Economic Analysis of Climate Change Adaptation Options in Honda Bay, Puerto Princesa, Philippines

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Front cover photo: Sweeping view of the Binduyan coastline where a combination of hard and soft climate change options can be planned and implemented. Photo by Patrick A. Regoniel, Melissa Theodora U. Macasaet, and Nelly I. Mendoza

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ECONOMIC ANALYSIS OF ADAPTATION OPTIONS IN HONDA BAY, PUERTO PRINCESA CITY, PHILIPPINES

Patrick A. Regoniel, Melissa Theodora U. Macasaet, Nelly I. Mendoza

EXECUTIVE SUMMARY

This research project identified and assessed the climate change impacts (i.e., sea level rise), and conducted a cost-effectiveness analysis (CEA) of the climate change adaptation (CCA) strategies of two coastal *barangays* (villages), namely, Babuyan and Binduyan located in Honda Bay, Palawan, Philippines. The methods used in the study included participant observation, informal interview, key informant interview, focus group discussion, household survey, photo documentation, and CEA. The respondents consisted of village heads and village council members, fishers, farmers, planners, resource managers, and other relevant stakeholders or resource users in the selected study sites.

The residents of both villages generally noted significant weather changes in the past, with more pronounced effects during the past decade. Several households lost their sources of livelihood and several properties due to typhoons, flooding, and erosion, which are all associated with sea level rise. Further, the investigation revealed the impacts of climate change on the two coastal villages and the corresponding site-specific CCA mechanisms adopted by the coastal residents.

The results of the CEA in Babuyan showed that *mangrove reforestation* would be the most cost-effective strategy for protecting households and properties from strong waves and storm surges. Mangroves thrive well in this village; thus, it can effectively minimize sand erosion in the coastal zone. Implementing an *information campaign and building a temporary evacuation center* in the coastal village would also be cost effective for protecting households from flooding. Meanwhile, the results of the CEA in Binduyan showed that *mangrove reforestation* would be less effective because mangrove areas for reforestation in Binduyan are limited; the sandy soil and inherently poor nutrient content of the soil in the village would not allow mangroves to thrive. On the other hand, *seawall construction* appeared to be more practical with the lowest cost effective ratio.

Upon validation of the CEA results, key officials in the barangays preferred CCA strategies that would be easy to implement, most feasible, or within their means to fund like mangrove reforestation.

1.0 INTRODUCTION

Honda Bay is one of the significant sources of reef fishery in the Philippines. The bay is located in the middle-eastern side (9° 50' to 10° 00' North and 118° to 119° 00' East) of mainland Palawan. The near shore regions bounded by the 15-kilometer municipal waters is a major fishing ground for the 1,968 small fishers of the 18 coastal *barangays* (villages) of the City of Puerto Princesa and for those coming from the adjoining barangays and commercial fishers outside of this zone.

At 280 km^2, the relatively shallow waters of the bay allow extensive growths of corals along the fringes of mainland Palawan and around the major islands (i.e., Cowrie Island, Bat Island, Meara Marina, Snake Island, Starfish Island, Pandan Island); islets (i.e., Luli Island, Fondeado Island, Arrecife Island, Señorita Island); and shallow reefs (i.e., Pambato Reef). These reefs do not only provide direct benefits (e.g., capture fisheries, mariculture, and tourism) to society, they also provide indirect ecological services such as habitat for marine organisms, nursery grounds for fish fries and juveniles, and buffer against strong wave action.

Many of the reefs in Honda Bay have been able to recover during the past two decades from the damages caused by unsustainable fishing activities (e.g., dynamite and cyanide fishing) that had been prevalent from the 1970s to the latter part of the 1980s. This recovery is largely attributed to the effective law enforcement of the city government, backed up by its ordinances and the Philippine Fisheries Code of 1997 (Republic Act No. 8550). Further, recognizing the importance of protecting these reefs, the local communities and the city government established 11 no-take protected marine sanctuaries and controlled the use of marine resources in some places reserved for tourism. The shift to ecotourism as an alternative livelihood provided the impetus that weaned local inhabitants from directly engaging in fishing or in fishing-related ventures.

However, recent episodes of sea level rise and high sea surface temperature in 1998 and 2010 appear to threaten the reef ecology balance of the bay. High sea surface temperature is known to cause bleaching, in which the symbiotic zooxanthellae are expelled from the coral polyp, thereby threatening the reefs' very existence. Meanwhile, sea level rise leads to stronger storm surges and flooding that erode the beaches and threaten the integrity of the coastal areas including infrastructures, fishponds, and agricultural lands.

The latter phenomenon is the focus of this study. Accordingly, cost effective climate change adaptation (CCA) measures must be explored to increase the resilience of coastal communities to the impact climate-induced sea level rise. It is against this backdrop that this study was pursued.

1.1 Description of Study Area

The City of Puerto Princesa is located 306 nautical miles southwest of Manila, 205 nautical miles from Panay, and about 250 nautical miles from Zamboanga. It is bound on the north by the municipalities of San Vicente and Roxas, and on the south by the municipality of Aborlan. Its western side faces the West Philippine Sea, while on its eastern coast lays the Sulu Sea.

Puerto Princesa City has a total land area of 253,982 ha, making it the largest city in the country. It is comprised of 35 urban villages and 31 rural villages. The total area of the urban villages is 14,716 ha or only 5.79% of the total land area of the city. The largest land area is comprised of rural villages with a total area of 239, 266 ha or 94.21% of the total land area of the city.

Binduyan and Babuyan are villages located northeast of Puerto Princesa City, facing Honda Bay. Binduyan is largely composed of households who reside alongside the national highway; majority of these households are clustered in the wider coastal portions on the northeastern portion of the village's boundary. Babuyan, on the other hand, is composed of three clusters of households: one densely populated, coastal cluster on its northeastern boundary, and two widely dispersed clusters on both sides of the national highway on the southern boundary.

1.1.1 Topographical features

About 64% of the total land area of Puerto Princesa City is composed of rugged (18%–36%) to steep slopes (>36%), making it highly vulnerable to soil erosion, even mudslides and landslides, when the areas with critical slopes become denuded. On the other hand, about 25% of its land area is composed of flatlands having slopes of less than 8%; these flatlands are suitable for agriculture and urban settlement. Meanwhile, the remaining 11% of the city's land area is composed of terrain with 8%–18% slope, which can be developed for upland agriculture and low-density housing (Figure 1).

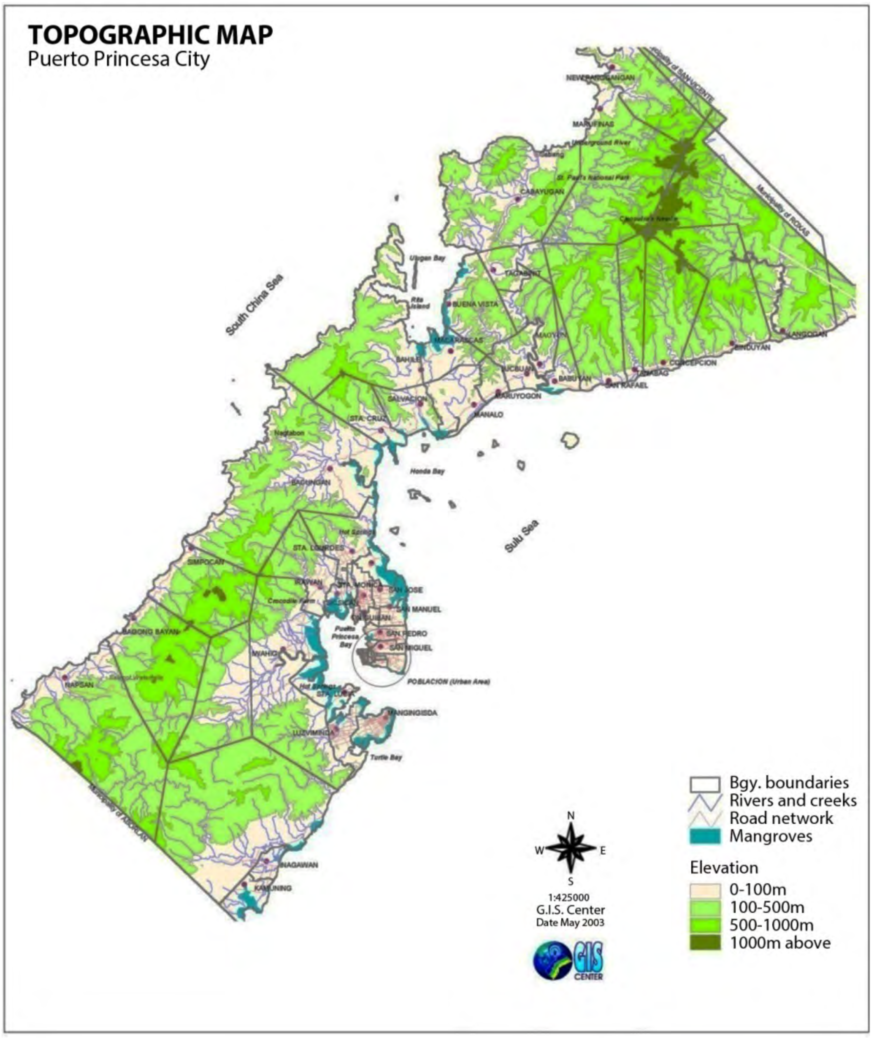

Figure 1. Topographic map of the city of Puerto Princesa

Source: City Government of Puerto Princesa (2011)

The relatively flatlands (0%–8% slopes) are found in several patches all over the city; most are concentrated in the villages of Iwahig, Inagawan subcolony, Bacungan, and Manalo on the eastern coast; and toward the west along the coastal plains in the villages of Montible, Cabayugan, Bahile, and Napsan. The concentration of 8%–18% slopes are found both on the eastern and western side of the city, particularly in the villages of Langogan, Bacungan, Maoyon, and Inagawan subcolony on the eastern side; and in Napsan, Bagong Bayan, Cabayugan, Marufinas and Bahile on the western side (Figure 1).

1.1.2 Rainfall and Temperature

Puerto Princesa is characterized by two types of climate patterns that are distinctive for the east and the west coast. The east coast has short dry season and more months of heavy rainfall. The area is dry from January to April, and the rainy season prevails throughout the rest of the year. October is the rainiest month. The west coast has equal lengths of dry and wet seasons. Dry season begins in November and lasts until April; the rainy months start in May and ends in October. The rainiest month in the west coast is October, just like in the east coast. February is the driest month in the area. The villages falling under this climate pattern are New Panggangan, Marufinas, Cabayugan, Tagabinet, Buenavista, Bahile, Macarascas, Simpocan, Bagong Bayan, and Napsan.

Table 1 shows the rainfall data from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration, Puerto Princesa City station from 1994 to 2011. The temperature data in Table 2 show that the annual average temperature from 1994 to 2011 ranges from 27.58°C to 28.48°C. The 2010 El Niño event reflected the highest temperature recorded at 28.48°C during the period.

1.1.3 Climate description

The city has, more or less, uniformly high relative humidity, which range from 79%–86% with an annual mean of 84%. The city has two distinct prevailing winds, the northeast (NE) monsoon and the southwest (SW) monsoon. The northeast monsoon generally sets in October and continues until April. The monsoon blows mainly between north and northeast, with a tendency toward an easterly direction at the end of the season. It has a velocity ranging from 15–25 kph at its height, and an average of 6 kph. Rain clouds during the NE monsoon practically lose all the moisture before reaching the southwest part of the archipelago, thus the city and the province as a whole receive no rainfall toward the end of the northeast monsoon (January-April).

The southwest (SW) monsoon or the summer monsoon follows the NE monsoon after a transition period of variable winds and calms. The SW monsoon prevails from June to October. It blows most steadily during July and August, although not as steady as the NE monsoon, reaching a maximum velocity of about 35 kph. In October or during the close of the SW monsoon, strong winds occur in the southern part of the city. The southwest winds bring torrential rains but with uneven distribution.

The NE and SW monsoons affect the eastern and western part of the city. When these winds blow, the seas become very rough. The calm months of the year are from April to June on both the eastern and western side of the city.

