Food and Agriculture Organization of the United Nations

Vulnerability and Livelihood Assessment of the Fisheries Sector and Coastal Areas of Belize

A focus on Belize City, Dangriga Town and San Pedro Town

Vulnerability and Livelihood Assessment of the Fisheries Sector and Coastal Areas of Belize

This report is prepared by Dr. Asha Singh, PhD for the United Nations Food and Agriculture Organisation (FAO) in collaboration with the Ministry of Blue Economy and Civil Aviation and the Belize National Designated Authority for the Green Climate Fund, with funding from the Green Climate Fund

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ACRONYMS

BWS	Belize Water Services
CC4FISH	Climate Change Adaptation in the Eastern Caribbean Fisheries Sector
CBO	Community Based Organization
CZMAI	Coastal Zone Management Authority & Institute
CH_4	Methane
CO_2	Carbon Dioxide
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization
GCF	Green Climate Fund
GDP	Gross Domestic Production
GHG	Greenhouse Gas
HMCCC	Human Mobility in the Context of Climate Change
IPCC	The Intergovernmental Panel on Climate Change
NGO	Non-profit Governmental Organization
N_20	Nitrous Oxide
NOAA	National Oceanic and Atmospheric Administration
ONI	Oceanic Niño Index
PPB	Parts per Billion
PPM	Parts per Million
SEAC	Sensitivity, Exposure and Adaptive Capacity
SME	Small Medium Enterprises
SST	Sea Surface Temperature
SQKM	Squared Kilometres
UNCTAD	United Nations Conference on Trade and Development
USD	United States Dollars
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

The Context

Climate change is a global phenomenon inflicting social, economic, cultural and environmental suffering and challenges from which Belize is not exempted. Rather, it is significantly magnifying the country's vulnerability because the coastal belt is the nucleus of the Belizean economy where a majority of the economic activities and infrastructures are situated. The Government of Belize is unequivocally aware that climate change is having an impact on its population's well-being, especially the burden experienced by coastal businesses and residents, not to mention the nature-based economies and livelihoods. This has spurned a proactive attempt to respond using a multi-pronged approach of improving access to resources, enhancing climate change advocacy and mainstreaming this phenomenon into its governance, management and disaster responses. However, several challenges remain, one critical factor being the limited or lack of site-specific assessment of vulnerability and livelihoods due to climate change. This report presents the findings of the detailed vulnerability and livelihood assessment conducted for Belize City, Dangriga Town and San Pedro Town.

The Approach

As per practice, vulnerability and livelihood assessments are measured by investigating the exposure, sensitivity and adaptive capacity of the relevant areas. However, there are no single standards for measuring exposure, sensitivity, or adaptive capacity and because of this, interpretation and analysis are linked to the scale of the study. Further, the Client requested the Consultant to align the approach in accordance with the CC4FISH toolkit which also placed emphasis on exposure, sensitivity and adaptive capacity. The vulnerability and livelihood assessment has several similarities and overlapping components in the context of climate change. In view of these commonalities, the study utilised a single approach which examined sensitivity, exposure and adaptive capacity from the physical, socio-economic, cultural, and environmental perspectives. The assessment utilised a combination of global, regional and local data and indicators in conducting the measurements, using data between the period 1991-2021 where available or any period in-between as per availability. Key informant interviews and stakeholder workshops also support the data gathering process for which 105 stakeholders and 24 agencies in the public and private sectors were consulted.

The Findings

Belize City, Dangriga Town and San Pedro Town are all vibrant townships which are home to several economic activities. While the level of activities varies, the contribution to the economic, social and cultural fabric of Belize is unequivocally important. The fisheries sector in these communities is largely artisanal, but significant in playing a crucial role in Belize's food security, employment and its service sectors vis a vis hotels and restaurants. Based on the data presented in this study, the observed trends correlate with the global narrative on climate variability, meaning that climate change is superimposing impact and stress on the Belizean landscape, but moreso, all the study areas of focus are exposed, including livelihoods, assets and infrastructure. Further, the study found that that the citizens face some level of sensitivity associated with climate change. Additionally, the fisherfolks demographics are particularly sensitive to a wider range of issues related to climate change. This has significant implications for their vulnerability, but more importantly, their well-being. However, the measures currently in place to support adaptive capacity reveal limited evidence of being present. In summary, these communities have shown to be significantly vulnerable from a socio-economic, environmental and ecosystem perspective, although in varying magnitude.

The Recommendations

Although the people and businesses in these communities are heterogeneous and operate with varying rationalities, the types of vulnerabilities they face are common to a large extent. Therefore, enhancing adaptation through supporting schemes can serve to empower them as agents of change, which over time, will continually shift the paradigm towards the required transformations to enhance climate resilience. The proposed recommendations include prioritizing protection and defences to safeguard assets and infrastructure in the coastal zones; strengthening financial resilience by enhancing the access to affordable insurance and loans; facilitate the uptake of managed retreat as a medium to long term adaptation tool; and boost adaptive capacity with information and communication.

