DEVELOPING CAPACITY TO ADAPT TO CLIMATE CHANGE

Economic Analysis of Adaptation Options

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ECONOMY AND ENVIRONMENT PROGRAM FOR SOUTHEAST ASIA
SEAMEO SEARCA
Climate Change and Water Program

Background

- Part of a three year study, Developing Capacity to Adapt to Climate Change.
- Focuses on the problem of flooding, valuing its impact and identifying adaptation options to minimize impacts.
- Study site: Sta. Cruz River Watershed (Sta. Cruz, Victoria, Pila, parts of Pagsanjan and Calauan)
- Highlights the usefulness of economic analysis as a tool for local government decision-making.

Developing Capacity to Adapt to Climate Change Project Overview

Year 1

VULNERABILITY ASSESSMENT

- Barangay Vulnerability Index
- HH Vulnerability Analysis
- Vulnerability Map

Year 2

ECONOMIC ANALYSIS OF ADAPTATION

- Cost-effectiveness Analysis
- Benefit-Cost Analysis

Year 3

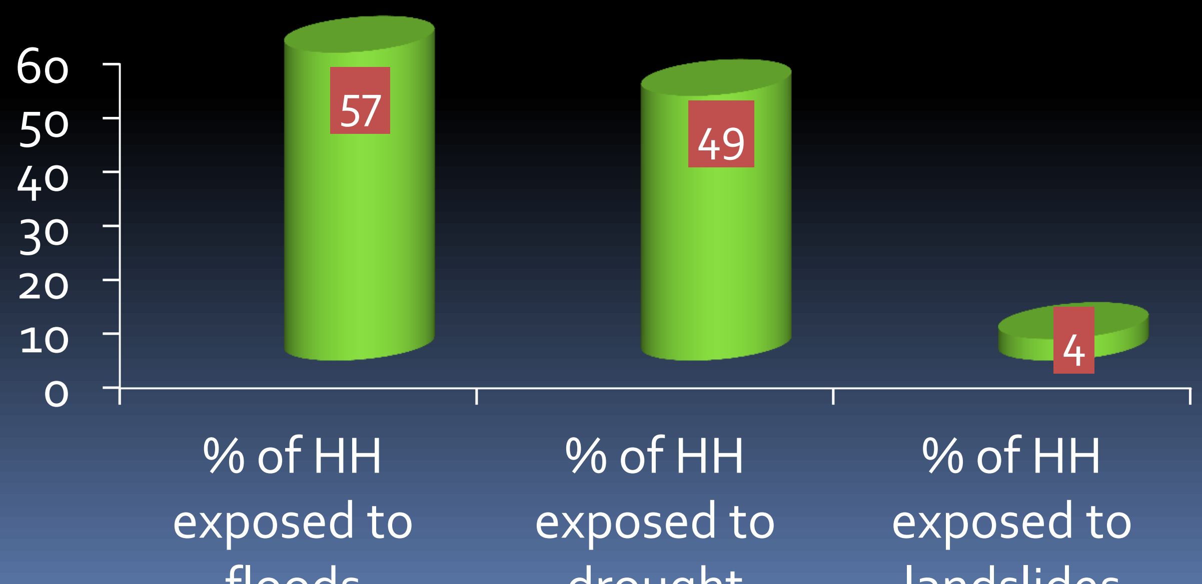
LOCAL GOVERNMENT ADAPTATION PROPOSAL WRITING

TRAINING AND RESEARCH

SOCIAL AND GENDER

Why Floods?

- Typhoons and heavy rains are expected to become more intense as a result of climate change.
- Vulnerability analysis shows that floods and typhoons have the widest impact in terms of the number of households exposed to the hazard.
- Presence of long-term flooding in the lakeshore municipalities lasting for as long as 4 months.



Typhoon Ketsana (2009): Photos courtesy of the Sta. Cruz Local Government

STA. CRUZ, LAGUNA

31 OCTOBER 2009

STA. CRUZ, LAGUNA

31 OCTOBER 2009

Typhoon Ketsana (2009): Photos courtesy of the Sta. Cruz Local Government

Why Sta. Cruz River Watershed?

- Where the top three most vulnerable barangays in the study site are situated (based from Year 1 Study)
- Where the highest peak run-off was estimated (based from a GIS model which used the Rational Method)

The Study Site…

YEAR 1 – VULNERABILITY STUDY

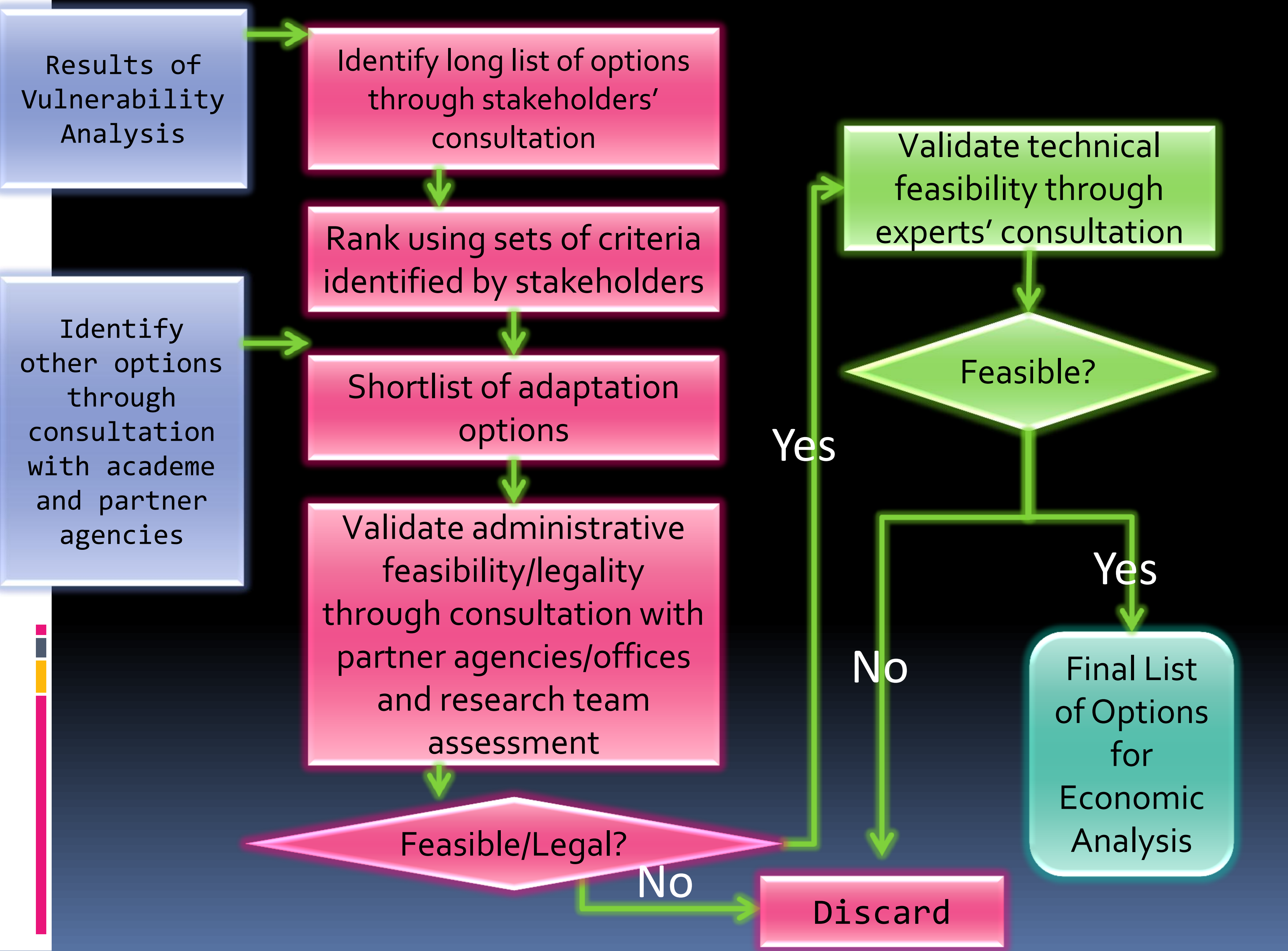
YEAR 2 – ADAPTATION STUDY

What is adaptation?

- Any modification in behavior or any intervention which reduces the negative impacts of climate related hazards.
- Autonomous versus Planned Adaptation
- Focus of the study is on planned adaptation strategies – coordinated by the local government.