Table 1. Rainfall data (in millimetres), Puerto Princesa City, 1994–2011

	Monthly Rainfall 1994–2011													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Ave
Normal	25.60	13.70	24.20	35.10	129.80	179.60	176.40	168.40	191.70	208.80	204.80	117.10	1475.20	122.93
2011	197.00	61.5	125.10	59.50	277.50	122.90	–	–	–	–	–	–	843.50	70.29
2010	33.50	1.30	2.10	100.70	49.60	124.10	153.50	135.30	57.50	232.10	274.40	346.00	1,510.10	125.84
2009	7.3	20.20	64.30	71.90	182.80	438.30	228.50	124.90	210.60	257.80	25.80	3.90	1,636.30	136.36
2008	20.40	86.70	1.50	185.40	210.50	190.20	123.10	95.90	284.30	312.70	445.00	198.70	2,154.40	179.53
2007	6.00	0.00	41.20	85.40	109.60	111.40	117.60	127.60	198.60	148.50	410.00	133.70	1,489.60	124.13
2006	16.70	0.60	142.30	87.40	189.10	159.70	140.70	369.90	266.60	217.50	95.40	33.10	1,719.00	143.25
2005	0.70	0.60	0.70	5.30	154.50	127.10	182.60	74.10	236.60	221.00	132.60	587.60	1,723.40	143.62
2004	2.00	0.20	1.30	37.30	74.60	314.19	171.30	362.30	20.00	320.30	102.00	68.60	1,474.09	122.84
2003	2.10	30.30	45.90	14.60	193.40	143.20	194.20	223.50	167.80	344.30	87.80	94.70	1,541.80	128.48
2002	0.00	6.70	45.90	12.00	47.90	84.00	90.10	321.30	175.00	138.90	239.30	24.90	1,186.00	98.83
2001	179.10	13.30	113.70	84.10	139.20	95.70	107.70	249.60	53.10	213.50	196.10	251.10	1,696.20	141.35
2000	18.70	179.70	139.10	155.20	136.10	108.10	117.40	241.40	162.20	212.60	156.50	238.40	1,865.40	155.45
1999	211.90	6.60	211.10	62.60	170.50	197.60	153.60	291.70	128.60	274.10	428.40	507.30	2,644.00	220.33
1998	0.20	31.60	0.01	5.40	65.90	182.60	97.90	180.00	182.20	147.10	491.10	334.90	1,718.91	143.24
1997	32.50	84.60	16.40	10.90	195.30	60.40	213.00	178.70	80.10	172.30	39.50	63.30	1,147.00	95.58
1996	59.80	5.00	6.20	94.30	118.30	188.40	137.80	99.50	81.40	178.10	236.60	79.20	1,284.60	107.05
1995	3.00	3.10	2.30	6.40	91.10	166.10	127.50	216.30	120.00	383.20	270.50	359.40	1,748.90	145.74
1994	4.20	0.01	4.20	59.20	137.10	136.20	96.10	207.80	249.80	177.30	1.30	53.50	1,126.71	93.89
Total	795.101	532.01	963.31	1,137.60	2,543.00	2,950.19	2,452.60	3,499.80	2,674.40	3,951.30	3,632.30	3,378.3	28,509.91	2,375.83
Ave	46.77	31.29	60.21	71.10	158.94	184.39	153.29	218.74	167.15	246.96	227.02	211.14	1,781.87	131.99

Source: PAGASA, Puerto Princesa City Station (2011)

Table 2. Average monthly temperature (°C), 1994–2011

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2011	27.4	27.4	28.0	28.3	28.6	28.4	–	–	–	–	–	–
2010	27.7	27.7	28.8	29.5	30.0	29.2	28.3	28.4	28.8	28.2	27.9	27.3
2009	27.7	28.1	28.6	29.2	28.1	28.2	28.2	28.7	28.4	27.9	28.3	27.8
2008	27.4	27.6	28.2	28.4	28.1	28.0	28.2	28.0	28.0	28.2	27.4	27.6
2007	28.1	27.7	28.6	29.4	29.5	29.4	27.8	28.3	28.3	28.2	27.7	28.2
2006	27.8	28.4	28.4	29.0	28.8	28.5	28.6	27.8	28.0	28.0	28.4	28.4
2005	27.0	27.3	28.4	29.0	29.3	28.4	28.1	28.6	28.2	28.4	28.3	27.2
2004	27.6	27.6	28.7	29.6	29.0	27.6	28.0	27.7	28.4	27.6	28.3	27.8
2003	27.8	27.4	28.3	29.4	29.2	28.3	28.2	28.4	28.1	28.0	28.2	27.4
2002	26.6	26.7	27.8	28.8	29.6	28.5	28.8	27.7	27.9	28.2	28.0	28.3
2001	27.2	27.6	27.7	28.7	28.3	27.8	27.6	27.2	28.0	27.6	27.3	26.6
2000	27.4	27.6	27.8	28.4	28.8	27.8	27.6	26.8	28.4	27.3	27.6	27.2
1999	27.5	27.4	27.4	28.2	28.0	27.4	27.6	27.4	27.6	27.6	27.6	27.3
1998	27.1	27.1	28.4	29.2	30.0	29.4	28.8	28.4	28.4	28.0	27.3	27.0
1997	26.5	27.0	27.0	28.6	28.6	28.5	27.8	28.1	28.2	28.3	28.4	27.4
1196	27.0	26.8	27.6	28.8	28.3	28.0	28.0	28.2	28.1	28.1	27.4	27.2
1995	27.2	27.0	27.8	28.8	27.8	28.2	27.6	27.6	27.6	27.1	27.5	26.9
1994	26.6	27.2	28.8	27.8	28.5	27.4	27.7	27.5	27.4	27.1	28.1	27.4

Source: PAGASA, Puerto Princesa City Station (2011)

1.1.4 Natural resources

About 73% of the total land area of Puerto Princesa is forested. This consists of primary forest (7%), more than half is secondary forest (52%), a small percentage is composed of karst forest (1%), and ultramafic forest (13%). The mangrove forest in the Iwahig region covers 5,735 ha, whereas brushlands and grasslands comprise 14% of the total land area of the city. Coral reefs along the coast fringe and line both sides of mainland Palawan, covering 3,074 ha. Dense seagrass covers about 836 ha and sparse seagrass covers about 880 ha.

1.1.5 Sociodemographic characteristics

Based on the actual 2007 census, the city's population was placed at 210,508 individuals, and was projected to grow to 243,241 by 2011 (City Government of Puerto Princesa 2007). The city's labor force comprised of 116,390 working population, which also included individuals 15 years old and older. In 2009, the per capita income in the city was pegged at PHP 41,391.86, while poverty incidence was estimated at 23.61% (City Government of Puerto Princesa 2009).

A total of 22 two ethnic groups can be found in Puerto Princesa City, with a total population of 46,077 individuals. The Cuyunen ethnic group is the largest in the city with population of 35,842 individuals. This is followed by the Tagbanua at 7,059 individuals. The Batak, Tagbanua, and Cuyunen ethnic groups are commonly found in the rural areas of the city, as well as in the villages chosen for this study.

School participation rate in Puerto Princesa City for the elementary and secondary levels indicates that more females (80.68% and 60.75%, respectively) than males (79.12% and 60.75%, respectively) are attending school. This may indicate the inability of parents to send their children to school due to the inaccessibility of schools in the rural villages. Generally, the basic literacy is high at 98.28%, indicating that the requirements for reading and writing have been achieved by majority of the population.

1.1.6 Description of current land use

The current land use in Puerto Princesa City is based on the City Zoning Ordinance No. 163 of the city government and the Ecologically Critical Areas Network (ECAN) Zone Maps for the Terrestrial and Coastal Marine Component adopted by the city on January 15, 2007. The general land uses in the study sites include land devoted to residential or housing purposes; and for tourism, agriculture, and aquaculture purposes, particularly crab and shrimp or prawn culture in the inner portions of mangrove areas. The limited arable sloping and flatlands are devoted to crops, mainly for the production of rice followed by corn, coconut, banana, cassava, mango, among others. Areas devoted for tourism purposes are fast gaining ground.

In particular, most of the land in Babuyan is allocated for aquaculture. Fishponds in the village occupy about 80 ha. These structures are largely owned by rich capitalists residing in the City of Puerto Princesa.

2.0 LITERATURE REVIEW

2.1 Evidence and Causes of Sea Level Rise

Historically, high levels of sea water have already been deduced from past fossil records. Overpeck et al. (2006) explained that corals on tectonically stable coasts from the last interglaciation period provided strong evidence that sea level had been ranging from 4–6 meters above the present levels during a sea-level high stand that likely lasted from 129,000 ± 1,000 years ago to at least 118,000 years ago. The causes of this sea level rise are not well understood, although global warming that leads to thermal expansion of oceans (Meehl et al. 2005), melting of Greenland ice sheets, and melting of mountain glaciers (Gornitz, Lebedeff, and Hansen 1982; Barnett 1984; Natural Environment Council 2008) at the polar regions of the earth remain the dominant explanations for the phenomenon.

According to Gornitz, Lebedeff, and Hansen (1982) and Barnett (1984), the global mean sea level has been rising for the past 100 years. The Intergovernmental Panel for Climate Change (1990) estimated that mean sea level rise is at 1.05 mm per year. Recently, Mikhailova (2010) has observed that mean sea level rise has increased—over the period of 1961–2003, the ocean level increased at a mean rate of 1.8 ± 0.5 mm per year; while over the period of 1993–2003, the rate of the ocean level rise reached 3.1±0.7 mm per year, on the average.

Cazenave and Llovel (2010) cited that sea level rise have increased significantly faster since the 1990s. While thermal expansion accounts for approximately 30% of the rate of sea level rise, the contribution of land ice appears to be the main reason for the increase in sea level in the past decade. Nicholls and Cazenave (2010) noted that global sea levels have risen throughout the 20th century and will certainly accelerate through the 21st century because of global warming.

2.2 Coastal Impacts of Sea Level Rise

Climate modeling is usually used to measure the rise in sea level, although in-situ validation also needs to be done. This is because although sea level has been clearly observed to increase on a global scale, the level of increase varies regionally. This means that some regions may be greatly affected while some may not be so.

Among the impacts of sea level rise are inundation of low-lying coastal lands; backwater phenomena in rivers; saltwater intrusion into natural water courses, artificial canals, and aquifers; deterioration of soils, wetlands, and vegetation cover; wave-induced erosion of coasts; and coastline retreat. Sea level rise increases the risk of a flood disaster; can damage port facilities and coastal structures; and can destroy buildings, farmlands, drainage and irrigation systems, dikes, and roads (Mikhailova 2010). Nicholls and Cazenave (2010) argued, however, that although these impacts may be potentially large, there are uncertainties involved in establishing the magnitude of these impacts. They recognized that the application and success of CCA measures require more assessment and consideration.

The impacts of sea level rise vary at the regional scale due to varying regional factors. Small islands, deltaic settings, and coastal ecosystems in Southeast Asia are particularly vulnerable to sea level rise. The impacts in these regions consist mainly of subsidence due to reduction of sediment supply, enhanced by subsurface fluid withdrawals of a growing population (Nicholls and Mimura 1998). These areas have low resource base that threaten the livelihood options of affected populations living in susceptible areas (Pernetta 1992).

Significant sea level rise can have extensive impacts on a highly archipelagic country like the Philippines where about 60% of the total population resides in the coastal areas. Perez, Amadore, and Feir (1999) predicted that a one-meter increase in sea level would inundate several areas along the coast of Manila Bay, which include 19 municipalities of Metro Manila, Bulacan, and Cavite, covering an area of 5,555 ha.

In Puerto Princesa City, the flood-prone areas in the northeastern portion of the city include the villages of Babuyan and Binduyan (City Government of Puerto Princesa 2011). Notably, there are areas within the city that are affected by inland flooding.

2.3 Possible Adaptations to Climate Change Impacts

Attaher, Medanyl, and Abou-Hadid (2009), in their assessment of farmer response to adaptation options, found out that farmers have a higher tendency to adopt high-cost and efficient structural adaptation measures over management adaptation measures that are of lower cost. They suggested that scientific evaluation must be undertaken to guide the community in choosing more practical solutions since hard strategies like erecting concrete structures (e.g., sea wall) will be costly. According to Perez, Amadore, and Feir (1999), a concrete sea wall 3 meters high and 1 meter thick with an underwater base that is 1.5 meters high and 3 meter thick will cost USD 0.6 million per kilometer. El-Raey, Dewidar, and El-Hattab et al. (1999) likewise brought out this cost-related difficulty, and pointed this as the main barrier to implementing CCA measures.