Structure of the Assessment Report

Throughout the document, there are text boxes which include information gathered from the stakeholder process on issues related to climate change. Additionally, non-climate change issues that are deemed to be exacerbating the vulnerabilities are also presented in boxes in the report. These serve as references to the reader, providing context and appreciation of the imposing forces beyond climate change which can be addressed to reduce the vulnerabilities faced by the communities. At the end of each Section, there are summary points designed to quickly give the reader a concise overview of the Section's content.

SECTION ONE provides the context for the assessment, describing the purpose, objectives, and methodology, including the data and indicators used to measure vulnerability and livelihoods. This section affords the reader an understanding of the scope of this study.

SECTION TWO describes the study areas of Belize City, Dangriga Town and San Pedro Town to present an overview of the coastal zones and fisheries sector. The descriptions provided are biased towards the elements that have implications for climate change vulnerability and livelihoods. The purpose for this bias is to bring into focus climate change and its links to vulnerability and livelihoods.

SECTION THREE reflects investigations conducted through an evidence-based approach of climate change from the Belizean standpoint, briefly looking at the global context through to the site-specific level. Each phenomenon that is identified as an example of climate change is studied using national data. The analysis provided firmly shows that Belize is experiencing climate change which is aligned to global trends and observations.

SECTION FOUR understudies the exposures to climate change in the coastal zone and fisheries sector, investigating how climate change is exposing the ecosystems, habitats, species, and infrastructures.

SECTION FIVE assesses the sensitivities to climate change in the coastal zone and fisheries sector, analysing them from several perspectives, including health, social, cultural and economic. These bring into focus the livelihood implications to the communities.

SECTION SIX investigates the adaptative capacity present to support resilience building via adaptation to climate change by examining the financing environment, physical infrastructure and accompanying enabling requirements for climate proofing, among others.

SECTION SEVEN discusses the vulnerabilities and livelihoods garnered from the assessment, looking at how the coastal zone and fisheries sectors are affected, and amplifying key findings.


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SECTION EIGHT presents the major conclusions of the study in the form of a SWOT and identifies lessons learnt from undertaking this vulnerability and livelihood assessment. The COVID-19 pandemic and its impacts are also discussed.

SECTION NINE recommends options for reducing vulnerabilities and enhancing livelihoods in a changing climate.

SECTION ONE

SETTING THE CONTEXT

This report presents the findings of the detailed vulnerability and livelihood assessment conducted for Belize City, Dangriga Town and San Pedro Town.

1.1 INTRODUCTION AND SCOPE OF THE STUDY

Climate change is a global phenomenon inflicting social, economic, cultural and environmental suffering and challenges across the world, magnifying nations' vulnerabilities in varying proportions. Belize, a coastal nation in Central America with a significant proportion of its land area under sea level at high tide, is spared no exception from climate change. Rather, it is significantly magnifying the country's vulnerability because the coastal belt is the nucleus of the Belizean economy where most of the economic activities and infrastructures are situated. In addition, a significant portion of the total population are coastal dwellers and inhabitants who are concentrated in twenty-seven (27) communities within the coastal belt.

The Government of Belize is unequivocally aware that climate change is having an impact on its population's well-being, especially the burden experienced by coastal businesses and residents, not to mention the nature-based economies and livelihoods. This has spurned a proactive attempt to respond using a multi-pronged approach of improving access to resources, enhancing climate change advocacy and mainstreaming this phenomenon into governance, management and disaster responses. However, several challenges remain, one critical factor being limited or lack of site-specific assessment of vulnerability and livelihoods due to climate change.

In response to this lacuna, action towards enhancing data and information is prioritised, with planned studies to be undertaken in site-specific locations. Under a Green Climate Fund (GCF) readiness project entitled, "Enhancing adaptation planning and increasing climate resilience in the coastal zone and fisheries sector of Belize", a portion of the funding is dedicated to improving knowledge and information by conducting a detailed vulnerability and livelihood assessment of the coastal zone and fisheries sector. This report presents the findings of the detailed vulnerability and livelihood assessment conducted for Belize City, Dangriga Town and San Pedro Town.

BELIZE

- Land area is 22,966 sq km, extending 280 km N – S and 109 km (68 mi) W – E and a total coastline of 386 km. The inclusion of maritime jurisdiction claimed under UNCLOS brings Belize's total land and ocean to ~45000 km2 as provided by the Ministry of Blue Economy and Civil Aviation.
- Belize's Barrier Reef is the second-largest barrier reef system in the world, dotted with hundreds of low-lying islands called cays.
- The coastal zone of Belize is defined as 3 km inland off the coastline (as per CZM Act, 1998), but the coastal belt is 10 km from the coastline.

CLIMATE CHANGE

Any significant change in the measures of climate lasting for an extended period. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer.

[1]While it is recognized that the largest population centers are coastal inhabitants, the disaggregation of the demographics as it appears in the report does not allow for a near accurate estimation.