Guiding Principles in the Identification of Adaptation Options for Economic Analysis

- Watershed Approach
  - Efficient
  - Effective
- Participatory Approach
  - Socially acceptable
  - Technically feasible


Results of Vulnerability Analysis
Identify long list of options through stakeholders' consultation
Rank using sets of criteria identified by stakeholders
Identify other options through consultation with academe and partner agencies
Shortlist of adaptation options
Validate administrative feasibility/legality through consultation with partner agencies/offices and research team assessment
Feasible/Legal?
Yes
No
Discard
Validate technical feasibility through experts' consultation
Feasible?
Yes
No
Final List of Options for Economic Analysis

Adaptation Options Considered

Scope of Implementation	Adaptation Option	Analytical Method
Lakeshore municipalities in Sta. Cruz watershed (Sta. Cruz, Victoria, Pila)	Early Warning System	Assessment: Benefit Cost Analysis Benefit Valuation: Contingent Valuation Method
Special Case Study for areas exposed to long-term floods: Lakeshore barangays in Sta. Cruz, Laguna	• Evacuation-already being considered by the LGU • Relocation • Building Modification	Assessment: Cost Effectiveness Analysis Cost Valuation: 'Synthetic Approach' to Direct Damage Cost Estimation

Three Sub-Studies

Study 1: Flood Inundation Maps and Damage Cost Estimates

Study 2: Benefit Cost Analysis of Early Warning System as an Adaptation Option for Lakeshore Municipalities in the Sta. Cruz Watershed

Study 3: Cost Effectiveness Analysis of Relocation, Evacuation and Building Modification as an Adaptation Option for Barangays at Risk to Long-Term Inundation

Why Economic Analysis?

- SCARCITY and LIMITED resources
- Many projects compete for valuable yet very scarce funds
- Economic analysis can help us choose which projects to implement.
  - Systematic decision-making
  - Transparent decision-making
  - Relatively “simple” decision-making
  - Acceptable criteria: Efficiency

Decision-making using Economics

- The project is good if it can improve the SOCIETY'S welfare, that is:

  Aggregate Benefit > Aggregate Costs

- Convert into a single numeraire, for comparability – usually in terms of money!
- Economic Analysis versus Financial Analysis
- Economic Analysis versus Fiscal Analysis
- Approaches:
  - Benefit Cost Analysis
  - Cost-Effectiveness Analysis

KEY: THE WHOLE SOCIETY'S POINT OF VIEW

- Benefit Cost Analysis (BCA): uses the concept of net present value (NPV) in deciding whether the project is good or not.
  - NPV = PV Benefits – PV Costs
  - Both benefits and costs are measured in monetary terms
  - Good if NPV>0, if you are analyzing one project
- Cost-effectiveness Analysis (CEA): helps identify the least costly option that can attain a specified objective based on the Cost Effectiveness Ratio (CER)
  - CER = Benefit/PV of Cost
  - Only the cost is measured in monetary terms
  - The best project is the one with the lowest CER

Three Sub-Studies

Study 1: Flood Inundation Maps and Damage Cost Estimates

- Maps: Rational Method and GIS Modeling
- Damage Cost: Using data from a HH Survey covering direct damage costs (property and assets)

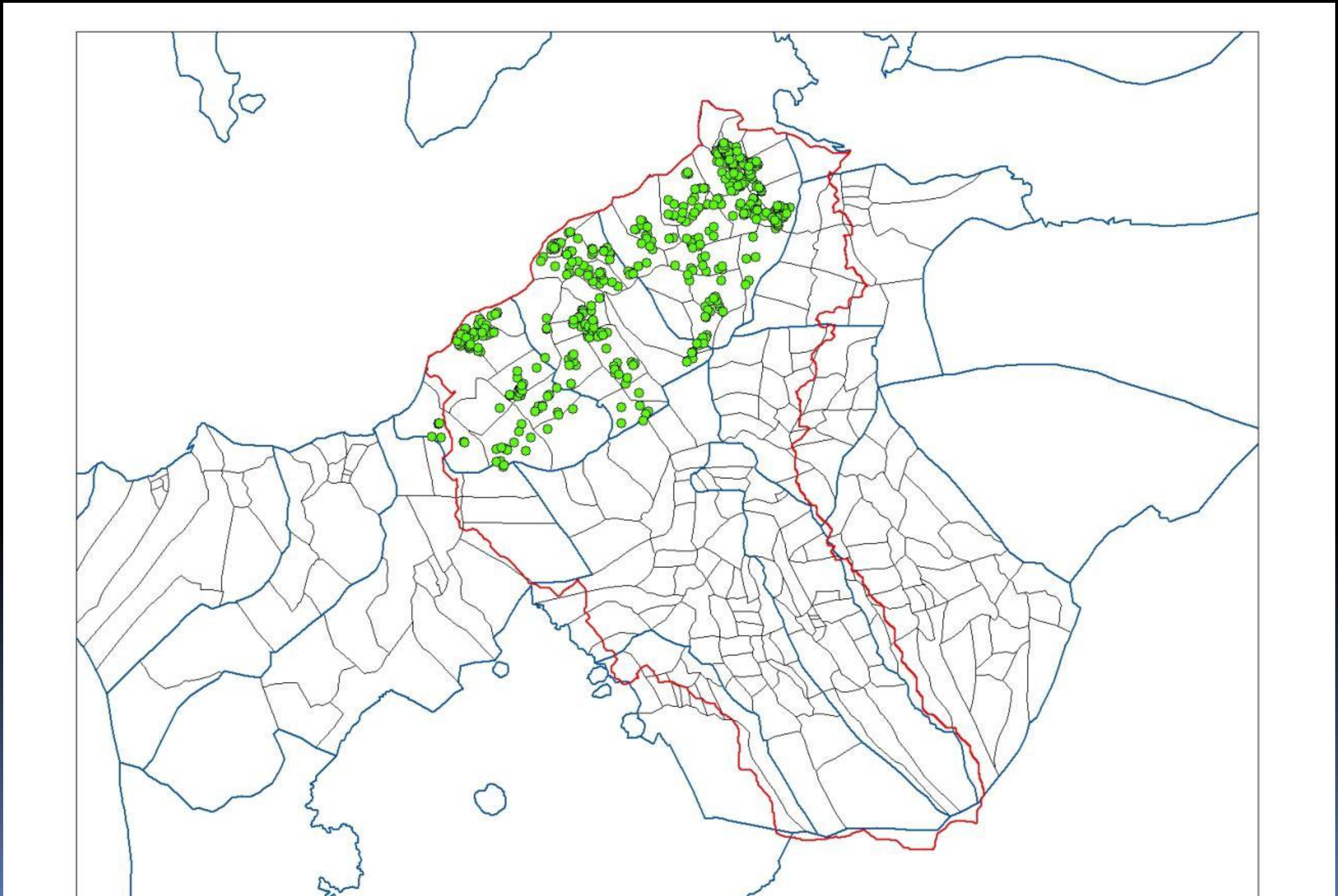
Study 2: Benefit Cost Analysis of Early Warning System as an Adaptation Option for Lakeshore Municipalities in the Sta. Cruz Watershed

- Benefit of EWS: Contingent Valuation Method
- Cost: Direct Costs

Study 3: Cost Effectiveness Analysis of Relocation, Evacuation and Building Modification as an Adaptation Option for Barangays at Risk to Long-Term Inundation

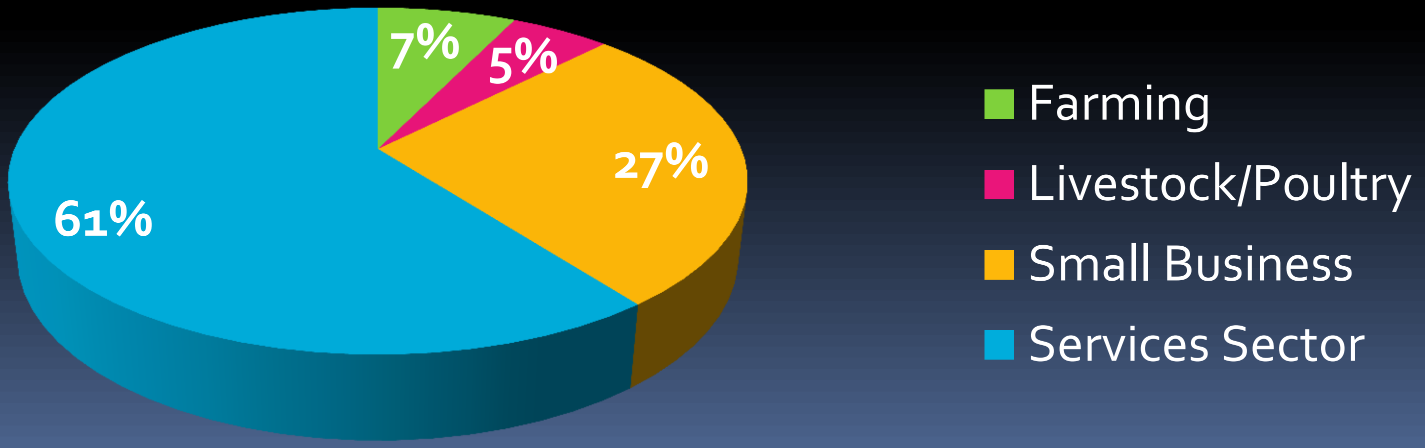
- Risk-based analysis: Simple Monte-Carlo experiment