Perez, Amadore, and Feir (1999) have cited that information campaigns could be a basic strategy for mitigating the effects of sea level rise; it will work in tandem with institutional actions (e.g., developing setback policies and construction regulations) and with adaptive planning in the context of an integrated coastal zone management. Such strategy could address short- and long-term problems with the involvement of communities in the area. In connection, El-Raey, Dewidar, and El-Hattab (1999) examined the various considerations of adaptation options to sea level rise in Egypt, and have cited that a combination of beach nourishment and hard structures (groins and breakwaters) would be the best option available for short-term protection of most of the coastal areas on the Nile Delta.

2.4 Factors Reflecting Adaptive Capacity of Communities

The USAID (2009) have enumerated a broad range of factors that reflect the adaptive capacities of communities. These factors mainly relate to political leadership and commitment and resource availability. In a similar vein, Fitzsimons et al. (2009) recognized that although complex technology (e.g., modeling weather patterns) can help people come up with CCA measures, people's customs, behaviors, and practices can help determine policy and investment priorities. They then developed a collaborative adaptive capacity framework for creating an adaptive capacity index, which incorporates qualitative and quantitative data from the sociocultural practices of communities. Swanson et al. (2009) came up with similar findings in Canada; the authors noted that although existing statistical data can be useful in understanding the capacity of agriculture producers and agro-ecosystems to adapt to weather-related shocks and stresses, prediction models should still be verified using on-the-ground research, such that suitable policies can be designed for future adaptation to climate change. On-the-ground research should incorporate multiple perspectives from the community that emanates concerns related to economic resources, technology, information/ skills/management, infrastructure, institutions and networks, and equity. This means that although expert judgment may be used to determine adaptive capacity (Alberini, Chiabai, and Muehlenbachs 2006), people should also be involved in the decision-making processes when coming up with the best CCA options for adoption.

As Brooks and Adger (2005) pointed out, adaptive capacity can be characterized by examining people's willingness and the available resources necessary to adapt to climate hazards. Agreement among members of the community is a vital requirement for adaptive strategies to be more effective.

3.0 METHODOLOGY

3.1 Methods, Sampling Strategy, and Data Analysis

The focus group discussions (FGDs) conducted in the villages of Babuyan and Binduyan were participated by representatives from various sectors in the community, namely, the local government officials, barangay nutrition scholar, barangay security personnel, farmers, fishers, representatives from the business sector, health workers, women, and youth. The topics discussed during the FGDs included (1) past, current, and planned resolutions and ordinances related to calamities and disasters; (2) projects/interventions and allocated budget to mitigate disaster-related issues; (3) ranking of hazards, and (4) perceptions on vulnerability.

A 28-page questionnaire was prepared, pretested, and administered to the community members in both villages in order to gather information about the respondents' household profile, water use, description and value of dwelling units, susceptibility and exposure to hazards, income and livelihood data, farming and fishing activities, climate change indicators, and household adaptation and coping strategies. A total of 300 respondents were interviewed.

The respondents of the household survey were determined using proportional sampling, clustering by *purok* (zone), and random sampling of households using the Puerto Princesa City Government's CBMS 2009 report on informal dwellers. A total of 300 respondents were interviewed in Binduyan (118) and Babuyan (182) (Figures 2 and 3).

Interviews were conducted every weekend when the household heads were assumed to be present. The enumerators listed down marginal notes related to the administration of the questionnaire (process), and unaccounted responses in the questionnaire that may impact the quality of responses. The enumerators particularly probed those questions relating to valuation of climate change impacts and attempted to minimize "unwilling to answer" or "I don't know" answers. The data gathered were then encoded in MS Access. This was exported and subsequently summarized and analyzed using MS Excel. Descriptive statistics and frequency distributions were prepared to describe the data.

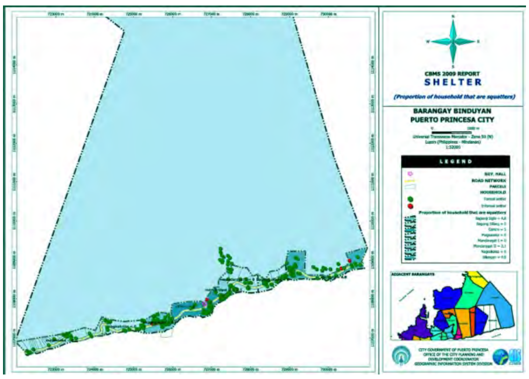

Figure 2. Map of households (informal settlers) in Binduyan

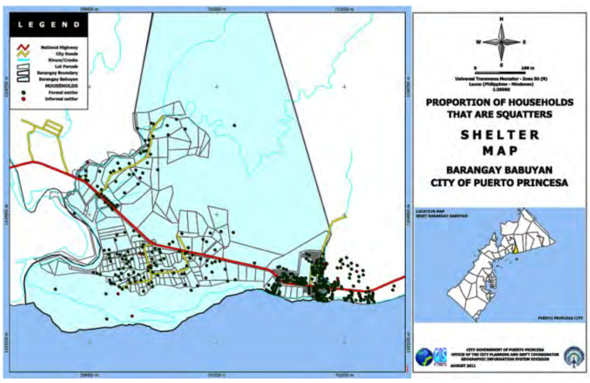

Figure 3. Map of households (informal settlers) in Babuyan

3.2 Cost Effectiveness Analysis of Planned Adaptation Strategies

3.2.1 Method of selection of planned adaptation strategies

During the FGDs, the participants identified the planned projects and interventions that would address climate hazards in the community. They were asked to write the adaptation strategies that they believed could address the climate hazards that they had experienced. After all possible options had been exhausted; these were reviewed and evaluated based primarily on the acceptability and practicality of the options and on the adequacy of the measure to the current climate threats. Other adaptation options were added during the process.

The cost of each CCA option was calculated using inputs from secondary literature and from key informants. The implementation cost was calculated and discounted to come up with the cost effectiveness ratio (CE ratio). The CCA option that showed the least CE ratio was deemed the best option to implement.

3.2.2 Impacts of adaptation options

The damages that could be incurred from climate impacts were valued based on the number of households that would be affected by the planned CCA options. The vulnerable households were identified using the hazard map that had been produced during the FGDs. The extent of damages caused by flooding, river overflow, and sea level rise were measured in terms of the area of fishponds and farmlands that would be spared from any intervention activity.

3.2.3 Analytical procedure

Using team-generated cost-benefit assumptions (based on key informant interviews and secondary literature), the researchers estimated the CE ratio of the different CCA options. Cost estimates, particularly on the hard measures, were made on a per unit basis (e.g., cost per linear meter) using an exchange rate of PHP 42.07: USD 1. A discount rate of 8% was used to compute the annual costs and benefits of each CCA option for the estimated lifespan of the CCA project. To compare the different options, the costs of those projects with shorter lifespans were recurred to match the expected lifespans of those projects with longer lifespan. The most efficient CCA option would have the least CE ratio.

4.0 COMMUNITY-BASED HAZARD AND PHYSICAL VULNERABILITY MAPPING

4.1 Historical Timeline Analysis of Bio-geophysical Impacts

Tables 3 and 4 present the historical timeline analysis in Babuyan and Binduyan with regard to the impacts of climate events that have influenced the lives of the local residents.

In Babuyan, the recorded high sea surface temperature in 1998, strong typhoons in 1995 and 1999, erosion in 2008, and grass fire in 2009 were the climate events that brought significant changes in the lives of the residents. Likewise, typhoons appeared to be much more frequent and intense during the last 15 years.

Table 3. Historical timeline, Babuyan

Year	Event Marker
1949	The former elementary school in Purok Masadya is near the riverbank or river mouth. The river bank was still wide during this period, and the river was narrower.
1956	The elementary school in Purok Centro was relocated because the river had widened due to erosion.
1992	The Babuyan Annex High School near the Barangay Hall relocation site was established.
1994	The Babuyan National High School in a Sitio Anilawan was transferred. The residents of Arrecife Island (Dos Palmas Resort) were relocated to Babuyan, which increased the population of the village.
1995	Three additional classrooms were built for the secondary level (3rd year to 4th year) high school in the village.
1996	An additional classroom was built for Babuyan Elementary School.
1997	A day care center was built.
1998	The Tarabiangan Center (City PNP) was established. Flooding occurred in the village due to Typhoon Norming.
1999	Two zones were added in Babuyan (Purok Baybay at Purok Baringbing) due to increase in population. Additional classrooms in Babuyan National High School were built.
2000	The barangay hall was built. A day care center was built through grant money (PHP 100,000.00) from the NGO Environmental Legal Assistance Center
2001	Typhoon Feriang devastated the village, affecting 439 persons.
2002	A concrete national highway was built. Microscopist laboratory was established to detect occurrence of malaria in the barangay. Nine farmers were provided with calamity seed assistance.
2002–2007	Incidence of malaria increased.
2003	An ordinance for Puntod Ilis Fish Sanctuary was legislated through City Ordinance No. 222 Typhoon Ineng affected 433 fishers/farmers. A grassfire occurred, affecting 111 crop farmers.
2004	The national highway was concretized. Typhoon Igme affected 10 fishers and 422 farmers; farmers and fishers were provided with cash assistance. Typhoon Karen affected five fishers; they were provided with cash assistance.
2005	The plan to develop Water Spring as a source of water for residents and barangay was approved.
2005–2006	PALECO lines were installed to provide the village with functional electricity.
2006	Coast watch tower (View Deck) and cell site tower (Globe) were established. The village allowed the quarry of Escolastica Saavedra. Typhoon Caloy affected 78 persons (house damage-CSWD), and were provided with cash assistance of PHP 1,500–5,000. Typhoon Inday affected 35 families (fishpond and agriculture) Typhoon Juan affected 29 persons (fisheries), and were provided with rice assistance.

Table 3 continued

Year	Event Marker
2007	Malnutrition decreased from 2007–2011. Smart Communications cell site tower was established Typhoon Lando destroyed fishing boats and affected 200 families affected (Agri) A functional spring water system was built. Mr. Sebido and Mr. Olorga were allowed to quarry in the barangay. Typhoon Lando affected 260 families; 1,325 individuals were provided with rice assistance.
2008	Buoys were placed in Puntodllis Marine Sanctuary. Typhoon Tonyo destroyed the guardhouse of the Puntodllis Marine Sanctuary. A drainage system was constructed. Malaria incidence decreased; mosquito nets were distributed among the families in the village. Typhoon Tonio affected 18 families; 78 persons had their houses damaged (CSWD); 1,085 farmers and 43 fishers (banca/fishpond damage) were affected.
2009	Incidents of typhoid fever, flue, dengue, loose bowel movement, coughs, and colds were recorded in Purok Baybay. A training on restoration was conducted by the Palawan Conservation Corps. The cottage in Purok Anilawan was renovated. A view deck area was restored. RA 9003 (Waste Segregation) was adopted and implemented by the barangay.
2010	Incidence of pests in crops was recorded.
2011	Barangay street lamps were installed (July 2011).

Table 4. Historical timeline, Binduyan

Year	Event Marker
1960	Binduyan was established as a barangay.
1963	The residents including the indigenous Bataks, received their first formal education.
1974	Only one mode of transportation was available in the village. Rice was not available for sale.
1975	The first logging concession was established. A store was erected and people started flocking in.
1976	Two rooms were added to the existing elementary school for Grades 1 and 2.
1977	Peace and order brigade was established in the village.
1978	A mother's class was offered in the village.
1980	*Kaingin* was prohibited and violators were caught.
1984	Cadastral survey was implemented.
1987	The barangay health center was founded. A dam for water supply was constructed.
1988	A concrete basketball court was built. Typhoon Welfring destroyed the roofs of houses.
1989	Surveys on integrated social forestry projects were conducted in the area.
1990	Olangoan Waterfalls was developed.
1991	Haribon Palawan, and environmental NGO, started to operate in the village.
1992	Two day care centers were established.
1995	Start of the Foundation Day Celebration Typhoon Pepang reminded the residents of the onslaught of a strong typhoon.
1996	The Irish Trochus farm was established.

Table 4 continued

Year	Event Marker
1998	High sea temperature and siltation killed fish and shells. Electricity generators were installed in the barangay. Comfort room for the barangays security outpost was built.
1999	Typhoon Normeng destroyed the roads and houses in the village and also killed one family; crops were destroyed; residents were relocated to nearby villages. The residents started collecting pebbles as a livelihood activity.
2000	Two elementary school buildings were constructed.
2004	A fish sanctuary in the village was constructed to protect the corals from illegal fishers. The national road was paved with concrete.
2005	The Palawan Electric Cooperative installed power connections in the village. The Binduyan barangay hall was built.
2006	Sun Rise Mansion Resort was constructed.
2008	Mercado's Resort was constructed. A major landslide occurred near the national highway from Binduyan to the next barangays northward.
2009	A spring was developed to serve the local residents with potable water. There was grass fire in the forests of Binduyan and Langogan, which damaged approximately 100 ha of land area.
2010	The number of "ballpen" squid and octopus caught started to decline. There was a pronounced increase in the slope of the coasts due to erosion. Rainy days became longer than dry days. After Typhoon Pedring, many crabs (*alimasag*) and skipjack tuna (*tulingan*) were caught by the fishers.