1.2 STUDY APPROACH

There are no single measures of exposure, sensitivity, or adaptive capacity in assessing vulnerability and livelihoods and because of that the interpretation and analysis is linked to the scale of the study and available data (Mozaria-Luna et al., 2015). However, understanding the vulnerabilities of communities and their strategies to cope with and adapt to climate change are extremely important to the development of policies that seek to preserve the communities' livelihoods (Kalikoski et al., 2010). Actions with the aim of reducing vulnerability to climate change should generally be focused on reducing sensitivity and exposure, and at the same time increase local adaptive capacity which is the approach of this study (Figure 1).

Against this context, it was requested for the Consultant to align the approach in accordance with the CC4FISH toolkit using a participatory approach when conducting the assessment. The vulnerability and livelihood assessment has several similarities and overlapping components in the context of climate change.

Both assessments deal with sensitivity, exposure and adaptive capacity (SEAC). In view of these commonalities, the study utilised a single approach which looks at sensitivity, exposure and adaptive capacity from the physical, socio-economic, cultural, and environmental perspectives. By utilising this approach, vulnerability and livelihood as they relate to climate change were also addressed in the socio-economic components of the analysis. Prefacing the assessment, the climate variabilities as they relate to Belize and to the extent possible the study sites were analysed. These are further explained below.

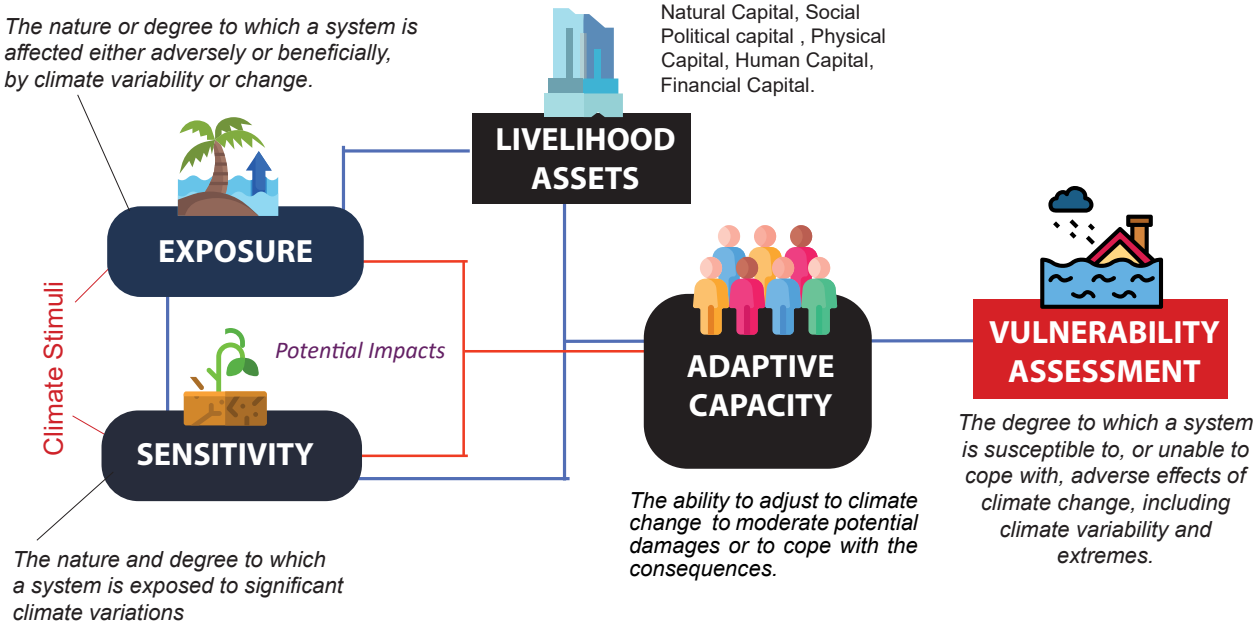

Figure 1: Illustration of Methodology

1.2.1 Data and Indicators

In the study various types of data were used in the analysis. Investigating the variability of climate change in the selected study sites utilises a combination of global, regional and local data and indicators to measure parameters that are impacted by climate change. Global data and information were utilised where there is no data for Belize. Belize's country data was used where there is no data for Belize City, Dangriga Town and San Pedro Town. Further, for Belize City, weather related data from the Phillip Goldson International Airport weather station were used. The Melinda Forest weather station which is 3 miles from Dangriga Town was used for the analysis for Dangriga Town. Currently, there are no weather stations in or in close proximity to San Pedro Town; hence where empirical references on San Pedro were made, they are from data obtained from the Hol Chan Marine Reserve.

The assessment utilised data between the period 1991-2021 where available or any period in-between, as per availability. This duration is in alignment with the international scientific norms where climate researchers traditionally use a period of at least 30 years to identify a genuine climate trend. The period (1991-2021) is the current period being used. Further this was endorsed by the stakeholders consulted from the Belize Meteorological Services.