Source of data: Survey of 500 randomly chosen households



Description of the Household Respondents

- About 64% are female
- 76% are married
- The mean age of the respondents is 48
- Mean years of schooling is 9
- The average individual income is Php 5,125 per month
- The mean HH monthly income is Php 17,000
- The average household size is 5



House Characteristics and Flood Exposure

- 77% own their house
- 91% are single-detached homes
- 75% have single-storey houses, 24% have 2-storey houses
- 83% have homes that are made from predominantly permanent materials

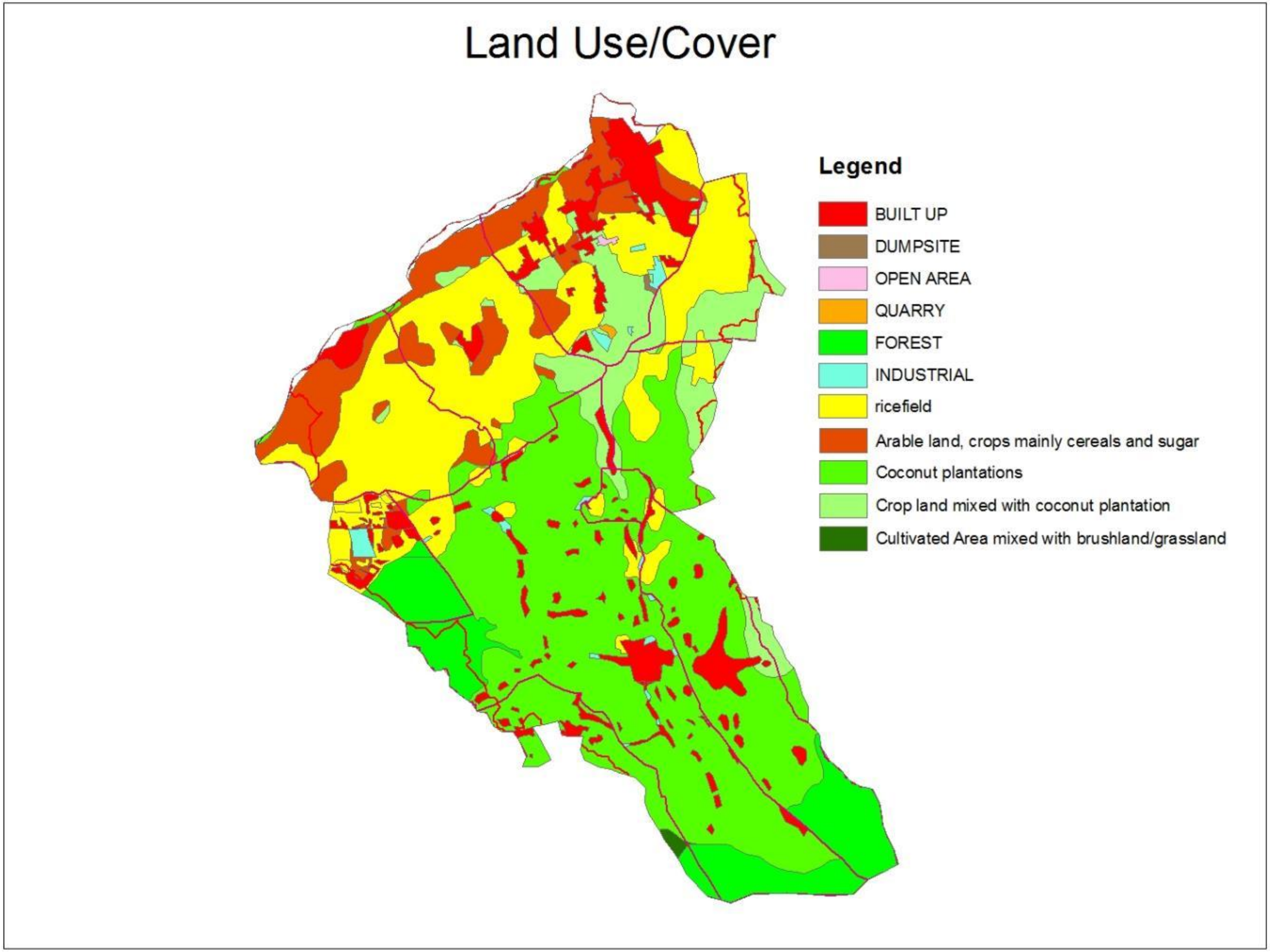
Flood Exposure	Mean	S.D.
Frequency of floods in the last 10 years	5	13
Frequency of floods flowing inside the house in the last 10 years	3	9
Highest flood height in feet	1	2
Longest duration of flood in days	16	34

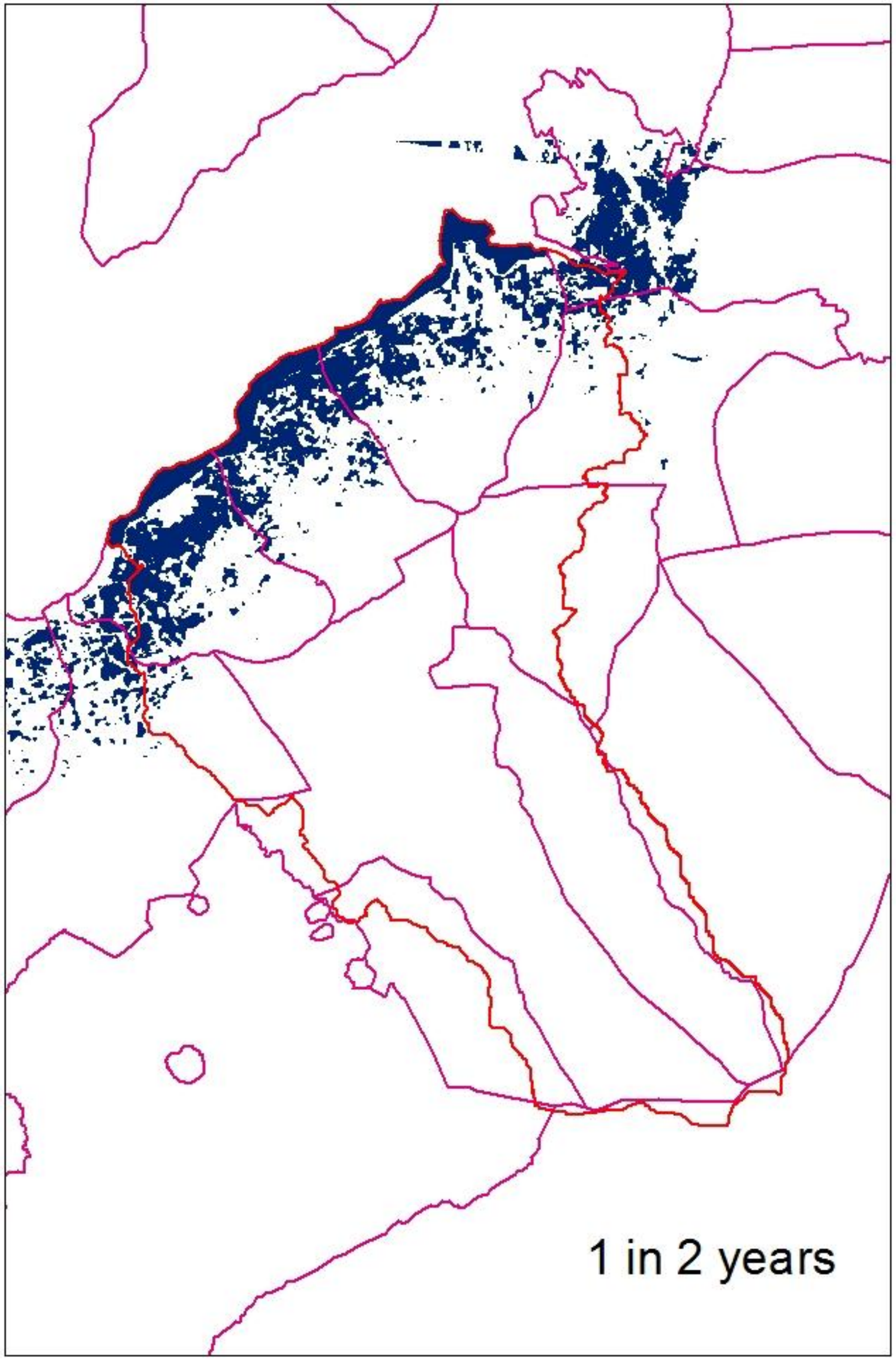
Highest Flood Depth (in feet)	% of Households Exposed
<1	50
1-2	15
3-4	14
>5	6

