Climate variability and development of adaptive capacity at the Bocas del Toro archipelago in Panama

Variabilidad climática y desarrollo de capacidad adaptativa en el Archipiélago Bocas del Toro en Panamá

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***Abstract*— Coastal marine zones are made up of beaches, mangroves and corral reefs. They are fragile ecosystems that are highly vulnerable to climate variability, especially a rising sea level, sedimentation and salinization. The main economic activities for the Panamanian communities living in the Bocas del Toro Archipelago include tourism and fishing, both of which are closely linked to the preservation of coastal marine ecosystems. A topic of regional interest is the understanding and valuing of the ecosystem services provided by the beaches, mangroves and corrals. They provide livelihoods for the communities and act as a natural defense against heavy swells and the erosion of beaches and coastlines as a result of a rising mean sea level. The coping strategies employed by coastal communities are planned based on their perceptions of the observed impact caused by climate variability. The kinds of perceptions of climate variability that are held by the local community in Bocas del Toro, as well as the actions they are taking to offset its effects on their quality of life, are looked at in this article.**

***Key words:* climate variability, adaptive capacity, Bocas del Toro Archipelago, climate change, marine and coastal areas.**

***Resumen*— Las zonas marino-costeras comprenden las playas, los manglares y los corales; ecosistemas frágiles al cambio climático global y a la variabilidad climática, en particular por efectos tales como el aumento del nivel medio del mar, la sedimentación y la salinización. En el archipiélago de Bocas del Toro en Panamá, las comunidades locales tienen como actividades económicas principales el turismo y la pesca, ambas estrechamente relacionadas con la preservación de ecosistemas marino-costeros. La comprensión y valoración de los servicios ecosistémicos que brindan las playas, los manglares y los corales a las comunidades como medios de vida y su uso como defensa natural ante oleajes fuertes y para evitar procesos de erosión de las playas y líneas costeras causados por el aumento en el nivel medio del mar, es un tema de interés regional. Las estrategias de adaptación de las comunidades costeras se planean a partir de la percepción que ellas tienen del impacto al que se están viendo enfrentadas a causa de la variabilidad climática. Este artículo indaga qué tipo de percepción tiene la comunidad local de Bocas del Toro sobre la variabilidad climática y las acciones que adelantan para contrarrestar sus efectos en las condiciones de su calidad de vida.**

***Palabras clave:* variabilidad climática, capacidad adaptativa, archipiélago de Bocas del Toro, cambio climático, zonas marino-costeras**.

I. INTRODUCTION

The Caribbean Islands possess geographic and social characteristics that are worth studying in light of the potential impacts for coastal marine ecosystems and local communities caused by climate variability in the short-term and climate change over the long-term. The islands are exposed to irregular rainfall distribution and increasing mean temperatures due to climate variability. At the same time, climate variables are altered by the El Niño/La Niña oceanic-atmospheric phenomena and rising sea levels. Social variables heavily influence the degree of adaptation to climate change and

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climate variability. For the most part, the local community in Bocas del Toro, Panama, have not completed secondary school and earn an average monthly income of 300 balboas (300 USD). It can be expected, then, that people's capacity to adapt is reflected in little to no environmentally friendly coping strategies, especially when it comes to their exposure to the long-term potential impacts of climate change.

Coastal marine zones are made up of beaches, mangroves and corral reefs. They are fragile ecosystems that are highly vulnerable to climate variability, especially a rising sea level, sedimentation and salinization [1]. The main economic activities for the Panamanian communities living in the Bocas del Toro Archipelago include tourism and fishing, both of which are closely linked to the health of coastal marine ecosystems.

A research topic of local and regional interest is the understanding and valuing of the ecosystem services provided by the beaches, mangroves and corrals. They provide livelihoods for the communities and act as a natural defense against heavy swells and the erosion of beaches and coastlines as a result of a rising mean sea level [2].

According to Imbach and Prado [6], the stages of the coping cycle are: awareness of change, action, decision-making, implementation and sustaining the action over the long-term. For the IPCC [1] coping strategies are those adopted in order to moderate the vulnerability of natural and human systems in the face of the real or anticipated impacts of climate change, or to take advantage of the potential benefits. The type of adaptation selected can be: preventive and reactive, private and public, autonomous or planned, as well as individual and collective. Some examples of adaptation include the construction of river or coastal dams and ecosystem renewal, like that of mangroves. Another important concept is that of adaptive capacity, which consists of the capabilities, resources and institutions present in a country or region that allows them to roll out suitable, timely, equitable, efficient and effective adaptive measures that contribute to sustainable development [7].