EVIDENCE OF CLIMATE CHANGE: Vulnerability and livelihood assessments, like other climate change assessments, specifically work to recognize, evaluate, and communicate the changes/variability associated with climate change within an area of interest. However, while much is known about the effects of climate change at a global scale, the ability to analyse climate change at the local levels, which are important to local decision makers and managers is more challenging and often not done. In an effort, to nudge the current norm, attempts are made to first assess climate change manifestation in a local context to enhance the evidence-based narrative of this phenomenon. It is envisaged that this component will enhance the overall robustness of this vulnerability and livelihood assessment while addressing the issue raised above regarding local scale climate information. The data used are itemised in Table 1.

EXPOSURE: Understanding exposure to climate change is a fundamental prerequisite to understanding vulnerability to climate change. The concept of exposure in this study demonstrates the ways in which the study sites (the coastal zone and fisheries sector) are susceptible to climate variability. The parameters and data used are itemised in Table 2.

[2]CC4FISH is a Toolkit for vulnerability and capacity assessments in Caribbean coastal and fishing communities. It is aimed at national fisheries authorities and other related government agencies, civil society organizations, including fisherfolk organizations, and other technical partners looking for practical tools that can be applied at the local level to inform climate change adaptation planning and action. Taken from FAO at https://www.fao.org/publications/card/en/c/CB6786EN/

Table 1: Data and Indicators used to assess climate change vulnerabilities in Belize

Climate Variability	Parameter Measured	Information Used or Data Period	Source	*Applicability of the Findings*				
				Global Context	*Belize*	*Belize City*	*Dangriga Town*	*San Pedro Town*
Temperature Changes	Average Annual Temperature & Average Monthly	1990-2020	1					
Sea Surface Temperature	Average annual	1990-2020	1					
Ocean pH (Acidification)	Ocean pH	Various period in 2020	2					
Sea Level	Qualitative Assessment	Referenced documents	3					
Storm Severity and Frequency	Storm mapping	1990-2020	1					
Changes in Ocean Current	Literature	Referenced documents	3					
Thermal Structure Adjustment	General Literature	Referenced documents	3					
El Nino Events	Mapping	1990-2021	4					
Wind Changes	Average Annual Speed	1991-2021	1					

1. Data obtained from the National Meteorological Service of Belize; 2. Data provided by Coastal Zone Management Authority and Institute of Belize 3. Sources referenced in narrative of this assessment 4. Data obtained from NOAA

Table 2: Data and Indicators used to assess Exposure in Belize

Thematic Sector	Parameter Measured	Indicator	Information Used or Data Period	Source	*Applicability of the Findings*				
					Global Context	*Belize*	*Belize City*	*Dangriga Town*	*San Pedro Town*
Coastal Zone	Flood Episodes	Annual Flooding	1990-2020	5					
	Erosion	Qualitative Assessment	Various sources	9					
	Storm Surges	Model data	1990-2015	6					
	Saline intrusion	Salinity Gradient	Salinity	7					
	Drought like conditions	SPI	Precipitation	1					
	Heat exposure	Qualitative Analysis	Various sources	9					
Fisheries	Habitats	Qualitative Assessment	Various sources	9					
	Species Composition	Species Capture	1990-2020	8					
	Yield, Productivity	Species Production	1990-2020	8					
	Distribution and Seasonality		1990-2020	8					
	Calcification	Crab Productivity	1990-2020	8					

1. Data obtained from the National Meteorological Service of Belize; 5. National Hydrological Service of Belize; 6. Global Storm Surges Database accessed from http://gssr.info/#:~:text=The%20Global%20Storm%20Surge%20Reconstruction,(2020); 7. Data obtained from the Belize Water Services; 8. FAO Global Fisheries Database accessed from www.fao.org; 9. Sources referenced accordingly in narrative of this assessment.

Sensitivity: In this assessment, sensitivity is based on potential fallouts owing to the exposure from climate change. These are discussed from several perspectives, looking at various aspects such as infrastructure and livelihoods, among others. The parameters are itemised in Table 3.

Table 3: Data and Indicators used to assess Sensitivity to Climate Change

Thematic Sector	Analytical Perspective	Indicator	Relevance of the Analysis		
			Belize City	Dangriga Town	San Pedro Town
COASTAL ZONE AND FISHERIES	Economic	Income, dependence on natural resources, food security			
	Health	Elderly, young			
	Structural	Infrastructure			
	Social	Conflict and displacement			

Adaptive Capacity: In the context of this study, the adaptive capacity is analysed from the perspective of how the management systems relevant to the coastal zone and fisheries have adjusted, in order to moderate the potential damage, take advantage of opportunities, or to cope with the consequences. The perspectives used in this component are itemised in Table 4.