4.2 Vulnerability Matrix

The following tables present the results of the vulnerability assessment as perceived by the village residents during the FGD. Table 5 presents the vulnerability matrix of Babuyan while Table 6 presents the results in Binduyan. The tables show the perceived likely impacts of typhoons, flooding, and drought/high temperature.

Table 5. Vulnerability matrix for Babuyan

Sector Ranking		Vulnerability					
		Typhoon	Flooding (Inland)	Flooding (Coastal)	Saltwater Intrusion	Soil Erosion	High Temp & Drought
1	Agriculture	HV	HV	MV	SV	HV	HV
2	Health	HV	HV	MV	MV	SV	HV
3	Aquaculture	HV	HV	HV	SV	HV	HV
4	Commercial/ Services	HV	HV	MV	SV	SV	SV
5	Housing	HV	MV	MV	SV	SV	SV
6	Infrastructure	HV	MV	MV	SV	MV	SV
7	Transport	MV	SV	SV	SV	MV	SV
8	Manufacturing	HV	MV	MV	SV	SV	SV

Note: HV = Highly Vulnerable, MV = Moderately Vulnerable, SV = Slightly Vulnerable

Table 6. Vulnerability matrix for Binduyan

Sector Rank		Vulnerability		
		Typhoon & Flooding	Soil Erosion/ Landslide	High Temperature and Drought
1	Agriculture	HV	SV	HV
2	Infrastructure	HV	SV	SV
3	Health	HV	SV	MV
4	Housing	HV	MV	SV
5	Commercial/Services	HV	SV	SV
6	Manufacturing	HV	SV	SV

Note: HV = Highly Vulnerable, MV = Moderately Vulnerable, SV = Slightly Vulnerable

In both Babuyan and Binduyan, the FGD participants agreed that *agriculture* was the most vulnerable sector to the impacts of typhoon, flooding, and high temperature and drought. The residents from both villages recognized the direct, negative impact of climate change to their crop yield. In Binduyan, typhoons affect the production of cashew and banana trees, while the lowland rice areas in Babuyan are likewise affected by typhoons. Both communities are also vulnerable to high temperature since this causes drought, which is harmful to crop production. Further, fishers are affected because they cannot go out to fish, aside from the fact that their gears are also destroyed after typhoons. Livestock-raising to supplement farmers' food and income are also affected. Fishpond operators estimated that sea level rise in Babuyan has been about 1 meter since the last 10 years or so. As a response, they have increased the height of their dikes to enclose their fishponds, thereby preventing storm surges and incoming water during high tides from flooding into the village.

In Babuyan, the *health sector* was ranked second-most vulnerable because of the illnesses associated with typhoons (heavy rains) and flooding; residents have suffered from flu, cough, colds, dengue, and muscle pains after typhoon and flood events. Illnesses associated with high temperature, as experienced by the same community, were hypertension and sore eyes. Although Binduyan residents ranked health as the third-most vulnerable sector, the same kinds of illnesses were common to both villages.

Infrastructure was ranked the second-most vulnerable in Binduyan, since the water supply system (particularly the main lines) gets damaged during typhoons or heavy rains. Babuyan on the other hand, ranked *infrastructure* sixth-most vulnerable; the water supply system gets affected during and after typhoons and heavy rains, especially when water sources overflows and gets filled with gravel and leaves. Village roads and bridges (footbridges) were also affected.

Babuyan ranked *aquaculture* as the third-most vulnerable sector since it has around 70 ha of fishponds as part of its fisheries; the village have also experienced difficulties during typhoons and drought or El Niño events. On the other hand, Binduyan was not beset by this issue as it has no area for fishpond construction.

The *services* sector was ranked fourth in Babuyan and fifth in Binduyan. Both villages are impacted the same way since typhoon and flood events cause loss of communication due to interrupted mobile phone signals and power services. Trading in the form of "buy and sell" is also affected due to the lack of farm and fishery products to sell. Non-timber forest products (e.g., rattan) that are gathered for selling are not be available since the accessibility to areas within the barangay is affected. Note that in Binduyan, pebbles become more available after a typhoon or flooding; these are then gathered and sold by the residents to augment their income.

The *housing* sector was ranked fifth in Babuyan; the impacts include destruction of roofs and house materials since most of the houses in the village are made up of light materials. On the other hand, *housing* was ranked fourth in Binduyan; houses get destroyed during typhoons due to felled trees and flooding.

Transportation was ranked seventh in vulnerability in Babuyan. Roads and bridges in the village are relatively accessible to jeepneys and tricycles even after typhoons since the national highway had been elevated when it was constructed. However, in Binduyan, *transportation* was not identified as a vulnerable sector.

The *manufacturing* sector was ranked eighth- and sixth-most vulnerable in Babuyan and Binduyan, respectively. The production of roofing materials stops since coconut tree leaves are not available, and the quality of such leaves do not make good shingles. Production of rattan crafts in the village is also affected since bamboo materials are not available after typhoons. These indicate that the sources of income, main or supplemental for households become affected.

4.3 Hazard and Physical Vulnerability Mapping

4.3.1 Hazards in Babuyan

The main hazards identified by the Babuyan FGD participants were health-related (Figure 4). According to the participants, the number of people afflicted with malaria in Purok Tugbuan had been larger than it was at the time of the study. They also noted that there had been an increase in typhoid fever and flu in Purok Baybay (place near the coast). These sicknesses coincided with the onset of the rainy season. They attributed this to the lack of toilets, lack of sound waste management practices, and the presence of a piggery near the sea. This could also be due to the increasing population in the villages.

The residents also noted saltwater intrusion in the public well; most of them still drink from it since the next source of freshwater is far from their homes. The common source of water is a spring, which has been developed with a system to supply most of the houses in the area and is monitored by the City Health Department for safety.

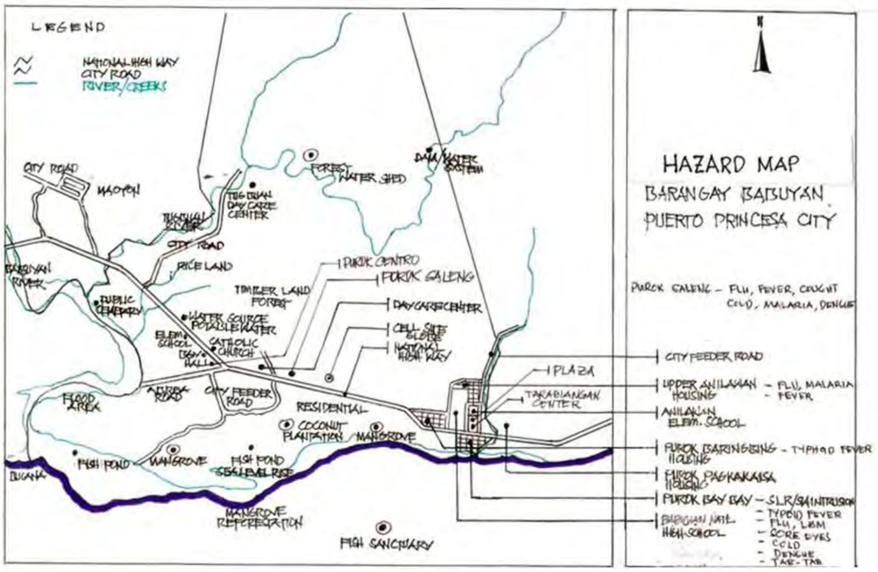

Figure 4. Hazard and physical vulnerability map of Barangay Babuyan

In 2010, there was red tide incident, particularly paralytic shellfish poisoning, in Babuyan due to the high temperature. The City Agriculture personnel of the Fisheries Section of Puerto Princesa had come over to warn the community; thus, they were spared from the harmful effects of contaminated shellfish that could have caused paralysis and death.

4.3.2 Hazards in Binduyan

The participants from Binduyan prepared a spot map of their barangay, and they used this to superimpose the different hazards the community was exposed to, specifically in those areas that were affected by grass fire, flooding, erosion, landslide, and drought (Figure 5). They also noted down the areas where incidence of sickness like malaria, flu, high blood pressure, fever, and malnourished children could be found.

The natural resources noted down by the residents include mangrove and nipa stands, and areas where sea turtle, dugong, whale shark, and dolphins can be found. The participants also marked on the map the locations of the beach resorts that they consider as important features of their village and the locations where the residents get their major income sources from (e.g., pebble gathering, slate-rock mining, and banana and cashew plantations).

Figure 5. Hazard and physical vulnerability map of Barangay Binduyan

4.4 Households and Sectors at Risk from Bio-geophysical Hazards

The flood susceptibility map of Babuyan shows the community's vulnerability to flooding, specifically that of those residing in the coastal low-lying areas along the riverbank and outflow of the Babuyan River (Figure 6). The households at risk to such hazards (e.g., flooding and soil erosion) are those that lie close to riverbanks or next to the seashore. Both villages have households that lie alongside a stretch of the national highway.

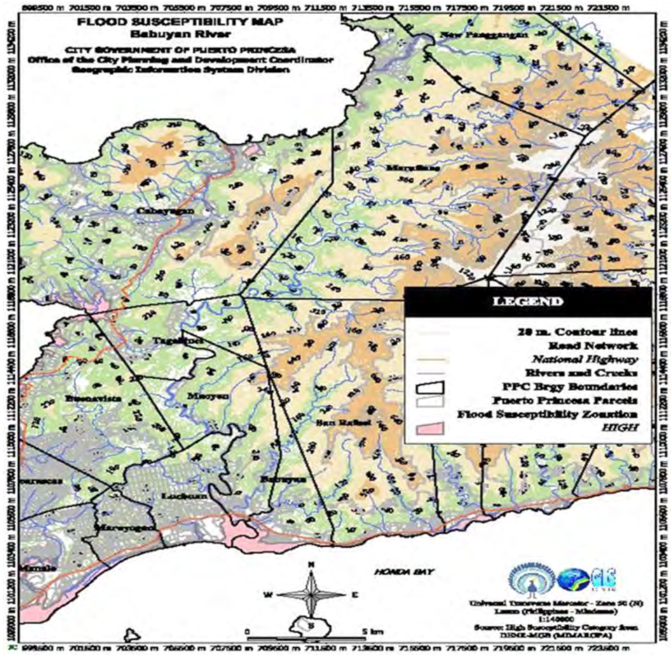

Figure 6. Flood susceptibility map of Babuyan

Source: GIS Puerto Princesa City (2012)

Erosion and sea level rise will affect those households located in steep slopes and low-lying areas, respectively. The exposed, low-lying areas are susceptible to episodes of storm surges and flooding, but maintaining mangrove stands foreshore can soften the force of the wind and sea surges. Households lying next to the high-sloping mountainous regions in Binduyan, however, are prone to flashfloods once the forest cover is removed.

Most of the houses in both villages are made up of light to mixed materials of cement, bamboo, and nipa. Strong typhoons can easily destroy these houses, whereas those with sturdy structures (as in resorts) will weather the impacts.

5.0 VALUING DAMAGES FROM CLIMATE RISK

5.1 Damages and Value of Damages to the Livelihood of Communities in Honda Bay

The hundreds of households located in the plain and coastwise-protected regions of Babuyan may be more affected by climate-related events (e.g., typhoons, flooding, and storm surges) compared with those residents located in the elevated, exposed sections of Binduyan. More livelihood opportunities are available in Babuyan, owing to the more extensive plain areas that allow farming activities and aquaculture production to take place in the village. Land-based livelihood opportunities in Binduyan are comparatively lesser due to the steep-sloping and rugged terrain of the village.

However, the data gathered in this study revealed that although the residents recognize the impacts of climatic events on their livelihoods, only a small segment of the population in both villages have experienced the negative impact of climate-related events. Few households indicated the value of loss attributed to typhoons, flooding, and storm surges.

