Their CO_2 Emissions. Climatic Change. 90 (3): 299–313.

Cardoso A. and J. Benhin. 2011. Assessing the Viability of Protecting Colombian Carribean Coast from Sea Level Rise: An Econmic Valuation Approach. Semestre. Economico. 14(29): 13–30.

Carson, R. 2000. Contingent Valuation a User's Guide, Environment and Science Technology. 34:1413–1418.

Ciriacy-Wantrup, S. 1947. Capital Returns from Soil-Conservation Practices. Journal of Farm Economics. 29:1181–96.

Davis, I.1977. "Emergency Shelter". Disasters. 1(1): 23–40.

Davis, R.K. 1963. Recreation Planning as an Economic Problem. Natural Resources Journal. 3: 239–249.

De Guzman, E. (n.d.). Eruption of Mount Pinatubo in the Philippines in June, 1991. Asian Disaster Reduction Center.1–17.

Dillman, D. 2000. Procedures for Conducting Government-Sponsored Establishment Surveys: Comparisons of the Total Design Method, A Traditional Cost Compensation Model, and Tailored Design. www.sesrc.wsu.edu/dillman/.../proceduresforconductinggovernment.pdf (retrieved October 20, 2012).

Esperanza, H.G. and S.F. Paat Jr. 2007.Community-Based Flood Early Warning System. Paper presented at East and Southeast Asia Regional Seminar on Flood Hazard Mapping. Kuala Lumpur. Malaysia. 7–9 February.

Ferris, E. 2011. Planned Relocations, Disasters and Climate Change. Paper presented during the Conference on Climate Change and Migration in the Asia-Pacific: Legal and Policy Responses. Sydney, Australia. 10-11 November 2011.

Gaillard, J.C. 2008. Differentiated adjustment to the 1991 Mt. Pinatubo resettlement program among lowland ethnic groups of the Philippines. The Australian Journal of Emergency Management. 23(2): 31–39.

Haab, T.C. and K.E. McConnell. 2002. Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation. Edward Elgar Publishing. Cheltenham, UK.

Hanemann, M. 1994. Valuing the Environment through Contingent Valuation. Journal of Economic Perspectives. 8(4): 19-44.

Layton, D.F. and G. Brown. 2000. Heterogeneous preferences regarding global climate change.The Review of Economics and Statistics. 82 (4): 616–624.

Leary, N. 1999. A Framework of Benefit-Cost Analysis on Adaptation to Climate Change and Climate Variability. Mitigation and Adaptation Study on Global Climate Change. 4: 307–318.

Lipton, D.; K. Wellman; I. Sheifer; and R. Weiher.1998. Economic Valuation of Natural Resources: A Guidebook for Coastal Resources Policymakers. NOAA Coastal Ocean Program Decision Analysis Series No. 5.

Markantonis, V. and K. Bithas. 2010. The Application of the Contingent Valuation Method in Estimating the Climate Change Mitigation and Adaptation Policies in Greece: An expert-based approach. Environment, Development and Sustainability. 12: 807–824.

Margulis, S.; A. Bucher; D. Corderi; U. Narain; H. Page; K. Pandey; T.T. Linh Phu; C. Bachofen; R. Mearns; B. Blankespoor; S. Dasgupta; S. Murray; E. Cushion; L. Gronnevet; L. Cretegny; P. Ghosh; B. Laplante; L. Leony; R. Schneider; P. Ward; and D. Wheeler. 2008. The Economics of Adaptation to Climate Change: Methodology Report. The World Bank: Washington DC, U.S.A.

Mendoza, M.E.T.; E.S. Visco; C.E.G. Jimena; D.T. Lagos; and J.M.S. Amparo. 2013. "The Human Ecological Imperatives of Community Resettlement as a Response to Environmental Crises". Paper presented during the XIX International Conference of the Society for Human Ecology. Australian National University. Canberra, Australia. 5-8 February 2013.

Mercy Corps Practical Action. 2010. Establishing Community-Based Early Warning System. Practitioner's Handbook. Mercy Corps. Nepal.

Messner, F. and V. Meyer. 2005. "Flood damage, vulnerability and risk perception – challenges for flood damage research". Schanze, J.; E. Zeman; and J. Marsalek (ed.). Flood Risk Management: Hazards, Vulnerability and Mitigation Measures. Nato Science Series. Dordecht, Springer.

Mitchell, R. and R. Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. The Johns Hopkins University Press.Washington DC. USA.

Oliver-Smith, A. 1991. Successes and Failures in Post-Disaster Resettlement. Disasters. 15(1): 12-23.

Pagulayan, R.C. 2012. PAGASA and Its Flood Early Warning Services. Paper presented at the the 1st Philippine International River Summit. Centennial Resort Hotel and Convention Center, Alta Tierra Village, Jaro, Iloilo City. May 30–June 1.

Perez, R.T; S.R. Espnueva; and H. Hernando. 2007. Community-Based Flood Early Warning Systems. Briefing Paper: Workshop on the science and practice of flood disaster management in urbanizing. Monsoon Asia. 4-6 April. Chiang Mai, Thailand.