Table 4: Data and Indicators used to assess Adaptive Capacity to Climate Change

Thematic Sector	Analytical Perspective	Indicator	Relevance of the Analysis		
			Belize City	Dangriga Town	San Pedro Town
COASTAL ZONE AND FISHERIES	Financial	Incentives, insurance			
	Physical	Structural			
	Adaptive Behaviour	Information, participation			

1.3 STAKEHOLDER ENGAGEMENT AS A COMPONENT OF DATA GATHERING

Consultations: One of the critical elements of this study is the emphasis placed on participatory engagement. In this regard, three stakeholder consultations were conducted, one each in Belize City, Dangriga Town and San Pedro Town. A total of 105 stakeholders, drawn from various sectors, participated in these consultations. In addition, a national stakeholder forum, which served as an inception consultation, was convened in Belize City of which 55 stakeholders from the private, public and NGO sectors participated. An additional consultation which served as a validation meeting was convened in which the findings of the study were presented to a forum of 34 participants drawn from various government ministries, private sector, NGO, CBO and international organisation.

One on One Interviews: At the project onset, one-to-one discussions were conducted with key technical (governmental sector) stakeholders, fisheries, conservation, port, indigenous people (including the National Garifuna Council) and tourism representatives. These discussions were conducted virtually which served to gather data and information to support the study, including their expert views on pertinent matters related to this assignment. In total, 24 agencies were contacted, of which 13 responded and provided input.

1.4 STUDY LIMITATION

The approach used to undertake this study requires data from several agencies. While every effort was made to gather these, in some instances, data was not shared despite the requests made. While climate change has become a verifiable reality in most communities in Belize and certainly those under this study, providing the argument grounded in evidence is still in its infancy due to lack of efficient climate information and data.

However, every effort was made by the Consultant to provide evidence to support a robust assessment to the extent possible. A significant degree of citizen science via the participatory consultation and interviews also helped to shape this study, but its statistical significance could not be measured.


SURF

SECTION TWO

SITUATIONAL CONTEXT OF STUDY AREAS

In this section, the descriptions provided are biased towards the elements that have implications for climate change vulnerability and livelihoods. The purpose for this bias is to bring into focus climate change and its links to vulnerability and livelihoods.

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2.1 THE COASTAL ZONE OF THE SELECTED SITES

BELIZE CITY

Historical Background: Belize City was formerly known as Belize Town, which was founded in 1638 by British wood cutters who first settled at the mouth of the Haulover Creek. Over time, this town was transformed into the country's most prosperous commercial centre, and by extension, the capital city after demitting colonial rule. However, the destruction caused by Hurricane "Hattie" in 1961 eventually prompted a relocation of the capital city inland in 1970. Now there are two cities (Belize City and Belmopan City).

GEOGRAPHY AND THE COASTAL ZONE: Belize City, which is approximately 19.5 square kilometres, is Belize's largest city and which is situated in the Belize District. The city is at the mouth of the Haulover Creek, which is a distributary of the Belize River. The latter empties into the Caribbean Sea from Belize City. Established in the colonial era as a town in 1638, since then Belize City has gradually grown into a vibrant city from what was a less extensive and fragmented town. It is now regarded as the commercial capital of the country with the highest concentration of businesses located here, of which 80% are SME (Serivap Global 2022), mostly small enterprises. It is also home to the largest sea and airport acting as the maritime and aviation hub of Belize. Fisheries and tourism and their related services are the two major economic and employment sectors which attract a large proportion of rural-urban migration and daily travels. Home to approximately 61,461 inhabitants (2022 Est) (World Population Review, 2022), the housing ranges from concrete structures which are mostly newly built infrastructures, to wooden homes on stilts.

The coastal zone of Belize City includes the mainland area and several Cayes - forty-six (46) named and unnamed singular cayes and ranges of cayes. The mainland portion of the region ranges from approximately twenty-six (26) miles north of Belize City along the coast to Mullins River Village located north of the Stann Creek District. This accounts for an area of approximately 233 sq. kilometres (CZMAI 2016). This total reflects a 3 km landward zone of influence. The spatial structure of Belize City is that of a monocentric city where most jobs and amenities are concentrated in a high-density central node. This extends to the north and to the west, with a radial movement of people and commuters travelling from suburbs and bedroom communities in a commuter belt, to the Center of the city. The economic foundation of Belize City is built on port activity, merchandizing, service industries, and hotels/leisure industries.

The majority of the city was once mangrove swamp and open sea, which were reclaimed over the years to make way for expansion. Belize City grew in an area that was physically disadvantageous – built upon a delta of alluvial detritus leaving the city surrounded on three sides by water with a large proportion of the area near the mean sea level elevation. The North Shore is an island within the Belize River delta. The small area above sea level has been built up partly by natural processes but largely by the filling-in of mangrove systems over the years, consolidating a largely piecemeal reclamation effort. As the city expand a network of canal and stormwater drainage systems drains was built to lower the water table and reduce flooding. However, the growth of the city has outpaced these systems' carrying capacity.