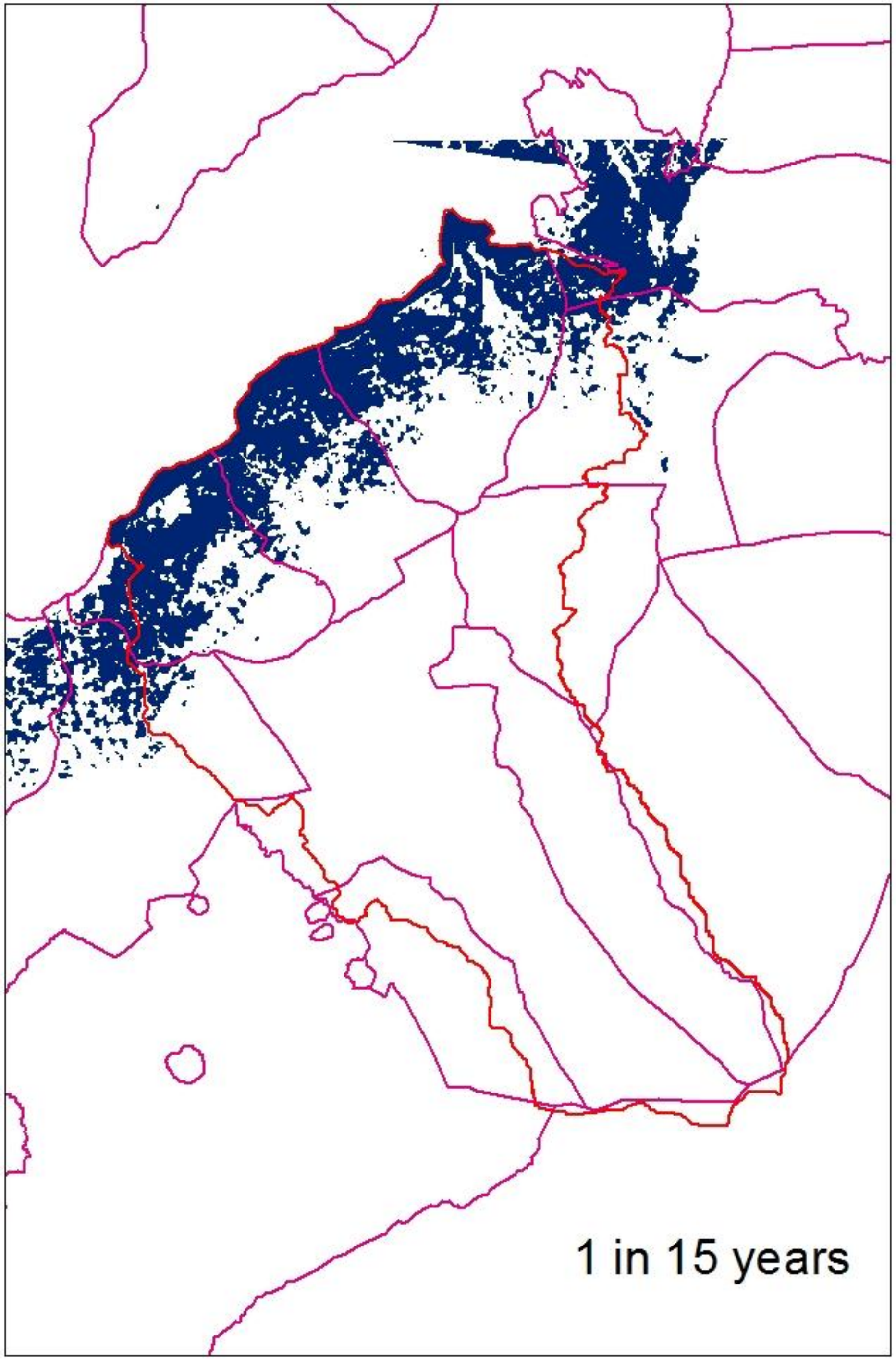
Longest Flood Duration	% of Households Exposed
< 1 day	49
1 day	22
1 week	8
1 month	5
2 months	6
3 months	8
4 months	1
5 months	1