The adaptive capacity of individuals refers to their ability to get out of adverse situations gracefully. At a societal level, adaptive capacity is more complex because it is affected by multiple elements that include bonds of solidarity, self-esteem, trust, collective identity and government integrity [8].

The various adaptation steps can be seen in figure 1, starting with an individual's perception of their sensitivity as defined by the IPCC [1]: the degree to which a system is affected, either adversely or beneficially, by climate variability or change. Next, vulnerability is identified and a position is taken (action), be it passive or reactive, *vis a vis* what is happening. This leads to decision-making and implementation over the medium- to long-term in order to reduce sensitivity. Each one of these steps is linked to a monitoring and reflection process which contribute to new, and perhaps more robust, cycles to the previous one.

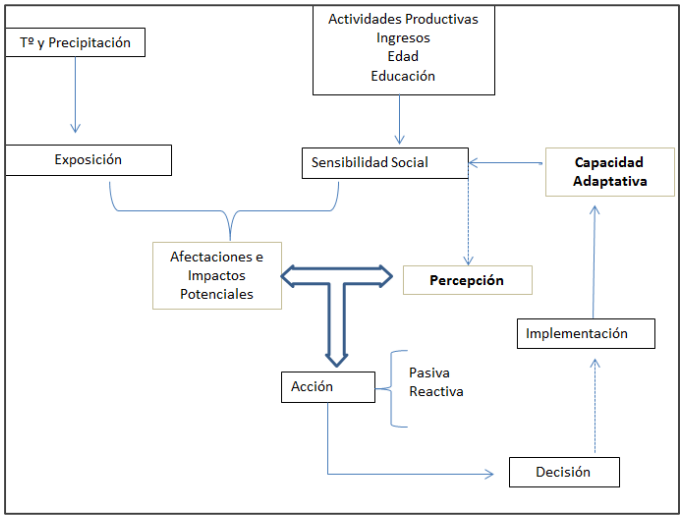

Fig. 1. Coping cycle
Source: adaptation of Imbach and Prado, 2012

The aim of the article is to present the effects of natural climate variability on the community and tourist industry of the archipelago, and the actions taken in the face of new climate scenarios in the zone. These flow out of the results of research into the local Bocas del Toro community observations of climate variability and the steps they are taking to counteract its effects on their quality of life.

II. MATERIALS Y METHODS

A. Area Under Study

The Bocas del Toro Archipelago is located on the Panamanian Caribbean coast in front of Costa Rica. It is part of the Bocas del Toro Province with the capital located on Colón Island. It has a population of 16,135 people spread across four administrative districts [3]. It is composed of 9 islands, 51 quays and 200 islets spread across marine prairie, corral reef and mangrove ecosystems that are highly attractive for tourism. Three species of marine turtles nest on its beaches: Baula (Dermochelys coriacea), Carey (Eretmochelys imbricata) which is critically endangered, and the green turtle (Chelonia mydas) which is endangered [4].

Fig. 2. Location of the Bocas del Toro Archipelago
Source: INEC, 2011

According to current IPCC predictions [1], the climate change vulnerability of communities inhabiting small islands is increasing due to the potential impact of rising sea levels.

This research was carried out in two stages. During the first stage, semi-structured interviews were carried out with six key informants during the months of January and February 2013 in order to identify the extreme weather events that had occurred over the previous 10 years. This information was used to build the survey. In the second stage, with the goal of understanding their awareness of climate variability in the zone, the survey was applied to 200 people living on the four main islands of the archipelago, viz. (Isla Colón, Isla Carenero, Isla Bastimentos, Isla Popa), and where the largest population concentration is found.

B. Community Coping Cycle

Panama is classified as a megadiverse country. Despite 12% of the territory being under some kind of protection code, the high poverty and inequality indexes (35% and 0.588 respectively) mean that natural resources are improperly exploited. The country occupies the 14th slot among countries with the greatest exposure to multiple hazards, and about 15 % of the territory is simultaneously threatened by two natural hazards. Climate Change (CC) will increase Panama's socio-environmental vulnerability [1] and the sectors due to be most affected are agriculture, water resources, forests, and the coastal zones. Especially vulnerable zones have been identified as the San Blas archipelago, the coastal areas of Bocas del Toro, Colón and western Panama Province [5].

Perception is a selection and categorization process of stimuli from the person's setting and results in building an interior world from selective references and memories [9]. For this reason, it is compared to data from the meteorological station on Colón Island.

These stages are consistent with the goal of ascertaining the effects of natural climate variability on the archipelago community and tourist industry, and the actions adopted given new climate scenarios in the zone.