The city is within the area that is regarded as the coastal belt of Belize. It is surrounded on three sides by water and has been developing from the eastern end and then along the two main highways around the mangroves of the greater area. The gravitational hub of the city is on the east side. The southern swampy area west of the seaport remains largely undeveloped, although there are slow but steady signs of greater urbanization.

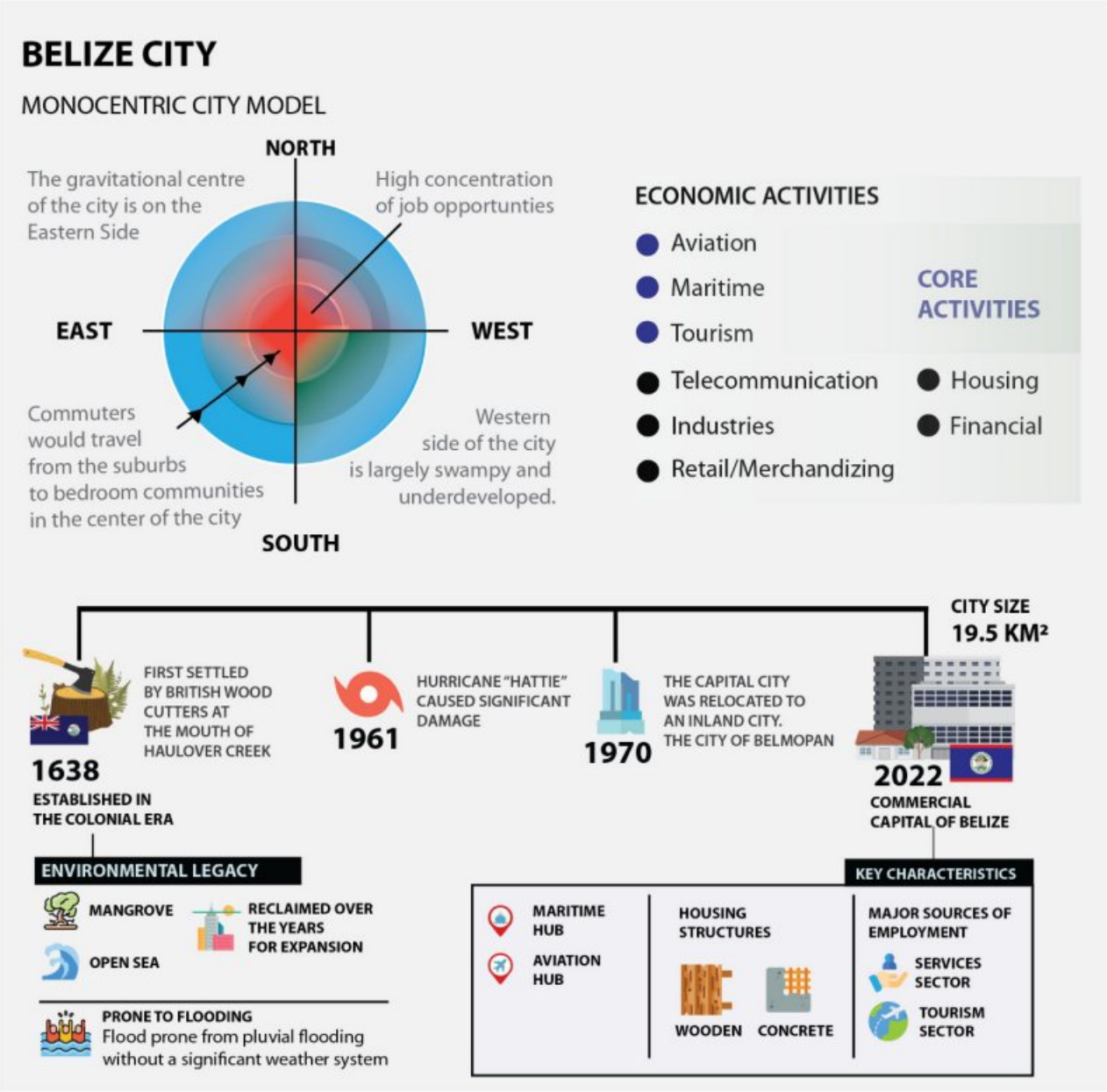

Figure 2: A Summary illustration of Belize City

INFRASTRUCTURE: This City is the hub for both national and international air, sea and road travel. The city has been developing from the eastern end and then along the two main highways around the mangrove centre. Most of the roads in the central area of Belize are narrow with shallow, unlined drains. Although drainage remains a key concern for the city, works carried out during the 1990s, including the lining and covering of drains, have improved the situation.

The importance and influence of the Northern Highway is notable in funnelling traffic toward the eastern side of the city, where most activity is taking place. The southern swampy area west of the seaport remains largely undeveloped. The strip development along the two corridors of the Northern and Western Highway appears to be a natural manifestation. This reflects an adaptive city structure in which the city is

expanding along existing transport axes away from the historically strong core at the eastern end. The location of commercial development along the two main highway corridors should be relieving the city centre of traffic congestion to some extent. However, many of these commercial buildings are distribution centres requiring access to the seaport located on the south-east side and on transport routes via the city centre. In terms of the housing, not a rich variety of housing types, tenures, and residents, in downtown Belize City is evident.