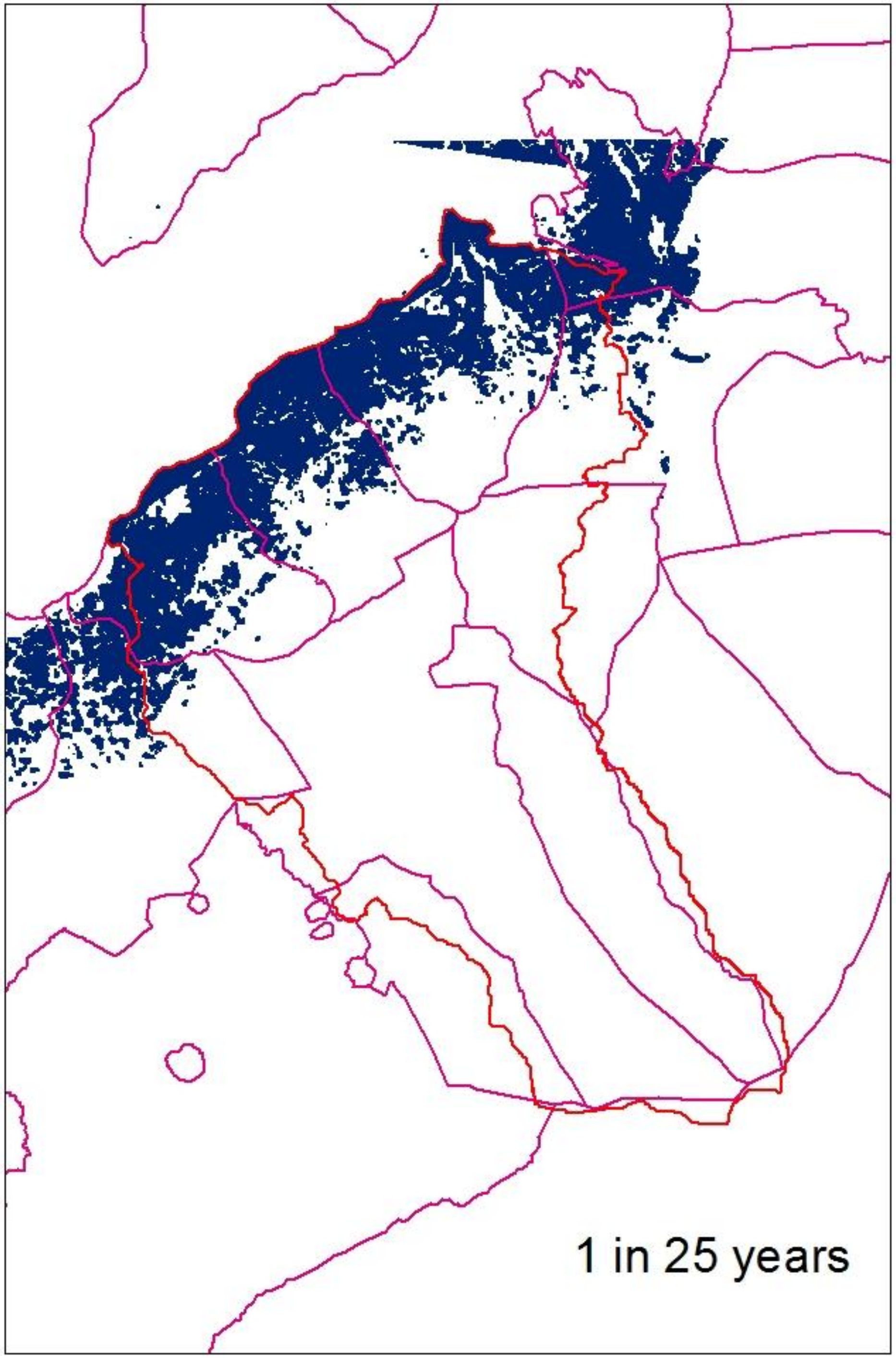
Flood Depth and Flood Duration

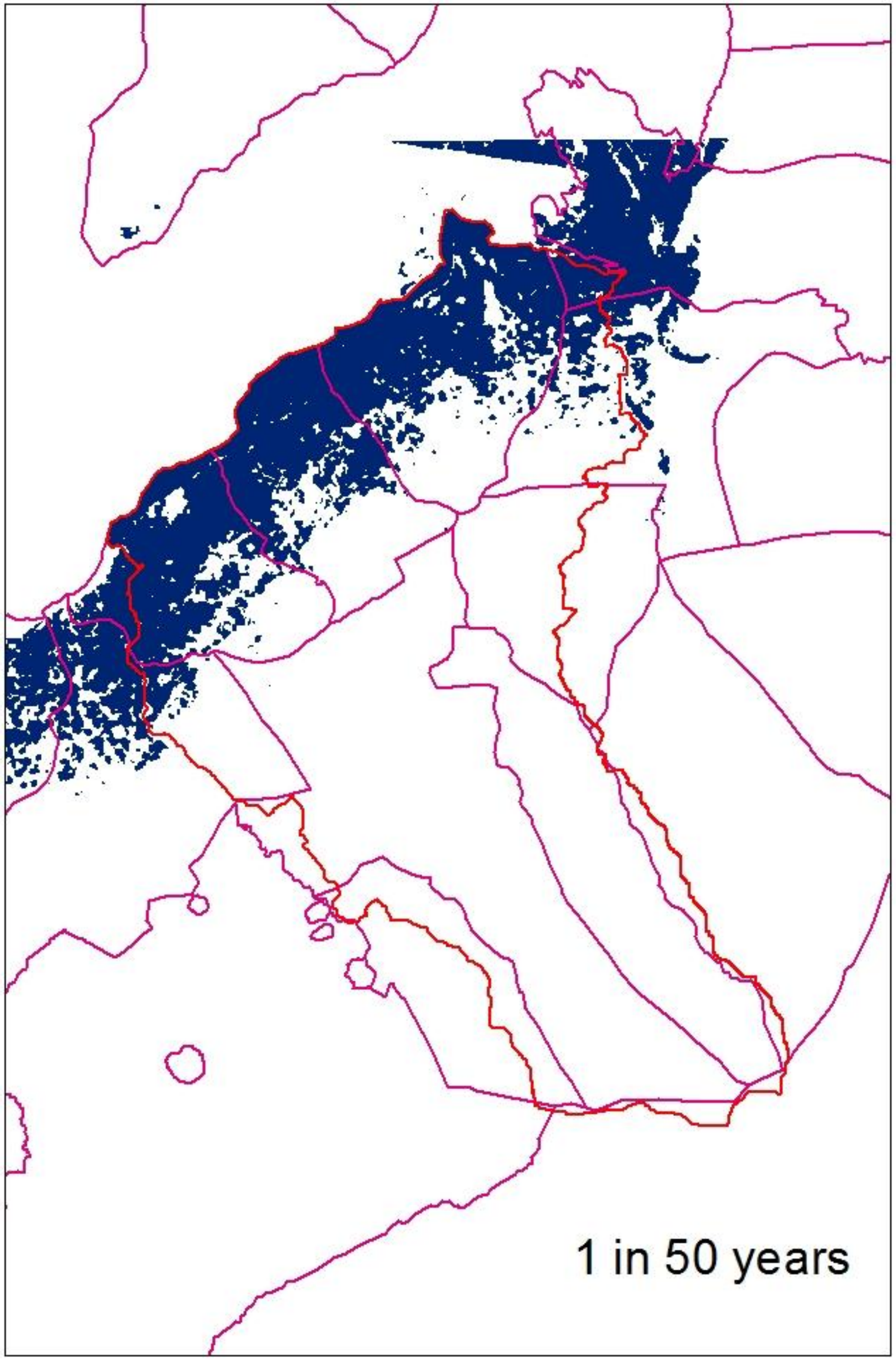
Study 1: Flood Inundation Maps and Damage Cost Estimates


Land Use/Cover
Legend
BUILT UP
DUMPSITE
OPEN AREA
QUARRY
FOREST
INDUSTRIAL
ricefield
Arable land, crops mainly cereals and sugar
Coconut plantations
Crop land mixed with coconut plantation
Cultivated Area mixed with brushland/grassland