C. Sample Characteristics

Those interviewed were adults, mainly of African descent and originating on the islands with almost equal gender participation. Most had not completed secondary school and show an income lower than 300 balboas, equivalent to the same amount in $USD. The sample characteristics can be seen in table 1.

TABLE 1.
SOCIO-ECONOMIC CHARACTERISTICS OF THE SAMPLE

SAMPLE CHARACTERISTICS		SURVEY RESPONSES (%)
Sex	Male	51
	Female	49
Age	Youth (18 a 30 años)	33.5
	Adults (30 a 50 años)	40
	Elderly (50 a 88 años)	26.5
Education	None	4
	Incomplete Primary	9
	Complete Primary	20
	Incomplete Secondary	29
	Complete Secondary	24
	University	14
Ethnic group	African descent	57
	Indigenous	35
	Foreign	8
Income	0-100 balboas	26.6
	101-200 balboas	12.0
	201-300 balboas	26.6
	301-500 balboas	14.6
	+ 500 balboas	20.2
Place of residence	Isla Colón	49
	Carenero	16
	Isla Bastimentos	22.5
	Isla Solarte	2
	Isla Popa	7.5
	Otro sitio	3

Source: INDEC (Instituto Nacional de Estadística y Censo). 2008. Results of standard of living survey (online). 2. Consultado 29 de octubre 2012. Disponible en http://www.contraloria.gob.pa/inec/Aplicaciones/ENV2008/intro.html

III. Evidence for Climate Variability in the Bocas del Toro Archipelago

In order to identify the year-on-year effects produced by climate variability, the National Oceanic and Atmospheric Administration (NOAA) data was consulted for the decade covering 2002 to 2012. These were then compared to the

information offered by the island inhabitants and to the local consequences.

Climate variability in Mesoamerica is closely linked to various oceanic and atmospheric phenomena such the La Niña and El Niño Southern Oscillation –ENOS, which have increased the frequency of "extreme weather events" characterized by maximum or minimum values for climate variables like temperature and precipitation. The record for the past 50 years provides evidence that the number of maximum or minimum measurements is increasing for all of Mesoamerica. These events translate into storms, flooding, or drought that affect the most sensitive and / or vulnerable communities.

During intense el Niño years (the Pacific Ocean temperature increases), the probability of storm and hurricane formation over the Caribbean is very low. Decreased precipitation and more dry days mean that the accumulated rainfall is lower than average. Conversely, in a year characterized by a cold ENOS, i.e. la Niña, above normal amounts of rain fall on Central America and the Caribbean [10]. The el Niño and la Niña anomalies have alternated over the last 10 years. As can be seen in Table 2, when there is an oscillation of +/- 0,5ºC per quarter, then it is prolonged for 5 consecutive seasons [11].

TABLE 2.
PERIODS WHEN EL NIÑO (RED) AND LA NIÑA (BLUE) HAVE BEEN ACTIVE 2002-2012

AÑO	DEF	EFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDE
2002	-0.2	0.0	0.1	0.3	0.5	0.7	0.8	0.8	0.9	1.2	1.3	1.3
2003	1.1	0.8	0.4	0.0	-0.2	-0.1	0.2	0.4	0.4	0.4	0.4	0.3
2004	0.3	0.2	0.1	0.1	0.2	0.3	0.5	0.7	0.8	0.7	0.7	0.7
2005	0.6	0.4	0.3	0.3	0.3	0.3	0.2	0.1	0.0	-0.2	-0.5	-0.8
2006	-0.9	-0.7	-0.5	-0.3	0.0	0.1	0.2	0.3	0.5	0.8	1.0	1.0
2007	0.7	0.3	-0.1	-0.2	-0.3	-0.3	-0.4	-0.6	-0.8	-1.1	-1.2	-1.4
2008	-1.5	-1.5	-1.2	-0.9	-0.7	-0.5	-0.3	-0.2	-0.1	-0.2	-0.5	-0.7
2009	-0.8	-0.7	-0.5	0.2	0.2	0.4	0.5	0.6	0.8	1.1	1.4	1.6
2010	1.6	1.3	1.0	0.6	0.1	-0.4	-0.9	-1.2	-1.4	-1.5	-1.5	-1.5
2011	-1.4	-1.2	-0.9	-0.6	-0.3	-0.2	-0.2	-0.4	-0.6	-0.8	-1.0	-1.0
2012	-0.9	-0.6	-0.5	-0.3	-0.2	0.0	0.1	0.4	0.5	0.6	0.2	0.3

Source: NOAA, 2013

From 2007 to 2012, two major hurricanes formed over the Caribbean that affected Central America. Félix-5 (September 2007) caused 130 deaths and 70 disappearances, as well as grave damage to infrastructure and flooding in Nicaragua and Honduras. Alex-2 (June 2010) caused 13 deaths in the state of Nuevo León and the destruction of 4 bridges along with flooding in the city of Monterrey. Before these devastating hurricanes, hurricane César in 1996 and Mitch in 1998 [12] can be remembered. In the following table (3) the hurricanes with their corresponding category are listed for the last six years. Where the activation of hurricanes coincides with the presence of ENOS (red background) the values are lower than for those years when La Niña (blue background) was present.