5.1.1 Climate-related damages to livelihood

From 2003 to 2008, Babuyan residents suffered the effects of strong typhoons on their fishing, farming (crops and livestock), and aquaculture activities. These impacts include the inability to fish due to the strong gusts of wind, damages to boats and other equipment due to the strong waves, and minimal fish trading due to the small amount of fish catch. Crop farming (i.e., rice and corn) was also affected due to the damages to crops caused by the strong winds and floods resulting from typhoons. The fishponds also overflowed, leading to losses in cultured milkfish and tilapia. On the other end, the extremely high temperature in 2003 caused grass fires, which consequently ravaged the community's farmlands. The 2009 El Niño also increased the incidence of pests in 2010, consequently damaging the community's crops. Overall, the livelihood activities of residents in Babuyan are resource-dependent, and thus vulnerable to climatic changes.

Meanwhile, households in Binduyan reported climate-related damages from incidents of flood, grassfire, erosion, landslide, and drought that had happened from 1998 to 2009. These events affected their sources of income (e.g., cashew and banana production) and subsistence activities (e.g., gleaning) due primarily to episodes of hot temperature. According to the residents, the populations of many target species (e.g., squid and octopus) have declined over the years. Recently, the residents noted that they have experienced more rainy days than dry days, which affected the flowering of cashew trees.

5.1.2 Value of flood damages

The value of damages to livelihood due to the worst and latest cases of flooding in Babuyan is summarized in Table 7. Based on the results, agricultural production was the most affected livelihood. Seven households indicated agricultural production loss of PHP 100–10,000 due to the worst case of flooding, and PHP 50–10,000 due to the latest case of flooding. Although only one fishpond owner indicated losses due to flooding, its value was high at PHP 20,000 (worst case) and PHP 10,000 (latest case).

On the other hand, loss of fishing income had the highest damage cost from the worst case of flooding in Binduyan (Table 7). Income loss was wide-ranging as households experienced extremes. At the minimum, damage cost incurred was PHP 200 while the maximum was PHP 21,000. The latest case of flooding apparently shows minimal damage to livelihood.

Table 7. Value of damages to livelihood due to flooding

Damages	No. of Affected Households		Damage Value (in PHP)	
	Proportion	%	Range	Average
BABUYAN				
Worst case				
Damage/loss to livestock	4/189	2.12	3,000–6000	4,500
Loss in agricultural production	7/189	3.70	100–10,000	3,514
Loss in fishing income	2/189	1.06	3,000–4,000	3,500
Loss in aquaculture production	1/189	0.53	20,000	20,000
Income loss due to work stoppage	6/189	3.17	400–4,000	1,628
Latest case				
Loss in agricultural production	4/189	2.12	50–10,000	3,825
Loss in aquaculture production	1/189	0.53	10,000	10,000
Income loss due to work stoppage	1/189	0.53	372	372

Table 7 continued

Damages	No. of Affected Households		Damage Value (in PHP)	
	Proportion	%	Range	Average
BINDUYAN				
Worst case				
Loss in agricultural production	1/42	2.38	600	600
Loss in fishing income	5/42	11.90	200–21,000	5,280
Income loss due to work stoppage	4/42	9.52	200–1,500	675
Latest case				
Damage/loss to livestock	1/42	2.38	500	500
Loss in fishing income	1/42	2.38	200	200
Income loss due to work stoppage	2/42	4.76	200–500	350
Loss in agricultural production	1/42	2.38	600	600

5.2 Damages and Value of Damages to Health

Damages to health in Babuyan were associated with the onset of the rainy season. Among these illnesses were malaria, typhoid fever, loose bowel movement, flu, dengue, pruritus, cough, and colds. The residents were aware that these sicknesses could be due to their lack of sanitary toilets, sound waste management practices, and high coliform from pigpens constructed near the sea. The residents also noted cases of malaria, flu, hypertension, fever, and malnutrition especially among children.

6.0 CEA OF PLANNED ADAPTATION STRATEGIES

6.1 Identifying Adaptation Strategies

During the FGDs conducted in Babuyan and Binduyan, the FGD participants identified several CCA options. These measures consisted of new and previously undertaken activities for resource management projects, with the assistance from the national government, NGOs, and the local government of Puerto Princesa (Table 8).

Table 8. Summary of adaptation measures in Babuyan and Binduyan

SITE	Objectives	Adaptation Options
Babuyan	To protect the household from storm surges and loss of property, and to minimize sand erosion	Breakwater construction
		Dike/levee construction
		Mangrove reforestation
	To prevent river overflow and to minimize siltation that damage coconut plantations and fishponds	Riverbank rehabilitation using vetiver grass
		Riverbank rehabilitation using vetiver grass combined with mechanical method
		Dike construction
		River dredging
	To protect household from inland flooding	Upland reforestation
		IEC/Establish early warning system and provision of temporary evacuation center
		Relocate affected households to safer place

Table 8 continued

SITE	Objectives	Adaptation Options
Binduyan	To protect households from strong waves and storm surges	Breakwater construction
		Mangrove reforestation
		Seawall construction
		Relocation of affected households

6.1.1 CCA measures in Babuyan

Construction of concrete breakwater. Building a concrete breakwater at the mouth of the Babuyan River is a CCA measure aimed to reduce the intensity of incoming waves that cause erosion and flooding. Such structure would protect households and prevent loss of properties. The flood susceptibility map (Figure 6) shows the location of the proposed concrete breakwater. The community plans to source outside funding for this project.

Construction of dike/levee. The community also identified construction of a dike or levee along the shoreline for coastal protection as a CCA strategy. The dike is expected to prevent coastal erosion, fishponds from overflowing, and coconut plantations from eroding. The dike to be constructed would be around 500 meters long.

Mangrove reforestation (community planting). Mangrove reforestation can address coastal erosion and protect the coastline. The community also believed that this would provide them shelter during strong winds and protect them from the strong waves brought by typhoons. Mangrove seedlings will be used to plant the identified five-hectare area that covers the 6.3 km of the shoreline.

Riverbank rehabilitation (vetiver grass planting on riverbanks). Riverbank rehabilitation is expected to address riverbank erosion that also leads to siltation and flooding in the coastal area. Using bioengineering technology for riverbank rehabilitation would entail planting deep-rooting vetiver grass that would hold together the soil in the riverbanks. In combination with other plants such as bamboo or mechanical structures, the whole system is expected to make this adaptation strategy stronger.

Riverbank rehabilitation (vetiver grass combined with mechanical method). Riverbank rehabilitation in combination with materials such as wire and other netting materials and PVC pipes including vetiver grass can be used for riverbank rehabilitation.

Dike heightening and providing strong base support in fishponds. This planned CCA measure involves increasing the height of the dike structure and providing strong base support for those fishponds situated in the flood-susceptible areas. This would also ensure that when storm surges or flooding occurs, the water will not reach the fishpond areas due to the stronger structure and increased height of the dikes. The dike construction is a planned CCA measure that will be undertaken by private fishpond owners in their respective areas.

Placing nets in the fishpond areas. This strategy would help prevent the fish stock from escaping should the water from the pond overflow during flooding or heavy rains. Private fishpond owners in the area will implement this strategy.

Upland reforestation to prevent flooding. About 5 ha of the upland area will be covered in the planned tree-planting activity. The community understands that upland reforestation will provide the residents protection against flooding.

Dredging of river. Dredging or clearing of riverbed with materials such as sand and gravel deposits will help address flooding; the gravel and other materials can prevent the flow of downstream water that overflow to farm areas and destroys riverbanks.

IEC campaign. Implementing IEC projects (i.e., early warning system) during extreme weather events such as typhoons or flooding can protect households. Likewise, improving the existing information system in the community in order to warn and inform every resident of the impending calamity will be undertaken.

Relocate affected household. Affected households, especially those living in high-risk areas, will be relocated to safer places in events of expected calamity. Properties will be acquired to establish the relocation sites using funds from possible funding agencies. Each household will be provided with financial assistance in the amount of PHP 50,000. The relocation will protect the residents from impending disasters, which may occur without warning such as storm surges and flooding.

6.1.2 CCA measures in Binduyan

Breakwater construction. This strategy will protect the community against storm surges and strong waves. This involves building a structure encompassing 8.58 km of the shoreline. Pump boats and other fishing gears and the properties of the community members will also be protected with this structure.

Mangrove reforestation. Mangrove seedlings will be planted on a one-hectare coastal area of the village. The mangrove area will protect approximately 8.58 km of the coastline from strong waves and coastal erosion. This will also minimize siltation of the adjoining rivers and the shallow areas of the coastal zone.

Seawall construction. This will protect households from strong waves and storm surges in the coastal area.

Construction of water supply Phase 2. This will involve laying of water pipes to ensure continuous water supply to households, thereby address the health concerns of the community.

Relocation of affected household. Relocating those households residing in the high-risk portion of the coastal area will protect them from the dangers of storm surges and strong winds during typhoons. The target households for relocation are those near the water (estimated to be within 10 m from the highest water mark).

6.2 Assumptions in the Analysis

6.2.1 Assumptions on the benefits and costs for Babuyan

The *construction of breakwater and dikes* will impact both the households and coastline (Table 9). Coastline residents will be protected from the impact of the strong winds and waves, and sand erosion will also decrease. Likewise, *mangrove reforestation* will benefit the shoreline and the households living along the coast. Although its effect will not be immediately felt, majority of the residents agreed to adopt this option because mangrove plantation is suitable to the coastal areas of Babuyan. The trend of benefits was assumed to be increasing with time. As the seedling matures, the capacity of the roots to prevent erosion will improve, and the developing canopy can change the velocity of winds to lessen the magnitude of its impact.

Fishponds and nearby coconut plantations are usually destroyed once they get flooded, which happens when the river overflows and when the sea level rises. Because of this, operators have become alarmed; they reacted defensively such that they immediately proposed *riverbank rehabilitation*. They presented various ways of implanting this strategy such as using vetiver grass and combining vetiver grass with other mechanical methods.

The community also proposed other strategies to prevent the river from overflowing, such as *river dredging and building dikes* at the mouth of the river. However, dredging requires annual maintenance that would require using heavy equipment such as backhoe loader. This method is a bit delicate and has to be implemented with extreme caution such that the dredging process will not destroy the riverbed, which could further erode the riverbank. Dredging operations should be strictly monitored to ensure responsible quarrying. The whole process is even seen to provide additional income to the community.

Fishpond operators also proposed *dike heightening and putting fishnets* around the fishponds in order to protect their fish farms from flooding. In December 2011, the water reached 1.9 meters, which exceeded the height of the fishpond dikes at only 1 meter. The ponds had overflown and the cultured fishes were inadvertently lost.

Meanwhile, the community proposed three CCA options to protect households from inland flooding, namely, *upland reforestation, establishing disaster warning system, and relocation of residents*. The funds for upland reforestation were proposed to be taken from the village fund, and seedlings will be provided by the city government. Likewise, the community did not object to the proposed *relocation of affected households* because the proposed site was not far from their livelihood sources. The funds needed to acquire and develop the relocation site would be sourced from the Congressional fund, although this would still require the approval of the second-district congressman.

Table 9. Assumptions on the impacts of the adaptation options (Babuyan)

Options	Impacts	Project Impact[1]	Trend of Benefits vis-à-vis Time
Breakwater construction	Household are protected from storm surges and loss of properties	45 years	Constant
	Coastline is protected from sand erosion.		
Dike construction	Household are protected from storm surges and loss of properties.	25 years	Constant
	Coastline is protected from sand erosion.		
Mangrove reforestation	Household are protected from storm surges and loss of properties.	50 years	Increasing with time
	Coastline is protected from sand erosion.		
Riverbank rehab using vetiver grass	Coconut plantations and fishpond are protected from river overflow.	15 years	Increasing with time
	Coral reefs are protected from siltation.		
Riverbank rehab using vetiver grass with mechanical method	Coconut plantations and fishpond are protected from river overflow.	20 years	Increasing with time
	Coral reefs are protected from siltation.		
Dike/levee construction	Coconut plantations and fishpond are protected from river overflow.	25 years	Constant
	Coral reefs are protected from siltation.		
Clearing of riverbed	Coconut plantations and fishpond are protected from river overflow.	1 year	Constant
	Coral reefs are protected from siltation.		
Upland reforestation	Households are protected from inland flooding.	25 years	Increasing with time
IEC/establish EWS and provision of temporary evacuation centers		1 years	Constant
Relocate affected HH to a safer area		lifetime	Constant

Note: (1) Pertains to number of years that impact will be felt over the lifetime of the project

Annual benefits of the adaptation options in Babuyan. *Breakwater construction* is expected to benefit about 200 households living in the coastal areas and along the 6.3-kilometer stretch of the coastline (Table 10). From an economic perspective, building a breakwater along a one-kilometer shoreline would benefit 32 households (7.83 km shoreline with 251 households). *Dike construction*, on the other hand, would benefit less number of households compared to *building a breakwater*. Dikes will be constructed at the mouth of the river, and would benefit only 126 households. In terms of cost, a kilometer of dike would benefit 20 households out of 126 potential household beneficiaries.