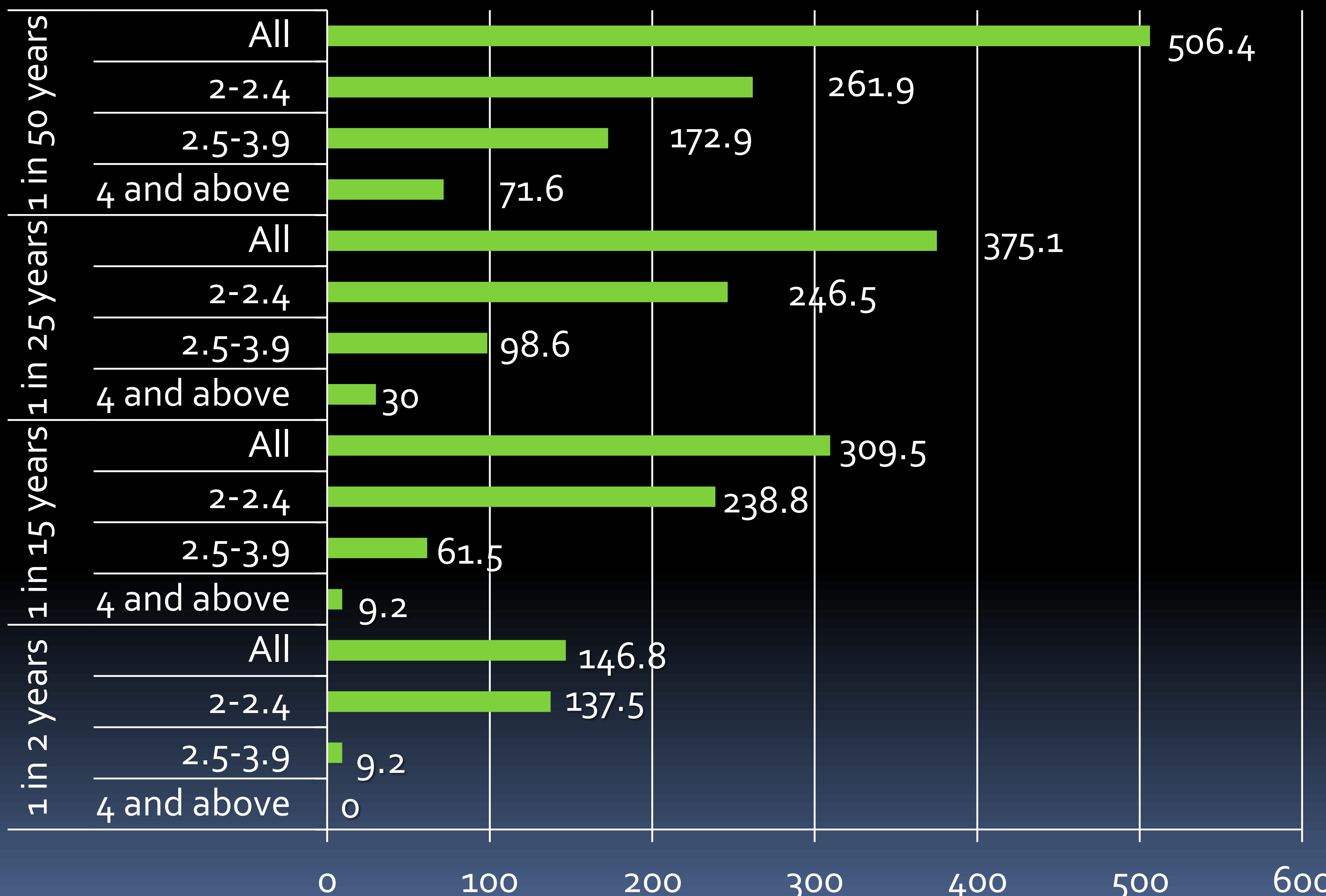

1 in 2 years


1 in 15 years


1 in 25 years

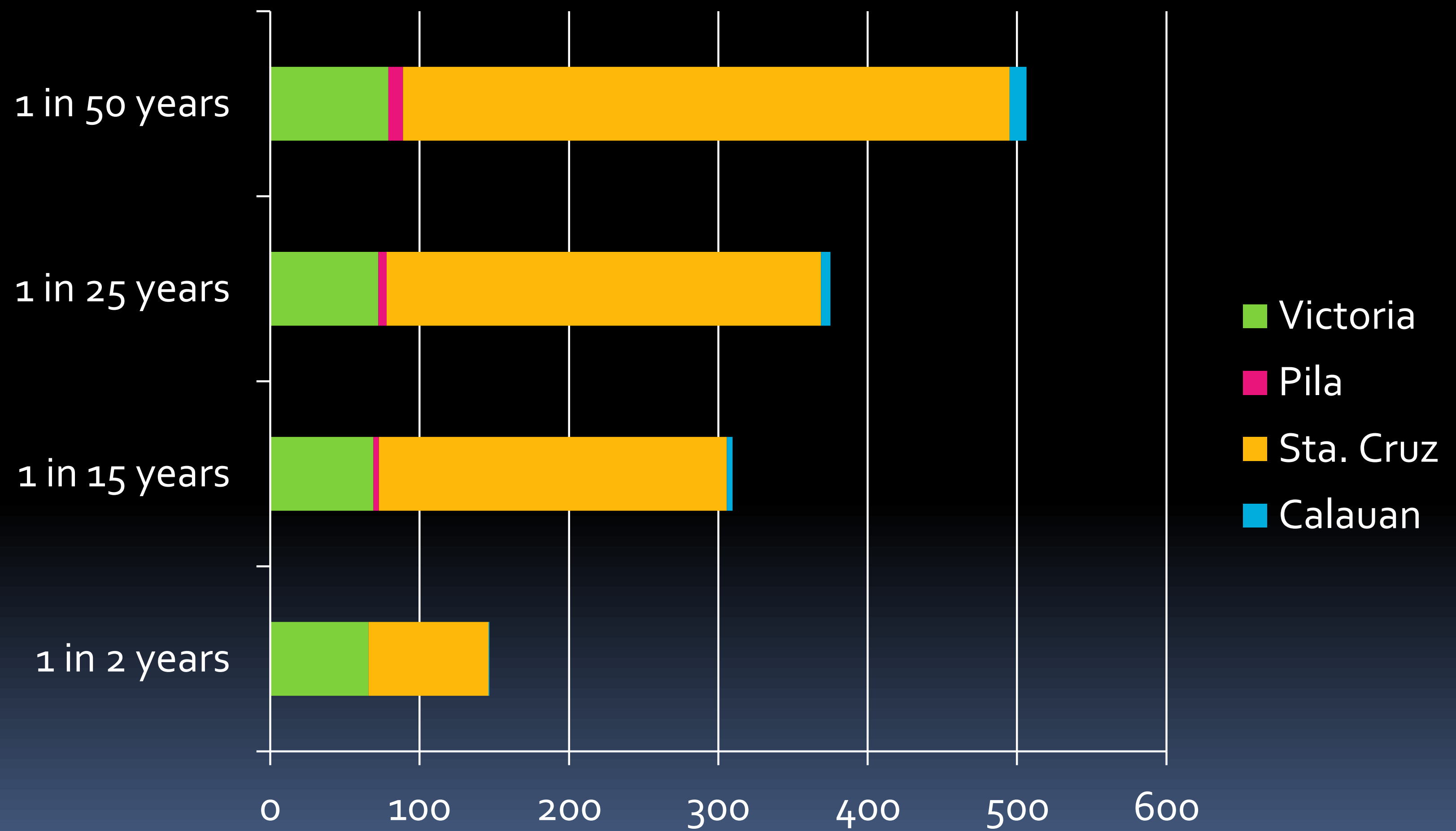

1 in 50 years

Projected Inundation in Built-up or Residential Areas (in hectares)

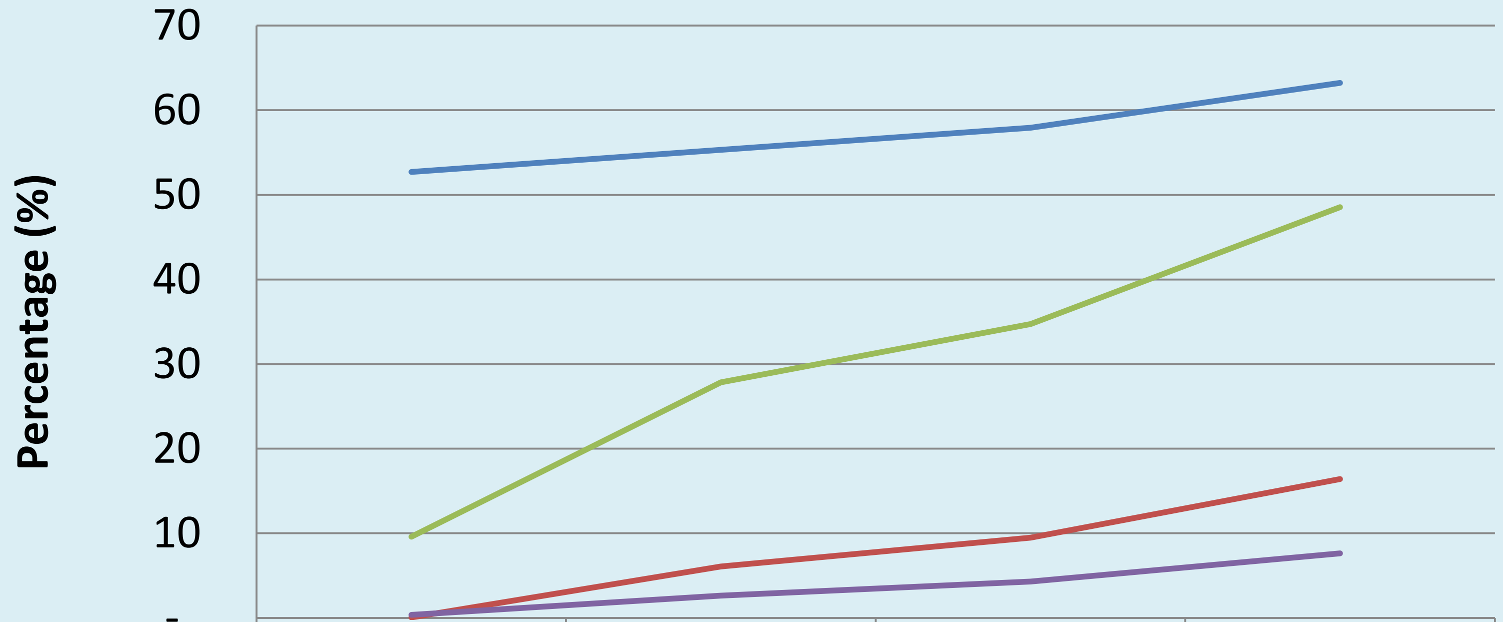


Which municipality is affected the most?

NOTE: The watershed only covers part of Calauan and Pagsanjan



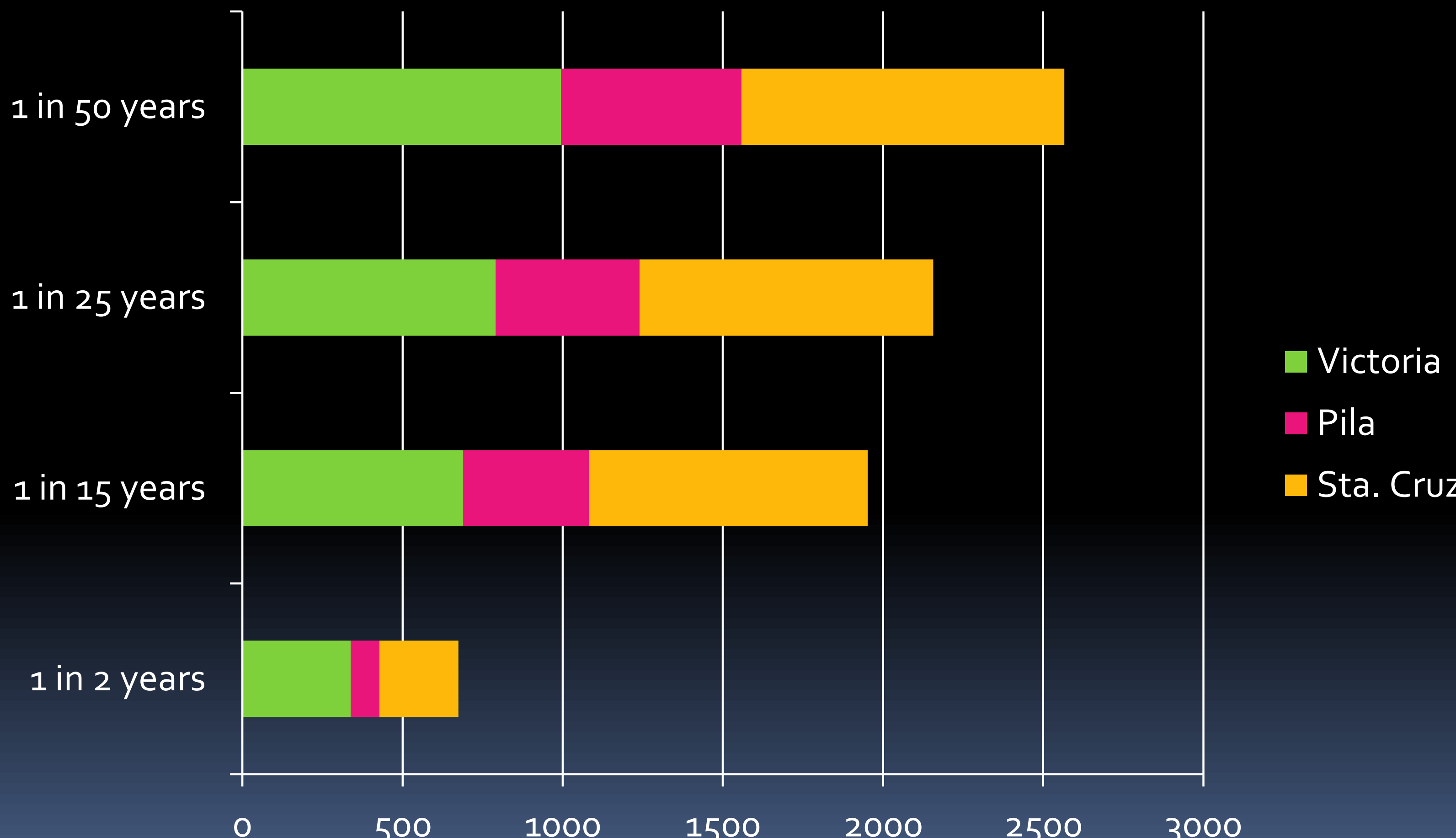
% of Built-up Areas Projected to be Flooded



	1 in 2 years	1 in 15 years	1 in 25 years	1 in 50 years
Victoria	53	55	58	63
Pila	0	6	10	16
Sta. Cruz	10	28	35	49
Calauan	0	3	4	8