ECONOMY: Belize City is the economic hub of the country, playing host to the majority of working-class Belizeans, who work in downtown offices, hotels and restaurants or as entrepreneurs plying their trade on the street sides or in established locations. Belize City is home to branches of all the major banks of Belize and the Central Bank, as well as nearly all insurance centres, marketplaces and the largest concentration of businesses when compared to other areas in Belize (Figure 2).

DANGRIGA TOWN

HISTORICAL BACKGROUND: Dangriga Town is the largest town/municipality in the Stann Creek District, a district which is predominantly rural in the centre of the mainland coast. It is the district capital and is regarded as a mid-size town in Belize. The name Dangriga comes from the Garifuna phrase "Dangrigeu Grigeu" which means "standing waters" which encapsulates the strong cultural imprint of the Garifuna people on this community. Before officially being renamed 'Dangriga', in recognition of the Garifuna in 1975, the community was known as Stann Creek Town given its positioning at the mouth of the North Stann Creek River. Today, this town is regarded as the cultural centre of the Garinagu (Garifuna) people. The Garifuna people are the largest ethnicity, although many other ethnic groups including Mennonites, Asian influence, and Central American migrants are also part of this town.

GEOGRAPHY AND THE COASTAL ZONE: Dangriga Town is approximately 2,176 square kilometres (Wikiwand, 2022). Situated at the mouth of the North Stann Creek River, Dangriga Town and its environs originally served as a refuge for the Garifuna people who escaped colonial rule in Honduras. The strategic location of Dangriga along the Caribbean coast presents significant geographic potential serving as feeder town connected by the hummingbird highway to facilitate easy access to and from the Capital City of Belmopan and Belize City.

The spatial structure of Dangriga Town does not follow either a monocentric or polycentric model; rather the planning seems haphazard and fragmented. The town is a hub for retailing, serving its residents and the suburban Dangriga as a whole. It is regarded as the administrative and commercial center of the district.

Most of the city is situated on what was once mangrove areas which are still interspersed among the residential buildings and lining major waterways. In many areas of the town there is evidence of waterlogged areas which can pose health hazards. Given the low-level elevation, Dangriga Town remain flood prone.

INFRASTRUCTURE: Home to approximately 9183 inhabitants (2022 Est) (Chislennost,2022), housing ranges from concrete structures to mostly wooden homes many of which are on stilts or elevated off the ground to protect against flood damage. The buildings in the town are generally small but functional and exhibit few signs of economic excess. This town has a domestic airport with provides a direct airbridge to several areas across Belize. Some of the main throughfare are paved, especially those that connect the

central business district and the airport. Most of the roads leading into housing settlements are unpaved (dirt roads). The town of Dangriga does not have an established sewer system; rather homes are either sewered into individual sceptic systems or outhouse latrine systems, although the latter is on the decline.