Mangrove reforestation is expected to provide progressive benefits. It was assumed that

1. only around 10% of the expected household beneficiaries would benefit in Year 5;
2. the number would increase by 25 households every year for the next four years;
3. 100% of the target beneficiaries would benefit from the mangrove reforestation starting the 10th year onward, provided that all conditions would be normal and the trees would reach its expected height; and
4. since the growth of mangroves is expected to buffer the shoreline, siltation is expected to decrease over time.

Rehabilitating the riverbank is expected to address siltation and flooding whenever the river overflows. In Year 1, *using vetiver grass alone for the riverbank rehabilitation* is expected to protect about 8 ha of fishpond area and coconut plantations from the floods caused by the overflowing river. In Year 2, about 24 ha would be protected, and this would increase by 20% every year thereafter. In the case of coral reefs, benefit would start in Year 4. On the other hand, the impact of *riverbank rehabilitation using vetiver grass combined with mechanical methods* is expected to be greater because of the additional materials used to reinforce the capacity of the grass in holding the soil. Thus, the amount of area protected would be larger than that in *riverbank rehabilitation using vetiver grass only*.

Building a dike at the mouth of the river would benefit a total of 107 ha of coconut plantations, fishponds, and coral reefs combined. Meanwhile, *riverbed clearing*, which will be implemented annually, would benefit a total of 61.5 ha of coconut plantations, fishponds, and coral reefs. The clearing process would require almost three months to complete. *Dike heightening and putting fish nets* around the fishpond are assumed to prevent fish from escaping to the sea and to the river, which could have environmental conflicts with wild fish stocks. The operators are expecting to preserve all their stocks by using these methods, although it would require a bigger amount of investment on their part.

Finally, about 126 households are believed to benefit from *upland reforestation*. The expected benefit would commence in Year 6, and would multiply at the rate of 25 households per year. Likewise, half of the total households are expected to be saved from any impending disaster should a *disaster warning system* be established. *Relocating the whole community* was another option considered that would save the residents from any typhoon- and flood-related disasters. Their relocation was planned to be done in two batches. The first batch would be composed of 125 households; after a year, the last 126 households would follow to complete the total 251 households.

Cost assumptions. The cost assumptions for the planned CCA options are presented in Table 11. There was no identified maintenance cost for the structures. Assuming the construction process followed strictly the standard for *seawall, dike, and breakwater*, no cost will be incurred within the specified effective life of the structures under normal conditions. *Mangroves planted during reforestation* were computed to have 80% survival rate thus, 20% of the seedlings planted need to be replenished the following year.

Table 10. Annual benefits of the identified CCA options (Babuyan)

Options	Annual Physical Benefits	Unit	Value per Unit	Information Source	Annual Monetary Benefit (USD)
Breakwater construction	200	household	1,493.39	FGD and KII with assistant city engineer and the chief of the Plans and Programs division, Palawan Provincial Planning and Development Office	298,677.19
	6.3	km (shoreline)	47,409.08		
Dike construction	126	household	276.28	Asst. city engineer and local contractors	34,810.86
	6.3	km (shoreline)	5,525.53		
Mangrove reforestation	None from 0 to 5 years 13 HH in Year 5 and an increment of 25 every year up to Year 9 126 HH in Year 10 onward	household	120.46	FGD and KII with the city agriculturist	varies
	None from 0 to 3 years 20% of the 6.3 km shoreline in Year 4 and an increment of 20% yearly	km (shoreline)	2,409.13		
Riverbank rehabilitation using vetiver grass	10% on the first year and an increment of 20% annually	hectares (coconuts and fishponds)	40.07	FGD and KII with the city agriculturist	varies
	None from 0 to 3 years 6 ha in the 4th year 12 ha in the 5th year and 18 ha on the 6th year 39 has in the 7th year onward	hectares (coral reefs)			
Riverbank rehabilitation using vetiver grass combined with mechanical method	10% in the 1st year and an increment of 25% annually	hectares (coconuts/ fishpond)	316.99	FGD and KII with the city agriculturist	varies
	None from 0 to 3 years 19 ha in the 4th year 39 ha in the 5th year onward	hectares (coral reefs)			

Table 10 continued

Options	Annual Physical Benefits	Unit	Unit Cost (USD)	Information Source	Annual Monetary Benefit (USD)
Dike/levee construction	69 years	hectares (coconuts/fishponds)	300.56	KII with the assistant city engineer and city agriculturist	34,810.86
	38 years	hectares (coral reefs)			
Clearing of riverbed	61.5	hectares (coconuts/fishponds)	213.56	KII with the assistant city engineer and city agriculturist	19,540.50
	at least 60% (30 ha)	hectares (coral reefs)			
Upland reforestation	None from 0 to 5 years Increment of 25 HH every year starting in the 6th year	households	2.30	FGD and KII with the city agriculturist	289.63
IEC/Establish disaster warning system and provision of temporary evacuation centers	126	households	1.84	FGD	232.07
Relocate affected HH to a safer area	1st year -125 HH 2nd Year -126HH	households	1,252.82	FGD and KII with the barangay chairman	314,458.11

Note: FGD = focus group discussion, HH = household, KII = key informant interview

Table 11. Cost assumptions for planned CCA options (Babuyan)

Adaptation Options/Cost Items	Volume	Unit	Unit Cost (USD)	Total Cost (USD '000)	Year Cost Incurred	Information Source
Breakwater construction				298.68		
Construction cost	100	m	298.6800	298.68	Y0	unesco.org/csi/pub/sm Assistant city engineer
Dike Construction				34.81		
Construction cost	1,000	m	34.8100	34.81	Y0	Assistant city engineer, local contractors, barangay officials
Mangrove reforestation				5,819.67		
Planting material	50,000	pcs	0.3000	15.08	Y0	City agriculturist
Planting material	300	pcs		0.09	Y1	
Labor	50,000	pcs	0.1200	5,804.50		
Relocation of affected households				314.46		
Acquisition/development of land	1	USD	23,210.0000	23.21	Y0	Barangay officials
House construction	125	USD	1,160.3600	145.05	Y0	
House construction	126	USD	1,160.3600	146.21	Y1	
Riverbank rehabilitation using vetiver grass				9.28		
Planting materials	18,000	Hill	0.0100	4.18	Y0	City agriculturist
Labor	90	MD	0.2000	0.42		
Transport	1	USD	2.0000	0.05		
Replanting				4.64		
Riverbank rehab using vetiver grass combined with mechanical method				41.35		
Planting materials	18,000	Hill	0.00023	4.18	Y0	City agriculturist
Labor	90	MD	0.00500	0.42	Y0	
Materials needed	1	USD	23.21000	23.21	Y0	
Labor for landscaping	1	MD	8.91000	8.91	Y0	
Replanting of vetiver grass				4.64		
Dike/levee construction				66.14		
Construction cost	1,000	m	34.81000	34.81	Y0	Assistant city engineer
Rehabilitation cost (90% of the construction cost)			31.33000			Local contractors Barangay officials

Table 11 continued

Adaptation Options/Cost Items	Volume	Unit	Unit Cost (USD)	Total Cost (USD '000)	Year Cost Incurred	Information Source
Clearing of riverbed				19.54		
Backhoe/dredger rent	320	hours	34.81	11.14	Y0	Assistant city engineer
Fuel	4,800	liters	1.39	6.68	Y0	
Oil/lubricants	1	USD	1.16	1.16	Y0	
Wages	40	days	13.92	0.56	Y0	
Upland reforestation				749.09		
Seedlings (free)						City agriculturist
Transaction cost	5000	USD	0.05	0.23	Y0	Local barangay officials
Replanting	1000		0.05	0.05	Y1	
Replanting	200		0.05	0.01	Y2	
Replanting	40		0.05	0.002	Y3	
Labor cost	6240		0.12	748.800		
IEC/Establish disaster warning system and provision of temporary evacuation center				0.23		
Supplies and materials	1	USD	0.23	0.23	Y0	Local barangay officials
Prep of temporary evacuation centers				1,160.90		

6.2.2 Assumptions on the benefits for Binduyan

Both *breakwater and seawall* are expected to protect the households and the coastline (Table 12). The breakwater has a life expectancy of 45 years, while the seawall has 15 years with no maintenance work to be done during these years.

Annual benefits of the adaptation options. The proposed *breakwater* is expected to protect only about 80% of the households living in the coastal area because the length of the breakwater will not cover the full length of the coastline. Thus, it is assumed that about 20% of the total households would not profit from the construction. Aside from protecting households, the degree of erosion are also expected to be minimized, and about 90% or 8.58 km of the total coastal areas would be protected (Table 13).

Cost assumptions. The construction cost of the breakwater and seawall was based from the KIIs conducted with the Puerto Princesa assistant city engineer and with the local contractors in the city and in the village. The cost estimates, particularly on the life span of the structures, were again validated with the barangay officials and from literature (Table 14).

The *mangrove reforestation* was predicted to have a very low survival rate, based on the experienced of the residents during their mangrove reforestation activities done in 2002. Survival rate was observed to be 30%; thus, 70% of the total seedlings planted needs to be replanted after a year.

6.3 Results of Cost-Effectiveness Analysis

The results of the CEA (Table 15) showed that hard adaptation options (i.e., *breakwater and dike construction*) to protect households from storm surges, strong waves, and loss of property were less cost effective in Babuyan than in Binduyan (i.e., *seawall construction*).

In Babuyan, *mangrove reforestation* came out to be the most cost-effective strategy in protecting households and properties and in minimizing sand erosion. Mangroves serve as buffer against storms and have grown well in Babuyan. However, it would take time for this function to be beneficial to the community. Meanwhile, results showed that *river dredging* had the least CEA among the options considered to prevent river overflow and to minimize siltation.

The most cost effective among the options presented was *riverbank rehabilitation using vetiver grass combined with mechanical methods*. This option had the highest CEA, although this may be due to the low cost of materials. Implementing an *IEC campaign and providing temporary evacuation center* to protect households from inland flooding had a lower CEA than *upland reforestation and relocation of affected households*. On the other hand, in Binduyan, *seawall construction* had the lowest CEA among the identified CCA options.

Table 12. Assumptions on the impacts of the adaptation options (Binduyan)

Options	Impacts	Project Impact	Trend of Benefits vis-à-vis Time
Breakwater construction	Households are protected from strong waves and storm surge.	45 years	Constant
	Coastlines are protected coastline from sand erosion.		
Seawall construction	Households are protected from strong waves and storm surge.	15 years	Constant
	Coastlines are protected from sand erosion.		
Mangrove reforestation	Households are protected from strong waves and storm surge.	50 years	Increasing with time
	Coastlines are protected from sand erosion.		
Relocation of affected households	Households are protected from strong waves and storm surge.	Lifetime	Constant

Table 13. Annual benefits of adaptation options (Binduyan)

Options	Annual Physical Benefits	Unit	Value Per Unit (USD)	Information Source	Annual Monetary Benefit (USD)
Breakwater construction	98 (80%)	HH	3,047.73	FGD and KII with the assistant city engineer www.lre.usace.army.mil	298,677.19
Seawall construction	62 (50%)	HH	842.20	FGD and KII with the assistant city engineer	52,216.29
Mangrove reforestation	None from 0 to 5 years 10 with an increment of 10 up to the 9th year 62 in the 10th year onward	HH	144.86	FGD and KII with the city agriculturist	8,981.20
Relocation of affected HH	123	HH	1,254.64	FGD and KII with barangay chairman	154,320.00

Table 14. Cost assumptions for the identified adaptation options (Binduyan)