		Area of Built-up Lands Predicted to be Inundated by Floods (ha)				
Return Period	Flood Depth (ft)	Victoria	Pila	Sta. Cruz	Calauan	Total
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	4 and 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	4 and 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	4 and 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
*** No data for Pagsanjan**						

Area of Rice Lands predicted to be Inundated by at least 2.5 feet (hectares)



% of Rice Lands Projected to be Flooded

	1 in 2 years	1 in 15 years	1 in 25 years	1 in 50 years
Victoria	15	31	36	45
Pila	4	18	20	26
Sta. Cruz	11	41	43	47

	Area of Rice Lands Submerged by atleast 2.5 feet (ha)			
Return Period	Victoria	Pila	Sta. Cruz	Total
1 in 2 years	338.4	89.3	246.3	673.9
1 in 15 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 Rice Lands	2,207.4	2,193.3	2,146.3	6,547.0

*** No rice lands are predicted to be inundated in Pagsanjan and Calauan**

Summary of Reported Damage Cost Per Household by Flood Event (in Pesos)

	Damage Cost per HH (Php)			
	Habagat 2012	Ondoy 2009	Santi 2009	All
Mean	6,511	9,374	16,969	10,450
Median	2,750	3,000	7,750	4,350
Mode	5,000	8,000		1,000
n	18	55	23	106

Estimates of direct damage cost per flood event by flood depth

	Direct Damage Cost per Household per Flood Event	
Flood Depth	in PhP	in US$
4 ft and above	8,200	205
2.5 to 3.9 ft	4,300	107.5
2 to 2.4 ft	1,700	42.5
0 to 1.9 ft	0	0

	Damage Cost per Hectare by Flood Depth (Pesos)				
Land Type	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	410,000	215,000	85,000	0	0
Rice Lands	29,600	29,600	29,600	0	0

Breakdown of damage cost estimates for rice lands (per hectare)

- Threshold Level : 2.5 ft
- Average yield per ha: 4,180 kg
- Average farm-gate price: Php 13/kg
- Total Revenue per ha: Php 54,340
- Total Cost per ha: Php 24,740 (DA, 2012)
- Net Revenue/Profit per ha:

Php 29,600 (US$740)

Uses of the estimates:

- Benefit Measure for Flood Control Projects, for e.g. Road Dike System or Lake Dredging
- Study 3: CEA of Relocation, Evacuation, & Building Modification
  - Residual Flood Damage Cost from Evacuation and Building Modification

Study 2: Benefit Cost Analysis of a Flood Early Warning System

Description of the Flood Early Warning System Project

- The proposed EWS technology utilizes the DOST-ASTI-developed Automated Weather System (AWS) and Water Level Monitoring System (WLMS).
- It will be installed in strategic points along the Sta. Cruz River
- Expected beneficiaries: Lakeshore municipalities (Victoria, Pila, Sta. Cruz)
- Based from weather and water level data collected, a warning will be issued.
- Mode of communication: sent through a text message to households subscribed in the service
- The lead time is between 2-4 hours and the information included are: areas that will be flooded and areas that need to evacuate immediately
- The institution responsible for the project are the local government of the three municipalities with support from upland municipalities
- The duration of the project is 10 years which covers the life span of the equipment (2014-2023)

Estimating the Benefits

- The benefit of the technology-based EWS was measured using the Contingent Valuation Method (CVM).
- The data used was collected through a survey of 500 households, which was conducted in 2012.
- Stratified Random Sampling Method was employed.

Contingent Valuation Method

- CVM is a stated-preference valuation technique
- HH or individuals are directly asked about their maximum willingness to pay for a good or service
- Max WTP = benefit of the project to the individual
- Note that HH are not actually made to pay
- For private goods, it easy to have an estimate of benefits (reflected in the market price). Not true for public goods, so we need to employ valuation techniques (e.g. CVM).
- Advantages:
  - Only method that can capture both the use and non-use values (Hanneman, 1994).
  - Theoretically correct measure of benefit/welfare impact (Compensating Surplus).
- Disadvantage: Prone to biases if not properly administered.

Administration of the CVM

- Survey protocol
- Questionnaire
  - CVM Scenario
  - Willingness to Pay (WTP) Elicitation Method
  - Payment Vehicle
  - Other components to elicit truthful revelation of WTP

The survey instrument and administration should be incentive compatible

CV Survey Protocol Applied in the Study

- Conducted face-to-face interview.
- Applied Stratified Random Sampling.
- Conducted focus group discussions prior drafting the questionnaire.
- Enumerators were trained before sending them off to the field.
- Pretested the questionnaire and the visual aid used (done in Los Baños, Laguna)
- The ‘Tailored Design Method’ was adopted:
  - Legitimacy
  - Confidentiality of Answers
  - Simple token (ecobag)
  - Send brief report on the findings of the study
  - Used visual aid (brochure)
  - Used the local dialect

Elicitation Method

- Single-bound dichotomous choice

A “yes” or “no” question, wherein respondents are asked if they are **willing to pay** a certain pre-determined amount for the project.

Bid levels used: Php 25, 50, 100, 200, 300 per month.

Payment Vehicle

- Mandatory payment (not voluntary or contribution).
- The payment will be collected as 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).
- Collected funds will be managed by the local government and audited by a private auditing firm.

Other Components

- Provision Point: To minimize strategic bias, it was explained that the project will be implemented only if more than 50% of the households vote 'yes'. And if so, everyone will be made to pay.
- Cheap talk: Respondents were reminded of their income constraint and the existence of alternative projects to the EWS.
- Debriefing questions: To identify valid from invalid and protest bids.
  - Invalid yes answers were converted to 'no'
  - Retained protest bids
- Certainty question: uncertain yes answers where converted to no votes.

Analytical Method

- Non-Parametric: Turnbull Lower-bound Estimate
- Parametric: Hanemann’s Binary Logit Model
  - Bid, Income, Exposure to Floods, Knowledge about EWS, Autonomous Adaptation Behavior, Respondent’s Sex, Education and Age, Dummy for Municipality.

Distribution of Responses to WTP Question (in %)

	Bid Levels (Php)				
	25	50	100	200	300
Yes	65	66	53	36	31
No	34	33	46	63	68

Reasons for ‘Yes’ Votes

Reason for Yes Response	Frequency	%
To ensure the readiness of my community during floods	173	73
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
I feel happy knowing that I could help others	23	10
The fee is affordable and our area is always at risk	23	10

Reasons for ‘No’ Votes

Reason for No Response	Frequency	%
The fee is unaffordable	105	39
Our electricity bill is already too high	58	22
There are other more important problems that must be prioritized	22	8
The government should pay for the project	48	18
Only the rich should pay for the project	4	1
I do not have confidence on the capability of the local government	7	3
The early warning system is not useful	17	6
I do not have confidence on the technology that will be used	5	2
We are already being warned by our local officials	3	1

Mean WTP Estimate

- Turnbull Mean WTP Estimate: Php 128 (US$3.05).
- Mean WTP from the logistic regression: Php 140 (US$3.33).
- The 99% Confidence Interval for mean WTP from the logistic regression ranges from Php 127 to Php 152 (US$3.02 to US$3.6)
  - This is consistent with the Turnbull estimate.

Testing Validity

- Results of the econometric regression shows that preferences conform to economic theory, that is:
  - WTP is negatively related to bid prices
  - WTP is positively related to income
- Prediction from the regression model vis-à-vis observed responses:
  - Correctly classified: 69%

	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
* Significant at 1%						
** Significant at 5%						
*** Significant at 10%				No. of observation		497
				Likelihood Ratio		75.09
				Prob>chi2		0.00
				Pseudo R2		0.11

Other Insights

- On Gender: Males are more likely to be willing to pay!
- On Risk Attitude: Those that are already undertaking autonomous adaptation are more likely to be willing to pay
- On Exposure: Those that are more exposed to the hazard are more likely to be willing to pay
- On Knowledge about EWS: Seems to be insignificant
- On Education: Seems to be insignificant

BCA of Early Warning System

- Present Value of Benefits at 15% discount rate: Php 340 million (US$8.1 million).
- PV of Costs: Php 10 million (US$ 0.25 million)
- PV of Net Benefits: Php 330 million --- GOOD!
- Benefit Cost Ratio of 33.
- IRR: 3,000%

Case Study	BCR
Sri Lanka, May 2003 floods case study	0.93
Bangladesh, 2007 Flood case study	558
Thailand, 2007 Flood case study	176
Reference: Subbiah, A.R., L. Bildan, and R. Narasimhan (2008)	

Study 3: Risk-based Cost Effectiveness Analysis of Relocation, Evacuation, and Building Modification

Background

- Need to come up with adaptation options that can address the problem of long-term flooding in Sta. Cruz
- In the recent flood event (Typhoon Gener, 2012) 8,917 houses were flooded.
- Inundation lasted for as long as 4 months.
- Historical account of long-term floods: 1972, 2009, 2012
- The local government of Sta. Cruz is considering the construction of an Evacuation Center. There are two possible sites: Oogong (4.6 ha) and Duhat (0.4 ha)
- What are the alternatives: Relocation & Building Modification