TABLE 3.
ATLANTIC HURRICANES REGISTERED BY YEAR

Huracanes del 2007	Huracanes del 2008	Huracanes del 2009
Dean cat.5 (13 a 23/8) **Felix cat. 5 (31/8 a 5/9)*** Humberto cat.1 (12 a 14/9) Lorenzo cat.1 (25 a 28/9) Noel cat. 1 28/10 a 2/11)	Bertha cat. 3 (3 a 20/7) Dolly cat. 2 (20 a 25/7) Gustav cat. 4 (25/8 a 3/9) Hanna cat. 1 (28/8 a 7/9) Ike cat. 4 (1 a 14/9) Kyle cat. 1 (25 a 29/9) Omar cat. 3 (13 a 18/10) Paloma cat. 4 (5 a 10 nov)	Bill cat. 4 (15 a 24/8) Fred cat. 3 (7 a 12/9) Ida cat. 2 (4 a 10/11)
Huracanes del 2010	**Huracanes del 2011**	**Huracanes del 2012**
Alex cat. 2 (25/6 a 2/7)* Danielle cat. 4 (21 a 31/8) Earl cat. 4 (25/8 a 5/9) Igor cat. 4 (8 a 21/9) Julia cat. 4 (12 a 20/9) Karl cat. 3 (14 a 18/9) Lisa cat. 1 (211 a 26/9) Otto cat. 1 (6 a 10/10) Paula cat. 2 (11 a 15/10) Shary cat. 1 (29 a 30/10) Tomas cat. 2 (29/10 a 7/11)	Irene cat.3 (20 a 29/8) Katia cat. 4 (20/8 a 10/9) Mara cat. 1 (6 a 16/9) Ophelia cat.4 (21/9 a 3/10) Philippe cat. 1 (24/9 a 4/10) Rina cat. 2 (23 a 28/10)	Chris cat.1 (19 a 22/6) Ernesto cat.1 (1 a 10/8) Gordon cat.2 (15 a 20/8) Isaac cat. 1 (21/8 a 1/9) Leslie cat.1 (30/8 a 11/9) Michael cat.3 (3 a 11/11) Nadine cat.1 (11/9 a 4/10) Rafael cat.1 (12 a 17/10) Sandy cat.2 (22 a 29/10)

Source: NOAA, 2013

The meteorological stations in Panama are operated by the electricity company (Empresa de Transmisión Eléctrica – ETESA) [13I. In 2006 they reported that in years where the El Niño phenomenon is present, rainfall goes down in the districts located in the Pacific watershed and go up for those located in the Caribbean watershed, taking into account local variations due to spatial and weather characteristics of a site and the anomalies of the event. The meteorological station for the Archipelago is located at the airport (Lat. 9º 20'; Long. 82º 15') and maintains records from 1972 onwards.

Thanks to the ETESA records and the responses given by key informants in the semi-structured interviews, it was possible to create a timeline showing extreme weather events that have affected the local community and the coastal marine ecosystem of the islands.

"There's a flood about every 35 years and in 2005 the strong rains caused flooding in Changuinola and Almirante. Here on the island, houses at the edge of the sea were lost and also the road going to Bluff Beach".

"In 2007 there was a drought and for two months there wasn't enough water on the islands".

"There was a very high tide in November of 2008 because of extreme rains. I lost six cabins that I had built along the sea in 1994 and the archipelago was cut off for a week".

"Between November 2008 and January of 2009 there was a flood that covered a wide swath of Orey forest on the islands. They're the rows of dry trees that you can see from the launch when you come to Colón Island".

"The sea rose approximately 3 feet (0.91 m) in 2009. That, and the extraction of sand from the beaches has caused the beach to erode and almost 10 meters of beach have gradually been lost".

"In 2010 the sea got warmer and coral died. Without a doubt this happens more often, although not everywhere, just in some places".

These events were backed up by the meteorological data provided by ETESA [14] in 2013. It confirmed that February and March 2007 were the driest months over the previous 10 years, and that November 2008 registered an accumulated rainfall of 1012.7 mm, the highest in the last decade and represents 1/3 of total rainfall (3354.8 mm) for that year.