Adaptation Options/ Cost Items	Volume	Unit	Unit Cost	Total Cost ('000 USD)	Year Cost Incurred	Information Source
Breakwater construction				298.68		
Construction cost	100	meters	298.68	298.68	Y0	Assistant city engineer Local contractors Barangay officials unesco.org/csi/pub/sm.ero18.htm
Seawall construction				104.44		
Construction cost	1,500	meters	34.81	52.22 52.22	Y0 Y26	Assistant city engineer Local contractors
Mangrove reforestation				3,468.42		
Planting materials	10,000 7,000 4,900 3,400 2,400 1,200 600 300	seedlings	0.30	3.00 2.10 1.47 1.02 0.72 0.36 0.18 0.09	Y0 Y1 Y2 Y3 Y4 Y5 Y6 Y7	City agriculturist Local barangay officials
Labor Cost	29,800		0.12	3,459.48		
Construction of water supply (Phase II)				11.60		
Project cost	1		11.60	11.60	Y0	Local barangay officials
Relocation of affected households				154.32		
Site development/ acquisition	1		11.60	11.60	Y0	Local barangay officials
House construction	123	number of houses	50.00	142.72	Y0	Local barangay officials

Table 15. CEA for identified adaptation options

Site	Objectives	Adaptation Options	CEA (in USD) per Unit of Benefit
Babuyan	To protect the household from storm surges and loss of property, and minimize sand erosion	Breakwater construction	276,552.95 per household
		Dike/levee construction	32,278.39 per household
		Mangrove reforestation	19,457.83 per household
	To prevent river overflow and minimize siltation that damages coconut plantations and fishponds	Riverbank rehabilitation using vetiver grass combined with mechanical method	34,020.93 per hectare
		Dike construction	32,232.28 per hectare
		Riverbank rehabilitation using vetiver grass	4,310.47 per hectare
		River dredging	2,139.16 per hectare
	To protect household from inland flooding	Relocate affected households to safer place	2,234.11 per household
		Upland reforestation	925.77 per household
		IEC/Establish early warning system and provision of temporary evacuation center	119.52 per household
Binduyan	To protect households from strong waves and storm surges	Breakwater construction	276,552.95 per household
		Mangrove reforestation	9,323.30 per household
		Relocation of affected households	1,249.69 per household
		Seawall construction	885.66 per household

6.4 Community Response to Presentation of CEA Results

The proposed CCA strategies, key indicators from the household survey, and CEA were presented for validation to the local officials of Binduyan and Babuyan, namely, the barangay chairman and members of the village council including the chairman of the barangay fisheries and aquatic resources management council (BFARMC).

In Binduyan, the planned CCA strategies taken from the results of the FGDs were (1) *construction of breakwater*, (2) *mangrove reforestation*, (3) *relocation of affected households*, and (4) *seawall construction* (Table 16). Based on the CE ratio, *seawall construction* would cost the least at USD 885.66 per household; this would be more cost effective than *mangrove reforestation* (USD 9,323.30 per household) and *breakwater construction* (USD 276,552.95 per household). The vulnerability of the area to strong waves and storm surges contributed to the high mortality rate of the mangroves planted; thus, this strategy would require several replanting, which makes it only second to *seawall construction* in cost effectiveness.

During the FGD, the barangay officials agreed to prioritize *seawall construction*. Also, they agreed to pursue *mangrove reforestation* and assessed the planting area to ensure that appropriate mangrove species will be planted such that mortality rate and replanting efforts will be reduced. On the other hand, because of the the high CE ratio of *breakwater construction*, it was assessed to be the least priority due to the cost involved. The option to *relocate affected household* had a CE ratio of USD 1,249.11 per household, which was more expensive; the funding for this project would have to be sourced from outside. The village accordingly planned to submit a resolution to access funds from the Priority Development Assistance Project (PDAP) of the 2nd district representative in order to acquire the property for the relocation site.

Table 16. CE ratio for planned options from strong waves and storm surge

Planned Options	CE Ratio
BINDUYAN	
Strong waves and storm surge (in USD per household)	
Breakwater construction	276,552.95
Mangrove reforestation	9,323.30
Relocation of affected households	1,249.11
Seawall construction	885.66
BABUYAN	
Storm surges, loss of property and sand erosion (in USD per household)	
Breakwater construction	276,552.95
Dike/levee construction	32,278.39
Mangrove reforestation	19,457.83
River overflow and minimize siltation (in USD per hectare)	
Riverbank rehabilitation using vetiver grass combined with mechanical method	34,020.93
Dike/levee construction	32,232.28
Riverbank rehabilitation using vetiver grass	4,310.47
Riverbed dredging	2,139.16
Inland flooding (in USD per household)	
Relocate affected household to safer place	2,234.11
Upland reforestation	925.77
IEC/Establish early warning system and provision of temporary evacuation center	119.52

Table 16 also presents the results for Babuyan. *Mangrove reforestation* had the lowest CE ratio of USD 19,457.83 per household followed by *dike/levee construction* (USD 32,278.39 per household) and then by *breakwater construction* (USD 276,552.95 per household). *Mangrove reforestation* was then prioritized since there were already ongoing programs (at the time of the study) for mangrove planting implemented by the local and national government. These programs can be tapped for funding to supplement the barangay funds. The City Government of Puerto Princesa also had a mangrove nursery, which could be a source of planting materials for the reforestation efforts of the village. Despite the costs involved in constructing these hard CCA measures, the participants were keen to implement them. The community intended to seek financial assistance from external sources. Feasible CCA strategies, such as reforestation, could be undertaken while funding will be sought for the more costly adaptation options.

Meanwhile, the planned CCA strategy for preventing river overflow and minimizing siltation is also presented in Table 16. *Riverbed dredging* had the lowest CE ratio of USD 2,139.16/ha, followed by *riverbank rehabilitation using vetiver grass* (USD 4,310.47/ha) and then by *dike/levee construction* (USD 32,232.28/ha). *Riverbank rehabilitation using vetiver grass and mechanical method* had the highest CE ratio of USD 33,994.31/ha. The succeeding discussion of the barangay officials on the planned CCA options and CE ratios focused on prioritizing *riverbed dredging*, while undertaking *riverbank rehabilitation using vetiver grass*. A program was already being implemented by the the City Agriculture Office of Puerto Princesa relating to this strategy; thus, the barangay could request for vetiver planting seedlings for the rehabilitation of the riverbank. Meanwhile, *riverbed dredging* needs to be strictly monitored to prevent excessive and destructive clearing of the riverbed. The funds to undertake this option could be sourced from barangay funds.

Table 16 also shows the CE ratio for the planned CCA strategy to protect households from inland flooding. The option with the lowest CE ratio of USD 119.52 per household was the *IEC/establishment of an EWS for calamity preparedness and provision of temporary evacuation center*, followed by *upland reforestation* (USD 925.77 per household) and then by *relocation of affected households to a safer place* (USD 2,234.11 per household). The barangay officials decided to prioritize *IEC/establishment of EWS and provision of temporary evacuation center* (CE ratio of USD 119.52 per household) since it would be the most beneficial during calamities while having the least implementation cost. This could be undertaken together with *upland reforestation* (CE ratio of USD 925.77 per household). Several ongoing government projects on reforestation were already being implemented, thus, the barangay could partner with the project implementers to lessen the cost of implementation.

7.0 HOUSEHOLD ADAPTATION

7.1 Household Adaptation Strategies

In Babuyan, only a very small percentage of residents adopted coping mechanisms in response to flooding or typhoon (Table 17). However, among those affected, *house improvement for resiliency to flooding or typhoon* was on top of the list. This was followed by *digging canals* to facilitate water flow. None of these coping mechanisms indicated that they intend to leave their homes. In Binduyan, on the other hand, *house improvements* ranked second. Foremost in their list was *planting of trees along the periphery of their property*. Considering that more than a fifth of the residents indicated so, this means that the residents put premium on trees as buffer against typhoon or flooding.

Table 17. Coping mechanisms and adaptation responses to climate hazards

Coping Mechanisms/Adaptation Responses	Frequency	Percent
Flooding/typhoon		
Babuyan (n = 189)		
Undertook improvements to make house more resilient to flooding	7	3.70
Dug canals	3	1.59
Pursued other means to generate additional income	2	1.06
Planted trees along perimeter of property	1	0.53
Prepared food	1	0.53
Binduyan (n = 42)		
Planted trees along perimeter of property	10	23.81
Undertook improvements to make house more resilient to flooding	5	11.90
Dug canals	2	4.76
Harvested crops or fish early	2	4.76
Reinforced ponds/ fish cages/animal pens	1	2.38
Moved fishing or farming equipment to safe place	1	2.38
Pursued other means to generate additional income	1	2.38
Coastal erosion		
Babuyan (n = 189)		
Installed temporary and semi-permanent protective structures	5	11.11
Pursued other means to generate additional income	3	6.67
Planted mangrove trees along the shoreline	2	4.44
Installed permanent protective structures	1	2.22
Evacuated/migrated to a safe place temporarily	1	2.22
Reinforced ponds/fish cages/animal pens	1	2.22
Binduyan (n = 35)		
Installed permanent protective structures	2	1.06
Prepared for evacuation but did not evacuate	1	0.53
Saltwater intrusion		
Babuyan (n = 189)		
Undertook other coping mechanisms to protect house from potential damages due to saltwater erosion	189	100.00
Treated water	5	2.65
Tapped from different water source	3	1.59
Harvested rainwater as alternative source of drinking water	1	0.53
Binduyan (n = 35)		
Undertook other coping mechanisms to protect house from potential damages due to saltwater intrusion	35	100
Harvested rainwater as alternative source of drinking water	1	2.86
Tapped from different water source	1	2.86
Treated water	1	2.86

Meanwhile, only a few responded to the threat of coastal erosion. *Temporary and semi-permanent protective structures* were installed by the residents of Babuyan to reduce the impact of coastal erosion. Many of them could not afford permanent protective structures. However, fishpond owners were *reinforcing and increasing the height of fishpond dikes* to make them more resilient to erosion and high tide incidents in order to prevent losing the fishpond stock. Another adaptation considered by the owners was to *place nets around the pond areas* to prevent losing the stocks when the dike breaches and when water overflows. Similarly, although only two respondents indicated that they installed permanent protective structures to prevent coastal erosion, almost all of the residents living along the coastal zone have *erected permanent, semi-permanent or temporary structures*.

Various coping mechanisms and adaptation responses were made by the residents of Babuyan against saltwater intrusion. Five households noted that they treat water before drinking. Just like in Babuyan, the coping mechanisms and adaptation responses of the residents in Barangay Binduyan were also varied.

7.2 Social/Household Vulnerability Index

7.2.1 Vulnerability to expected poverty (VEP) measures

The vulnerability to expected poverty (VEP) framework was used in this study to measure the sample communities' vulnerability to climate hazards. VEP estimates show the probability that a household will fall below the minimum consumption threshold level at which they will be considered as poor. The threshold used was the World Bank minimum of USD 1.25 per capita per day (World Bank 1997). The estimates have a range of values from 0 to 1, with 0 having the lowest vulnerability and 1 the highest vulnerability. In this study, households with a VEP estimate of 0.00 to 0.49 were considered not vulnerable. Those with 0.50 to 0.79 were considered moderately vulnerable, and those with VEP estimates of 0.80 to 1.0 were highly vulnerable. The variables used in the regression were gender and education of household head; dependency ratio; household assets; number of contacts for credit; percentage of income from agriculture, fishery, and forestry; dummy variables whether household is involved in farming, fishing, aquaculture and mariculture, gleaning, and livestock raising; number of flooding experienced by household; and dummy variables for erosion and saltwater intrusion.

Table 18 shows that more than half of the households are vulnerable. About 34% were classified to have moderate vulnerability, while a significant 22% were considered highly vulnerable. The mean VEP for all households was 0.51, while for households that were considered not vulnerable, the mean VEP was 0.18. A VEP of 0.69 was estimated for those with moderate vulnerability, and 0.87 for those who were highly vulnerable.

The profile of the vulnerable households needs to characterized and analyzed. Such information could guide the government, private organizations, and the community in developing the best strategy for implementing a CCA program. Thus, this could serve as a rough guide in identifying which sectors to prioritize and what possible interventions to carry out. It is also a means by which CCA planners can roughly assess the adaptation needs of the communities living in the study site.

Table 18. Distribution of households according to level of vulnerability and mean VEP estimates

Vulnerability Level	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
Number of Households	130.00	101.00	67.00	298.00
% of Households	44.00	34.00	22.00	100.00
Mean VEP	0.18	0.69	0.87	0.51
SD of VEP Estimates	0.17	0.07	0.05	0.32

In this study, the researchers looked at the primary occupation of the household heads, their perceptions of their knowledge and preparedness to deal with future climate change impacts, and the damages and impacts that they have experienced from past climate related hazards and events. Looking at the role of gender would also provide interesting insights.