Policy Objective

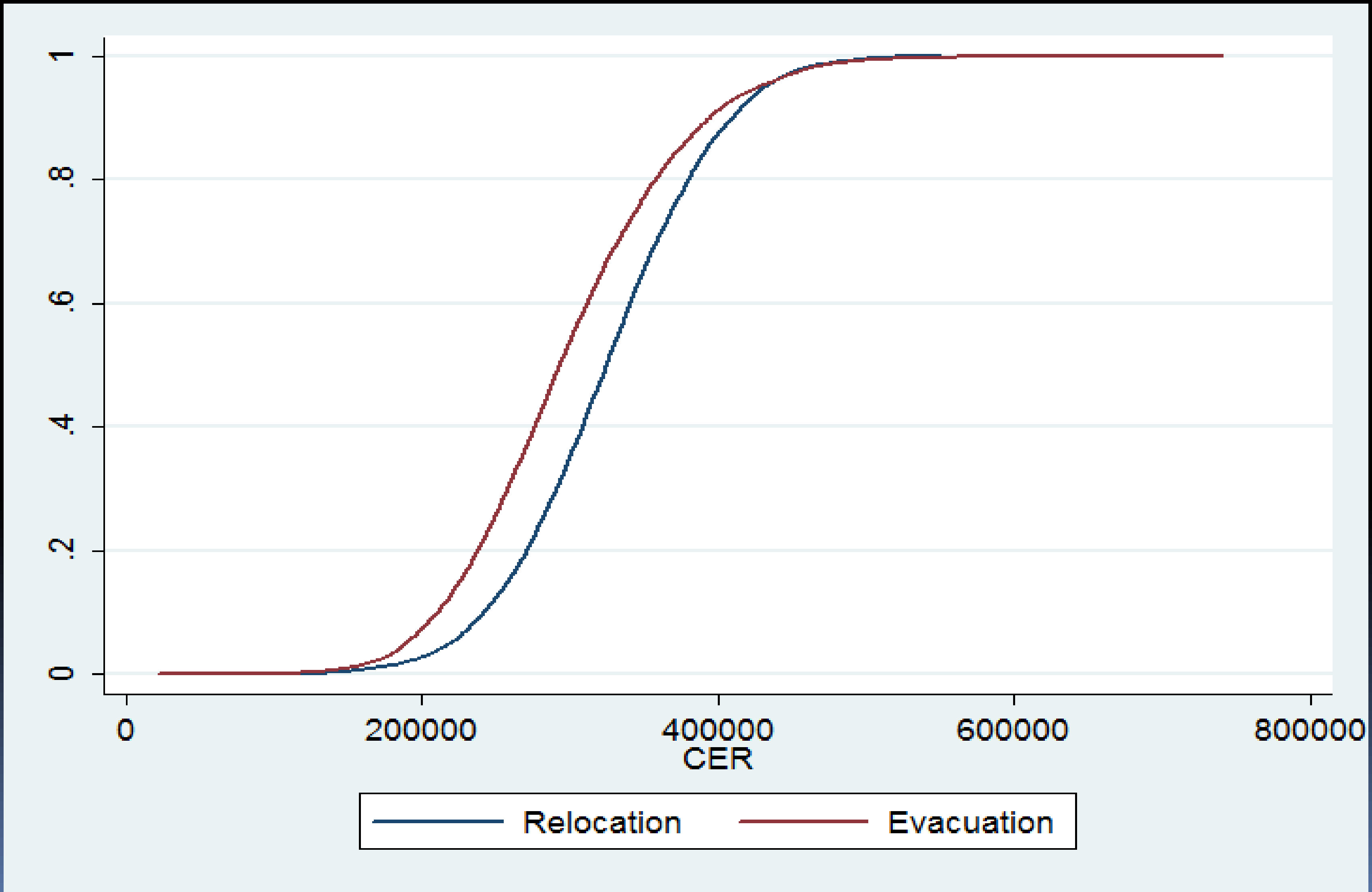
- The objective of the interventions is to provide poor flood victims in Sta. Cruz, Laguna with a dignified temporary or permanent shelter so that they will be able to avoid hazards brought about by floods.
- All options are designed to cater to 2,100 families (Effectiveness Measure).

	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 like 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 behaviour associated with moral hazard. That is, there is an incentive for households to locate in risky areas if government shoulders the cost of building modification.

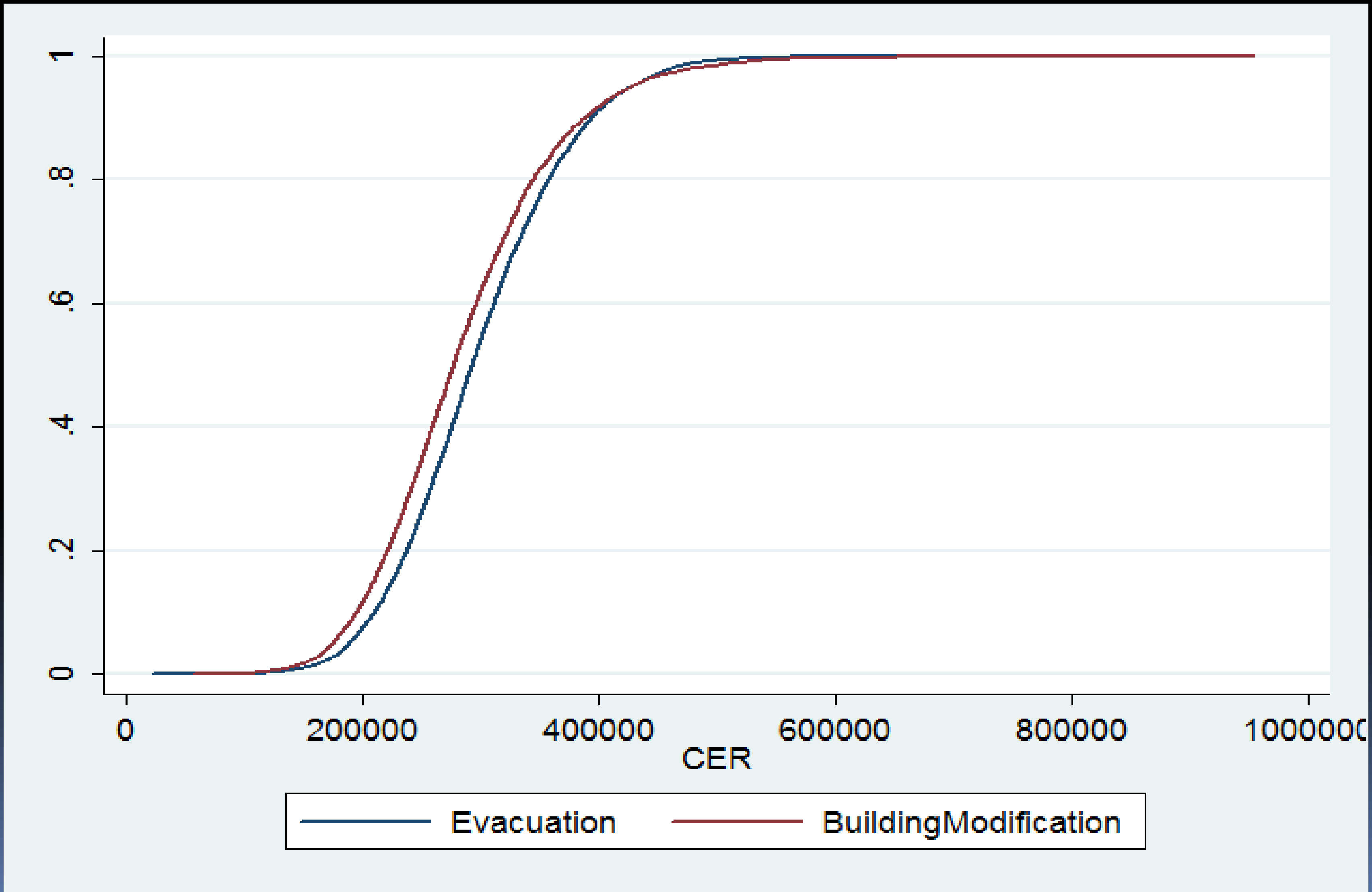
Cost Effectiveness Ratio

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

Risk-Based Cost Effectiveness Analysis



Risk-Based Cost Effectiveness Analysis



Limitations and Conclusions of the Cost Effectiveness Study

- The CEA considered only the direct costs associated with the interventions
- A simple Monte-Carlo Analysis was undertaken, assuming normal distribution
- Building Modification consistently resulted in a lower Cost-Effectiveness Ratio

Main Findings of the Study:

- A Technology-based Flood Early Warning System is economically-feasible for the Sta. Cruz River Watershed.
- To address the long-term inundation along the lakeshore barangays of Sta. Cruz, building modification seems to be more cost-effective than building an evacuation center or relocation.

End of Presentation

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