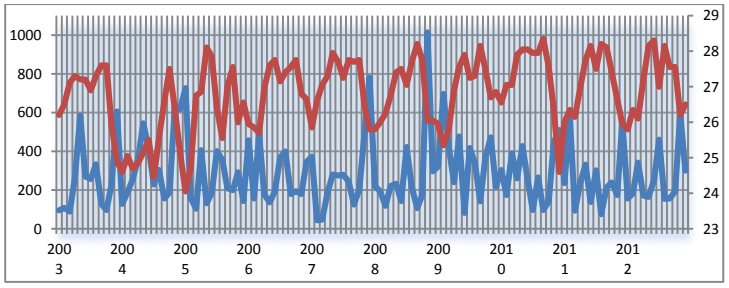

Fig. 3. Precipitation log in mm (blue) and mean temperature in º C (red) for the Bocas del Toro Archipelago over the last decade.
Source: ETESA, 2013.

Rain falls throughout the year on the Archipelago and as a result the inhabitants do not identify a clear dry or rainy season. The logs show the distribution and it can be seen that the least rainy months are February, March, September and October, while the rainiest months are November, December, January, July and August. Average monthly precipitation is 300 mm for the zone, with a mean monthly temperature oscillating between 24 and 28ºC.

Recent studies by ECLAC and BIOMARCC [15] and [2] show that the northern Panamanian coast and the southern coast of Costa Rica will tend to experience swells of up to 1,6 and 2 meters for the 2010-2040 period because now higher swells are

being generated in the Atlantic. Another ECLAC study [16] indicates that for every 1 °C increase in temperature, there will be an increase of 7% in average global atmospheric humidity meaning that higher intensity rainfall events can be expected. These same studies show that some floods and landslides in Central America have been the result of the accumulated effects of climatic events and not necessarily extreme weather events *per se*. Socio-ecological systems vulnerability has multifaceted interfaces that cast uncertainty over future scenarios due to climate variability, geographic and atmospheric characteristics, that have greater impact at a local level [17].

IV. Results and Discussion

The survey results are presented below (expanded mode). Closed questions were used for identifying whether the island inhabitants had noted variations in familiar climatic elements such as tides and rainfall, and if they connect these with how they were personally affected afterwards. They were also consulted on whether they have developed or identified actions that can be taken to protect themselves from suffering negative impacts in the future as part of developing local social adaptive capacity.

What emerged for the four archipelago islands studied was that the community has not taken any steps even though they have identified changes in climate over the previous 10 years. This demonstrates individual reactive adaptive capacity. In the same vein, local and national institutions suffer from lack of physical, human and financial resources to prepare for future scenarios that are greatly uncertain.

A. Perception and impact due to rainfall variations

Due to its extension and geomorphological characteristics, the islands of the Bocas del Toro Archipelago do not have any rivers from which to get water. As such, the communities depend on the rain to maintain the water tables of the Mimitimbi y Big Creek groundwater sources that supply the inhabitants and hotels of Colón Island with water. Changes in the amount and duration of the rains has been noted by 61,5% (123) of the island inhabitants surveyed, 38% (76) had not noted changes and one (1) person did not answer the question.

When asked about the changes that had been noted (n=123), 43% (53) believe that it rains more than before, 52% (64) indicate it rains less, and 5% (6) think the rains are more intermittent. In this particular case of the Bocas archipelago, the information from the semi-structured interviews with key informants (restricted mode) was triangulated with the comments made by those surveyed.

"The logs from the last 15 years show that it rains for shorter times in the Caribbean …Bocas is dehydrating".

"When I was a girl it rained a lot, up to weeks at a time; now it rains less and days pass without any falling".

The divergence in perception could be due to factors that were not taken into account in this study such as how long people have lived on the islands. People who have spent their entire lives there have a more complete spatial and temporal reference point from which to make comparisons about changes between actual and past climatic conditions. The climate logs for the last decade show that there has been great year-on-year variability that has been reinforced by the el Niño and la Niña phenomena.

When asked whether they had been affected by the 2007 drought period (February and March), 69% (138) responded in the affirmative, 27,5% (55) responded negatively and 3,5% (7) of the respondents were not resident on the archipelago during the event.

When asked about what actions they took to ameliorate the lack of water for domestic use caused by the drought, one third said that they bought bottled water implying an additional family expense. Another third used well water because they lived in isolated areas where the municipal water truck did not reach. The final third that lived within the urban perimeter of Colón Island benefited from water supplied by the IDAAN (Instituto de Acueductos y Alcantarillados Nacionales – National Aqueduct and Sewage Institute) during the drought months. The people who looked for water in other areas explained that this meant spending time and money on fuel for their boats.