7.2.2 Occupation of household head, knowledge of climate change, disaster preparedness, and household vulnerability

Majority of the household heads of the vulnerable groups (78% of those who were highly vulnerable and 69% of those moderately vulnerable) were engaged in agriculture, fishery, and forestry (Table 19). Accordingly, the government should develop interventions targeted to these groups to make them less vulnerable to climate change; such interventions could be in the form of providing them with alternative livelihoods in order to augment their income, especially since these sectors are highly dependent on natural resources that are highly sensitive to external shocks.

Table 19. Distribution of households based on the occupation of household head (percentage distribution)

Occupation	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
Officials of government, organizations, corporations, managers, managing proprietors, and supervisors (business owner, store owners, wholesale buying and selling)	9	2	3	11
Professionals	2	1	–	2
Technicians and associated professions	1	1	–	2
Clerical support workers	–	–		8
Service-oriented workers (e.g., barangay nutrition scholars and health workers; day care workers; sales, shop, or market workers; and barangays tanods)	–	2	–	17
Farmers, fishers, and forestry workers (includes gatherers of non-timber forest products)	65	69	78	163
Trades and related workers (e.g., masons, carpenters, construction laborers)	11	9	7	17
Plant and machine operators and assemblers (truck/bus/ heavy equipment drivers, seamen)	1	6	–	18
Laborers and unskilled workers	5	6	6	17
Special occupations (e.g., military personnel)	2	1	–	1
Total	100	100	100	100

Likewise, knowledge and information are crucial elements in ensuring that households are able to implement adequate preparations to withstand the impacts of climate change. Based on the results, majority of the highly vulnerable households had knowledge about the issue (Table 20). On the downside, compared with households who were not vulnerable, a higher proportion (18%) of the highly vulnerable households had no information about climate change. This highlights the need to provide assistance to highly vulnerable households, not only through physical projects but also through providing education and information dissemination.

Table 20. Level of knowledge of households about climate change (percentage distribution)

Level of knowledge	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
No information	11	11	18	12
A little bit of knowledge	45	52	42	47
Adequate knowledge	38	36	36	37
Fully knowledgeable	5	1	3	3
Total	100	100	100	100

In the survey, the household respondents were asked about their perceptions of their degree of preparedness to deal with the future impacts of climate change. Such information is relevant as it can give an idea whether households undertake autonomous adaptation and whether their stance is proactive or reactive. In Table 21, 88% of the vulnerable households thought that they were at least somewhat prepared for future calamities. This proportion was higher for those who were not vulnerable, representing 92% of the total households.

Table 21. Level of preparedness of households to deal with future impacts of climate change (percentage distribution)

Level of preparedness	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
Not prepared	8	12	12	10
Somewhat prepared	44	39	39	41
Adequately prepared	34	37	33	35
Fully prepared	12	13	13	13
Total	100	100	100	100

7.2.3 Bio-geophysical impacts and vulnerability

Looking at the impact of past climate hazards on the vulnerable households can also serve as a guide to the strategic formulation and targeting of CCA programs. It is a means by which planners can assess the adaptation needs of the communities living in the study sites. Table 22 summarizes the incidence of these impacts among households with different vulnerability levels.

Results show that climate hazards (e.g., typhoon and floods, erosion and sea level rise, and saltwater intrusion) seem to have little effect on the population of the study sites. Likewise, the incidence of the impacts was more prevalent in non-vulnerable households than in vulnerable households. In fact, no household belonging in the highly vulnerable group reported sustaining damages from past typhoon and flood events. A few, however, reported sustaining damages from erosion and sea level rise and saltwater intrusion. This may highlight the need to implement livelihood programs in the study sites (instead of hazard mitigation projects) to augment the income of the vulnerable households.

Table 22. Incidence of climate impacts based on vulnerability (in percentage)

Climate Impacts	Percent Affected			
	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
Typhoon and flooding				
Damage to house	2	1	–	3
Damage/loss of appliances	–	1	–	1
Loss of livestock	3	–	–	4
Damage to assets (boats, motorcycles)	2	–	–	2
Loss in agricultural production	5	2	–	8
Loss in fishing income	4	1	–	6
Loss in aquaculture production	–	1	–	1
Income loss due to work stoppage	6	3	–	11
Erosion and sea level rise				
Damage to house	2	1	–	1
Damage/loss of appliances	–	–	1	0
Loss of livestock	–	–	–	–
Damage to assets (boats, motorcycles)	2	1	1	1
Loss in agricultural production	2	–	–	1
Loss in fishing income	3	2	3	3
Loss in aquaculture production	2	–	3	1
Income loss due to work stoppage	3	–	3	2
Saltwater intrusion				
Loss in agricultural production	2	1	–	1
Household members got sick from typhoid	–	–	1	0
Household members got sick from diarrhea	–	–	–	–
Household members got sick from other gastrointestinal illnesses	2	1	1	1
Household experienced lack of fresh water for domestic uses	2	–	–	1

7.2.4 Gender dimension of vulnerability

This study also examined the gender element of climate vulnerability in order to find out if there is any relationship between gender and its impact on the degree of vulnerability to climate change of households. It is often asserted that CCA programs and interventions should be gender-sensitive; thus, the gender composition of the vulnerable households should also be examined.

Table 23 shows that about 24% of the highly vulnerable households are female-headed. This percentage is significantly higher than that of the non-vulnerable households, which was only 5%. For the moderately vulnerable, however, female-headed households comprised only 4% of the total number. Meanwhile, Table 24 shows that the incidence of vulnerability is higher for female-headed households. In fact, 74% of all female-headed households were considered vulnerable compared with only 55% for male-headed households. The difference in incidence was more pronounced for highly vulnerable households.

Table 23. Distribution of households based on gender of household head (percentage share)

Level	Male	Female	Total
Not vulnerable	95	5	100
Moderately vulnerable	96	4	100
Highly vulnerable	76	24	100
All	91	9	100

Table 24. Incidence of vulnerability for male- vs. female-headed households (in percent)

Level	Male	Female
Moderately vulnerable	36	15
Highly vulnerable	19	59
All vulnerable	55	74

8.0 INSTITUTIONAL ANALYSIS

8.1 Decision Making and Planning by LGUs on Climate Change

In 2010, the Philippine Disaster Risk Reduction and Management Act (RA Act 10121) was passed. This law prescribes the manner that local government units (LGUs) should planning, decide, and respond to disasters and to the threats posed by climate change. Supplemental directives from the Department of Interior and Local Government (DILG) were also issued to provide LGUs with guidelines on community preparedness and response to calamities in every flood- and landslide-prone barangays.

According to these policies, each LGU should come up with a disaster risk reduction management (DRRM) plan that incorporates CCA measures. Plans should be aligned with the LGU's Comprehensive Land Use Plan and Comprehensive Development Plan. Such plans include establishing a local DRRM office at the city level (headed by the city mayor) and a barangay DRRM council (headed by the barangay chairperson) at the barangay level. Among the duties and responsibilities of the said councils, the most that relates to climate change are the following:

1. Identify and implement cost-effective risk reduction measures and strategies;
2. Consolidate local disaster risk information, which includes natural hazards, vulnerabilities, and climate change risks; and
3. Maintain a local risk map.

In response, the City Government of Puerto Princesa issued Executive Order No. 09, which organized the City Disaster Risk Reduction and Management Office (CDRRMO) of the City of Puerto Princesa and designated temporary officers and staff of the said office, among others.

All barangays, including Babuyan and Binduyan, are required to submit their DRRM plans to the DILG. On the other hand, the City DRRM submitted its Climate Change Adaptation Measures to the city council for its adoption, which was prepared through a consultative and participatory manner.

8.2 Awareness, Perception, and Capacity of LGUs to Deal with Climate Change

Through the FGDs, both Binduyan and Babuyan were able to identify their respective planned projects and interventions that would address the climate hazards present in their communities. Table 25 shows the planned interventions of both villages. There were identified interventions that can be done autonomously by the community, and there were those that need to have assistance from outside the barangay, particularly in conducting technical studies that would detail the construction specifications and the costs and benefits of each CCA option.

Table 25. Planned interventions, Babuyan and Binduyan, 2012–2016

Site	Intervention
Babuyan	Planned Babuyan project/intervention to address climate change (2012–2016)
	Construction of permanent guard house of Puntod Ilis Marine Sanctuary (Phase 1)
	Footbridge construction (Purok Tugbuan)
	Implementation of IEC on waste segregation and collection
	Concrete breakwater structure construction (Bucana Phase 1)
	Riverbank rehabilitation (vetiver grass planting on riverbanks)
	Mangrove reforestation (community planting) (5 has)
	Construction of wharf (Purok Baybay)
	Additional funds to be used during calamities for food and medicines
	Upland reforestation to prevent flooding
	Clearing of riverbed to prevent erosion and water outflow (flooding)
	Coral rehabilitation project (coral gardening)
	Increase budget for fish sanctuary protection and management and improve facilities for tourist/visitors
	Access to website for promotion of the fish sanctuary project
Binduyan	Planned Binduyan project/intervention to address climate change (2012–2016)
	Resolution to construct breakwater for protection against strong waves
	Ordinance to prevent grass fire
	Resolution to release 70% of the 5% calamity fund from the barangay budget
	Resolution to provide funds for waters system Phase 2
	Resolution to properly collect milkfish fry along the coastal areas
	Resolution to plant mangroves

8.3 Resources/Constraints of LGUs to Implement Planned Adaptation

At the village level, the planned CCA measure that would have had the highest chance of being implemented was the option (1) with the least CE ratio, (2) found to be within the available funds of the barangay, and (3) prioritized by the barangay officials.

The budget for the implementation of the chosen planned CCA option could be sourced from the Barangay Infrastructure Funds and from the Internal Revenue Allotment. The barangay DRRM plan should also include the planned CCA options. Thirty percent of the calamity fund can be used for disaster quick response, while the remaining 70% can be used for preparedness, mitigation, and recovery under RA 10121.

At the city level, projects that address preparedness, mitigation, and recovery for disasters and climate change impacts can be funded using the 70% allotment of the calamity fund for the year as long as it is an identified DRR or CCA measure in the DRRM plan. At the city and barangay levels, the presentation of CE ratio for the planned CCA options can assist the barangay and city leaders in deciding which option to implement.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Climate change impacts, such as flooding due to sea level rise, could already be felt by the residents of the two communities in the study sites in Honda Bay, Puerto Princesa City. The most vulnerable sector is agriculture. Houses built close to rivers or nearshore areas and low-lying areas are prone to hazards brought by flooding and erosion. These impacts (i.e., impacts of typhoons, flooding, and storm surges) can be quantified through valuation of damages sustained by households. Accordingly, CCA strategies that would address these impacts can be quantified, and the respective CE ratio of the different options can also be determined.

Among the different CCA options identified by the participants of this study, *mangrove reforestation* in areas where mangroves can grow well was considered the most cost-effective strategy to protect households and properties and to minimize sand erosion. Hard adaptation options like *breakwater and dike construction* could be adopted by the two villages provided that adequate funds are available.

The results of the analysis provided leaders and decision makers with concrete basis for project implementation toward mitigating the adverse effects of climate change. Barangay officials tended to favor options with lower CE ratio since their barangay funds can cover the cost; those with high CE ratio have been reserved for future implementation, especially those without firm funding commitments.

Basically, resource availability was one of the major considerations in identifying the CCA options to be implemented by the community in order to enhance their resilience to the impacts of climate change.

Based on the findings and conclusions derived from this study, the following recommendations are arrived at:

1. In Babuyan, the community should be further encouraged to engage in mangrove reforestation projects. Such project is desirable in the long-term in order to protect households from storm surges, loss of or damage to properties, and sand erosion. Whenever possible and if funds would allow, the community may pursue hard CCA options as quick fix to the threat of sea level rise with added benefits such as fish landing facility.

   Despite the low CE ratio of *river dredging*, the community should adopt strategies with lesser environmental impact, like *planting of vetiver grass along the riverbank* to minimize the flooding caused by river overflow. Whenever necessary, river dredging would complement this option.

   To protect households from inland flooding, *establishing EWS and providing temporary evacuation centers* appeared to be the most practical CCA strategy. However, this may be difficult because the weather can be difficult to predict. Thus, the community should further explore alternative options to ensure the safety of the residents.

2. In Binduyan, *seawall construction* appeared to be the most cost-effective CCA option to protect households from strong waves and storm surges. This option would be more effective if combined with *mangrove reforestation*. Planting of mangroves in suitable areas along the shoreline will be highly beneficial to the coastal residents.

In general, the community should base their decision primarily on the affordability of the adaptation strategies without sacrificing the environmental sustainability of the preferred option.

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