Penning-Roswell, E.; C. Johnson; S. Tunstall; S. Tapsell; J. Morris; J Catterton; and C. Green. 2003. The benefits of flood and coastal defence: Techniques and data for 2003. Flood Hazard Research Centre. Middlesex University, UK.

Philippine Department of Agriculture. "Production Cost Per Hectare for Lowland Irrigated Rice". <http://www.rfu6.da.gov.ph/agribiz/invrice.htm> (retrieved February 1, 2013).

Rothman D.; B. Amelung; and P. Polome. 2003. Estimating Non-Market Impacts of Climate Change and Climate Policy. OECD Project Report.

Subbiah, A.R.; L. Bildan; and R. Narasimhan. 2008. "Background Paper on Assessment of the Economics of Early Warning Systems for Disaster Risk Reduction" submitted to the Joint World Bank-UN Project on the Economics of Disaster Risk Reduction.

Scudder, T. and E. Colson. 1982. "From Welfare to Development: A Conceptual Framework for the Analysis of Dislocated People". *In* E. Hansen and A. Oliver-Smith (ed.). Involuntary Migration and Resettlement: The Problems and Responses of Dislocated People. Westview Press. Boulder, USA. 267–287.

UK DOE (United Kingdom Department of Environment). 1991. Policy Appraisal and the Environment: A Guide for Government Departments. London: Her Majesty Stationary Office.

UNISDR (United Nations Office for Disaster Risk Reduction). 2007. *Terminology.* Retrieved from UNISDR Web site: http://www.unisdr.org/we/inform/terminology. February 2, 2013.

USACE (U.S. Army Corps of Engineers). 2006. Alaska village erosion technical assistance program: An examination of erosion issues in the communities of Bethel, Dillingham, Kaktovik, Kivalina, Newtok, Shishmaref, and Unalakleet. Army Corps of Engineers Report. USA.

Strengthening local capacity in the economic analysis of environmental issues

Recent EEPSEA Research Reports

Partnership Regimes for the Production of Biofuels and Natural Rubber in Upland Palawan, Philippines
Marvin Joseph F. Montefrio
2013-R14

Optimal Forest Management for Carbon Sequestration: A Case Study of Eucalyptus urophylla and Acacia mangium in Yen Bai Province, Vietnam
Nghiem Thi Hong Nhung
2013-RR15

Fiscal Gap and Financing Protected Areas in the Philippines
Alexander D. Anda, Jr. and Marlon M. Atienza
2013-RR16

'Muang Fai' Irrigation System in Northern Thailand: Farming Productivity and Water Use Efficiency
Arriya Mungsunti
2013-RR17

Household Vulnerability to Climate Change in Selected Municipalities in Laguna, Philippines
Jaimie Kim B. Arias, Ma. Emilinda T. Mendoza, Vicente G. Ballaran, Jr. and Rowena A. Dorado
2014-RR1

Altruism, Cooperation and Trust: Other-regarding Behavior and Collective Actions in Thailand
Rawadee Jarungrattapong and Suparee Boonmanunt
2014-RR2

Economic Valuation of the Caramoan, Camarines Sur Beachscape: An Environmental Services Payment Scheme for Sustainable Ecotourism
Raul G. Bradecina
2014-RR3

Economic Impacts of Artificial Reefs: The Case of Fisher Households in Peninsular Malaysia
Shaufique Sidique, Kusairi Mohd Noh, Gazi Md Nurul Islam and Aswani Farhana Mohd Noh
2014-RR4

Cost-Benefit Analysis of Flood Control Adaptations to Climate Change in the An Xuan Tributary Basin, Thua Thien Hue, Vietnam
Bui Dung The and Bui Duc Tinh
2014-RR5

Economic Analysis of Flood Adaptation Options in the Sta. Cruz River Watershed, Laguna, Philippines
Jaimie Kim B. Arias, Vicente G. Ballaran, Jr., Maria Emilinda T. Mendoza, Rowena A. Dorado, and Bessie M. Burgos
2014-RR6

Financial and Economic Viability of Bioplastic Production in Thailand
Siriluk Chiarakorn, Chompoonuh K. Permpoonwiwat and Papondhanai Nanthachatchavankul
2014-RR7

Regional Economic Development, Energy Consumption and Carbon Emissions in China
Chunhua Wang
2014-RR8

Policy Conflict and Performance of Emissions Trading Markets: An Adaptive Agent-based Analysis
Bing Zhang and Yongliang Zhang
2014-RR9

Payment for Environmental Services in South East Asia: A Regional Review of Policy Implementation
Nguyen Thi Y Ly and Pham Thanh Nam
2014-RR10

Economic Benefits of Management Options for a Suburban Forest in South Thailand
Saowalak Roongtawanreongsri, Prakart Sawangchote, Sara Bumrungsri and Chaisri Suksaroj
2014-RR11

EEPSEA is administered by WorldFish on behalf of its donors, Sida and IDRC.

Sida IDRC CRDI