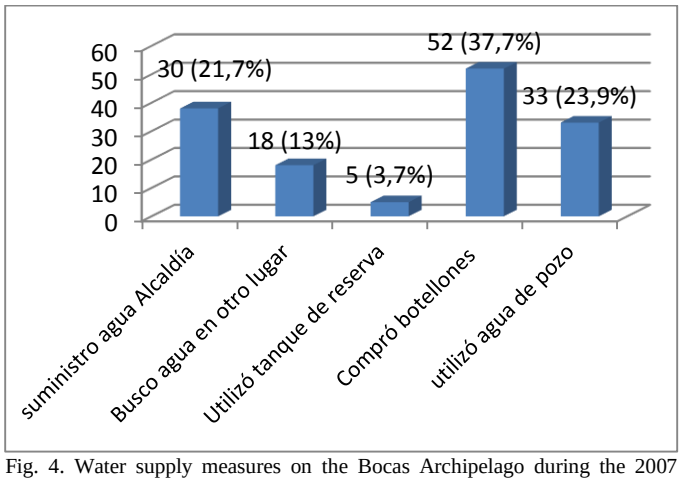

Fig. 4. Water supply measures on the Bocas Archipelago during the 2007 drought months
Source: Authors

Floods are referred to as "llenas" by the zone's inhabitants. An extreme event happened in November 2008 in which 1012.7 mm were accumulated over the month. Respondents were asked whether their families or assets had suffered losses due to the flood and 21% (42) responded yes, 74% (148) responded no and 5% (10) are unsure or did not respond.

The fact that a high percentage (69%) of respondents report being affected by the drought while a smaller percentage

(21%) complain of being affected by flood could be due to the insularity characteristics of the territory.

B. Perception and impact of higher swells

One of the most obvious consequences of higher swells and rising sea levels, is coastline erosion and loss of beaches [5] [18] and [19]. Changes in the beaches and roads were noted by 71,5% (143) of the community but 25% (50) have not noted changes and 3,5% (7) are unsure. Beaches are an important part of the island ecosystems because they are a tourist attraction and they are also a nesting site for marine turtles. If beaches are lost, then nests are lost and turtle populations that are already endangered are harmed.

Tide changes and higher swells are expected in the future in the Central American Caribbean because of climate change [20]. Through the use of closed questions, it was possible to verify that people have noted changes in the high tide over the last ten years: 76,5% (153) said yes, 23% (46) said no; and one person was unsure.

The rise in sea level and higher swells in the future could affect human settlements located on mangrove flood plains behind the airport on Colón Island (La Solución and Loma Espino neighborhoods). The large majority are indigenous, as well as native, people that have come to Colón Island looking for work, who live in crowded circumstances without access to basic services such as potable water and sewage systems. These households are especially vulnerable given their spatial segregation and poverty. According to the IPCC [7], people living in marginalized areas are among the most vulnerable.

The capacity to respond to the adverse impacts of an extreme event can indicate the adaptive capacity of a community facing climate variability [1], [21], [22] y [23]. Upon consultation, it was found that the respondents have taken individual action to avoid suffering losses in the future due to very high tides. Affirmative responses were given by 16% (32) of the respondents, 58% (116) gave a negative response, and 26% (52) were unsure or did not respond. Actions taken by locals to cope with high tides in the future are summarized in table 4. The majority of people have opted to invest in infrastructure that reduces the impact of high swells that rise above the coastline and reach their houses. The next strategy is to raise the level of the house or move away. A small number (6,25%) recognize the power of the mangroves to decrease their vulnerability to high seas s.

TABLE 4.
ACTIONS TAKEN BY THE SETTLERS OF THE BOCAS ARCHIPELAGO TO DEAL WITH HIGH SEAS

Measures	% (n=32)
Raise the house or find a higher place to live	18,75
Build breakwaters, walls and reclaim land	53,12
Move the house a few meters inland	6,25
Not cut the mangrove	6,25
Not live close to the sea	3,13
Move house	12,5

Source: Authors

The low positive response to the question about actions taken could be because they believe in the insularity of the island and that the absence of large rivers means flooding is not a real threat, as well as the positive connotation attached to high tides as fortuitous events. Through the surveys it was discovered that a large number of houses on the islands of the archipelago are located in the coastal zones making them vulnerable to the rise in mean sea levels. It was also discovered that some investors have made walls and reclaimed land to stem the erosion caused by waves in front of their houses that are built close to the coastline, and they have planted mangrove.

C. Building Adaptive Capacity in the Archipelago

Current research shows that social variables play an important role in the degree of adaptation to climate variability and climate change at both a local level and on a national scale. For this reason, building adaptive capacity in individuals can be measured by their adoption of environmentally friendly actions or interventions to decrease their exposure to potential impacts, or not [24]. Survey respondents (n=200) were asked if they believe that something can be done to avoid the impact of extreme events and 50% (100) gave a positive response, 49,5% (99) said no and one person did not know.

Those that responded in the affirmative (n=100) were asked who should do something and what it should be. Eighty percent (80%) of the respondents concur that the national and local authorities should take actions to decrease the impact of loss of beaches, ensure compliance with regulations, and decrease exposure. Some 20% of sample respondents think that vulnerability can be reduced by changing local behaviors (Table 5).

TABLE 5
ACTORS & ACTIONS IDENTIFIED BY RESPONDENTS THAT COULD REDUCE VULNERABILITY

Actors who should do something	Actions that should be taken	% (n=100)
National Government	Reinforce walls around the islands Ensure legal compliance and not grant concessions for developing tourist projects. Carry out environmental monitoring and follow-up and increase personnel present in the zone. Build breakwaters in certain places	25%

Local government	Clean and maintain drains and canals. Raise funds and protect the population Carry out beach cleanup days Pay the needed attention to the issue Manage waste properly Not grant permission to mine sand from the beaches Keep the population informed and practice transparent management. Do not approve construction on reclaimed land. Build walls to protect the beaches Resettle people living in high-risk areas	35%
Local Communities	Stop chopping the mangroves down Plant more trees and look after the environment Burn less garbage and learn to recycle Prepare for natural disasters	15%
Tourism Entrepreneurs	Build more walls and breakwaters to protect the beaches and shorefront hotels	5%
National Environment Authority [Autoridad Nacional del Ambiente(ANAM)]	Meet their obligations to protect the beaches and ecosystems Have more personnel in the area	20%

Source: Authors

According to the second communiqué of Panama on climate change, adaptation is limited by the lack of historic data on sea levels making it difficult to assess the vulnerability of the coastal marine zone. The coastal zone from Changuinola to Punta Valiente is classified in this same report as highly vulnerable to: the effect of high swells and rising sea levels; flooding owing to changes in land use in mangrove areas; and the loss of beaches to residential urbanization [25].

The next question was whether help from the government could be expected in order to recover from damages caused by extreme events. Thirty-six percent (36%) of the sample (72) did not expect any help and would solve the damages themselves while 62% (124) do expect help and 2% (4) are unsure or did not respond. The responses could reflect paternalism on the part of the government, or that people feel so pessimistic and impotent that they do not believe in their own ability to recover from an extreme event similar to the earthquake of 1991.

When asked whether they had identified or realized some action to avoid sustaining damages in the event of an extreme event, two-thirds did not identify any. In addition, 6% think that nothing can be done to avoid the losses caused by nature, 18% of the sample recognized that actions focused on changing behavior were possible and 0,5% have considered emigrating (Table 6).

TABLE 6.
FUTURE ADAPTIVE MEASURES IDENTIFIED BY RESPONDENTS

Actions	% (n=200)
None	75.5%
Raise the level of the house	1.5%
Build walls and reclaim land	6%
Store water in cisterns	1.5%
Track weather information and prepare for emergencies	2.5%
You can't do anything in the face of Nature	6%
Reforest, not chop down trees or mangroves	2.5%
Recycle, not burn garbage, not dump garbage in the sea	4%
Leave the island	0.5%

Source: Authors

It can be concluded from the responses that the community does not take any responsibility for potential damages and impacts to which they are exposed. As a result, this lack of action makes them even more vulnerable to the effects of short-term climate variability and long-term climate change on them and their assets.

According to Nicholls et al. [26], the absence of effective coping strategies for dealing with rising mean sea levels, wind, and tropical storms, will have environmental, social and economic consequences nationally and further afield. A concern about permanent and intermittent flooding of low-lying coastal zones in the world is also expressed in a UNESCO report [27]. The danger exists that in the future low-lying areas, especially equatorial islands, will disappear as sea levels rise, leading to the forced displacement of entire populations to the continents.

Increased vulnerability is contingent upon the unique regional and local characteristics. Even so, there is agreement that it is a result of skewed development paired with environmental degradation and fast, unplanned urbanization in dangerous areas while government fails and few livelihood options are available to the poor [12]. Most of the elements that increase vulnerability are currently a feature of the islands that make up the Bocas del Toro Archipelago.

Recent studies recognize that not all Climate Change coping strategies are good or sustainable. Some may even have negative consequences for some sectors because they undermine the welfare of others by impeding access to resources or the ecosystems upon which they depend for their livelihoods. Therefore, adaptation actions must contribute to social justice and environmental integrity as much as possible [28].

A recent study carried out by BIOMARCC [2] and USAID [29] rated the adaptive capacity of some of the Panamanian coastal districts using 10 socio-economic indicators (percentage of households going with basic needs

unmet, demographic dependence, percentage of people whose economic activity is fishing, percentage of people whose main economic activity is agriculture, percentage of the population that is illiterate, number of primary healthcare units per 1000 people, percentage of people without piped clean water, percentage of households without sanitary facilities, percentage of protected territory, percentage of forested territory). The Bocas del Toro district was rated as having a high adaptive capacity using these indicators. The absence of institutional criteria or indicators leaves out an important part in reducing local and national vulnerability leading to an excellent grade when really, as Nicholls [27] points out, adaptive capacity is influenced by cultural, political and historic issues. Coping strategies encompass a wide range of options starting with efficacious government at different levels.

Building adaptive capacity is based on how holistic and connected the different components of social development are and the synergy amongst them [30]. Through the semi-structured interviews conducted with key informants it was revealed that the national authorities charged with protecting the environment and reducing socio-ecological vulnerability suffer from a lack of personnel and physical and financial resources.

The requirements for the existence of true adaptive capacity begin with creating political spaces characterized by trust on the part of the interested actors, linking local knowledge with scientific approaches for managing environmental variables, strengthening local organizing to respond to external pressures, and achieving political advocacy at different government levels [17].

V. CONCLUSIONS

The meteorological data available, and that was used in this study, only allows for observing climate variability over the last ten years, but is not valid for carrying out statistical analysis to identify climate change trends.

The Bocas del Toro islands are exposed to the effects of climate variability as identified by the irregular rainfall distribution and rising mean temperatures, both of which are altered by the oceanic-atmospheric phenomena known as El Niño and la Niña, as well as the rising mean sea level. Most of the population is aware of the changes in these climate variables that affect them the most.

The results show that a large percentage of the island populations are affected by drought, limiting the availability of water fit for human consumptions. For this reason, the population and the Municipality have created a series of strategies for coping with drought, all centered around supply, but not quality when it comes to using well water. This practice affects the family economy either through increasing expenses, work overload or the use of time to look for water in other places. It can be shown that the population does not have the same response capacity when it comes to damages caused by high swells and rising sea levels.

Even so, the population does recognize that the large swells are eroding the beaches and damaging infrastructure like the only coastal road joining Bocas with Bluff Beach and Estrella Beach. It is strange that a place that economically depends on tourism does not have any plans or programs in place to protect the infrastructure that guarantees a flow of visitors to these sites. Entrepreneurs, local government and the community are impervious to this reality.

Half the community recognizes that something can be done to avoid sustaining damages. By this is meant that in addition to being aware of the changes, they think that local authorities should protect the environment, and that national government authorities should enforce the law and invest in activities to protect infrastructure so that the impacts attributed to climatic phenomena can be diminished.

The community's adaptive capacity is weak. The study reveals inaction on the part of the population. Only a small portion considers that they have some responsibility, betraying the fact that their adaptivity is reactive because they will only take action when they are affected by some event. This decision almost always leads to a costly engineering intervention or moving away.

The island populations need to be informed, conscientized and receive sponsorship from local and national governments to carry out activities that build and strengthen their adaptive capacity. By the same token, investors and tour operators can also contribute physical and financial resources toward maintaining and protecting the infrastructure that is essential to their business and that contributes to the sustainable development of the islands.

The private sector has done its part to protect its investments by reclaiming land, building walls and planting mangroves to avoid erosion caused by high tides that also threaten their infrastructure. It would be interesting to research how much these interventions have cost as compared to the value of the protective ecosystem services provided by the mangroves that have been cut down.

The private sector initiatives on the islands could be used as a starting place for negotiating a public-private alliance that propels planning and implementing actions that tend to reduce the vulnerability of vital areas of the archipelago and forestall reactive adaptation that wastes energy for little benefit over the medium- to long-term.

Although the results are preliminary, they are a wake-up call to institutions and civil society to build workable and sustainable adaptation scenarios and proposals for the socio-ecosystems of the islands that comprise the Bocas del Toro Archipelago.

Lastly, more thorough research is needed to identify the variables that can aid communities in marginalized settlements to build their adaptive capacity in a way that leads to behavioral change in the future that contributes to the search for solutions to their problems.

The November 2008 floods cost Panama 10 million dollars in damage, with 16 deaths and 23,292 people affected across the country. This is just one example of the magnitude of losses that could be reduced by taking action in the present.

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