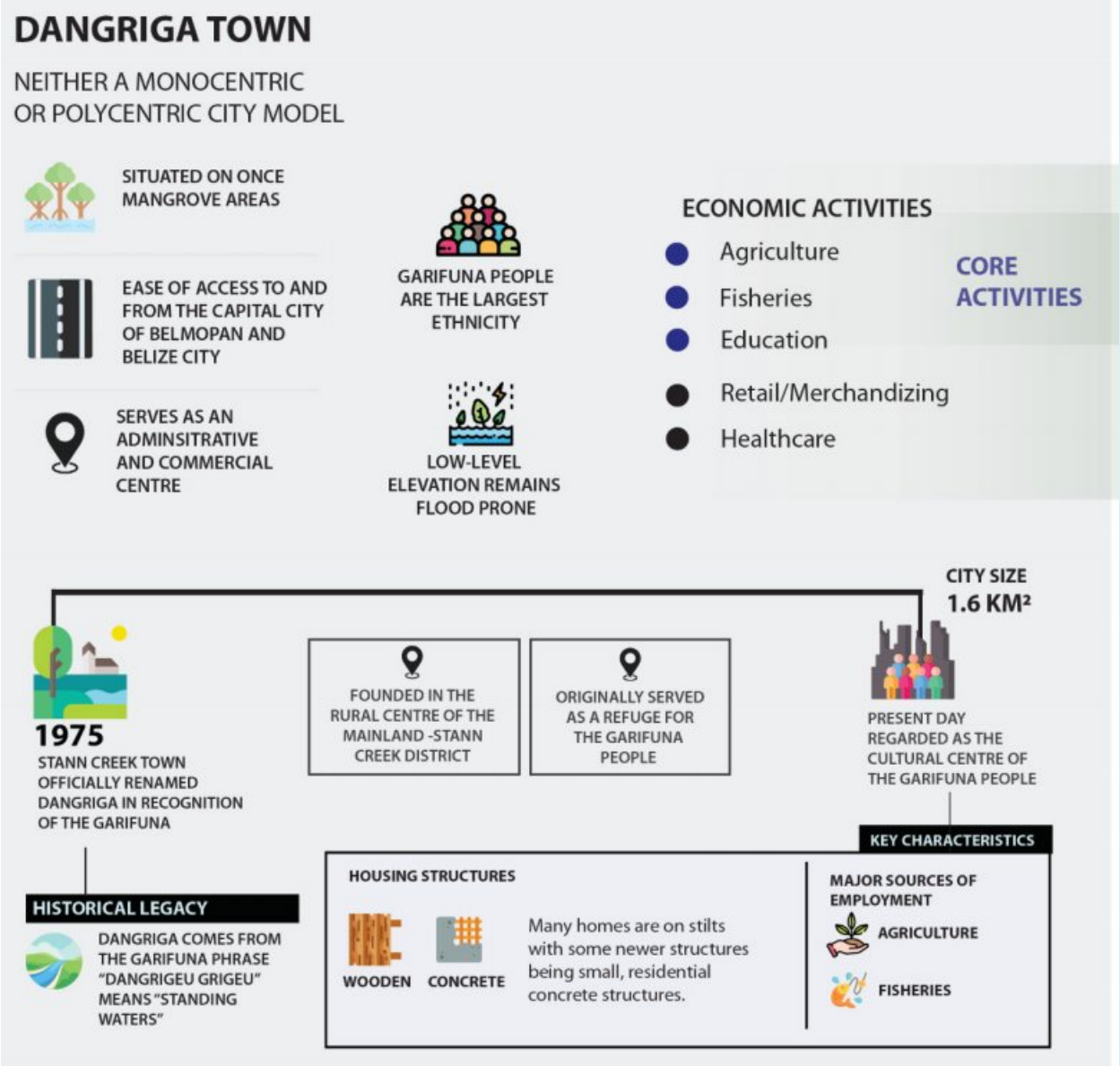

Figure 4: A summary illustration of the characteristics of San Pedro Town

The Garinagu is an ethnic group of mixed West African and Native American heritage. They came to live in coastal Central America during the eighteenth century after their deportation from the Caribbean island of St. Vincent, the locale they consider to be the birthplace of their people (Taylor 1951, Kerns 1983, Hadel 1987, Gonzalez 1988, Cayetano 1990,) Bonner 2001.

ECONOMY: The economic foundation of Dangriga Town was built around farming and still is, albeit changes in the dominant crop types. However, over the last decade tourism and fisheries have become part of the employment matrix. Commerce, including activities related to the port at Commerce Bight located just south of the town (Dangriga Town Council, 2004) was also identified as part of the economy (no longer operational). Most of the Dangrigans live in the town accessing their employment and farms in greater Dangriga. The central business district located along Dangriga's busiest road, contains restaurants, food carts, markets, and retails shops. The Garifunas are traditionally educators and health sector workers, which means many of blue-collar workers work outside of Dangriga.

SAN PEDRO TOWN

HISTORICAL BACKGROUND: San Pedro Town was once a fishing village which was given its current status in 1984. It is located on the southern part of the island of Ambergris Caye in the Belize District and is regarded as the major settlement on the Caye. According to Chislennost, (2022), the town has a population of about 11576 and is regarded as the second-largest town in the Belize District after Belize City. San Pedro Town is the only island municipality in the country.

GEOGRAPHY AND THE COASTAL ZONE: San Pedro Town is the nucleus of Ambergris Caye with at least six settlements along the periphery of the town core. These include San Juan, Boca del Rio, San Marcos, all of which are located north of the town core. South of the town core are the San Pablo, San Pedro settlements, and the Escalante subdivision. San Pedro Town is approximately 22,963 sq. km (Casado Internet Group,2022), but boasts impressive mercantile abilities for such a small island.

San Pedro Town is predominantly a Mestizo community. Mestizos are by far the major ethnic group, comprising 77% of the population in 2000, and over 72% of the population in 2010. San Pedro Town has one of the highest proportions of foreign-born population among the 9 municipalities.

INFRASTRUCTURE: Narrow streets necessitate the use of golf carts and bicycles for most transportation as average size vehicles would be cumbersome and bulky for the streets of San Pedro. However, some average sized vehicles are permitted. Low rise hotels, guest houses and boutique style resorts and condos, from modest to high end, are nestled along the coast and throughout the town. Buildings are generally around three storeys. There are three north-south streets and seven east west streets.

Primarily used for transporting goods and construction materials from Belize City, the San Pedro Terminal serves as a major sea bridge for goods and passengers. However, San Pedro Town has a significant number of privately owned piers for dockings, which can be visible almost every 100 ft. Some piers are also used primarily as fish landing sites. There is also a municipal airport, serviced by two airlines offering daily flights to various destinations throughout Belize.

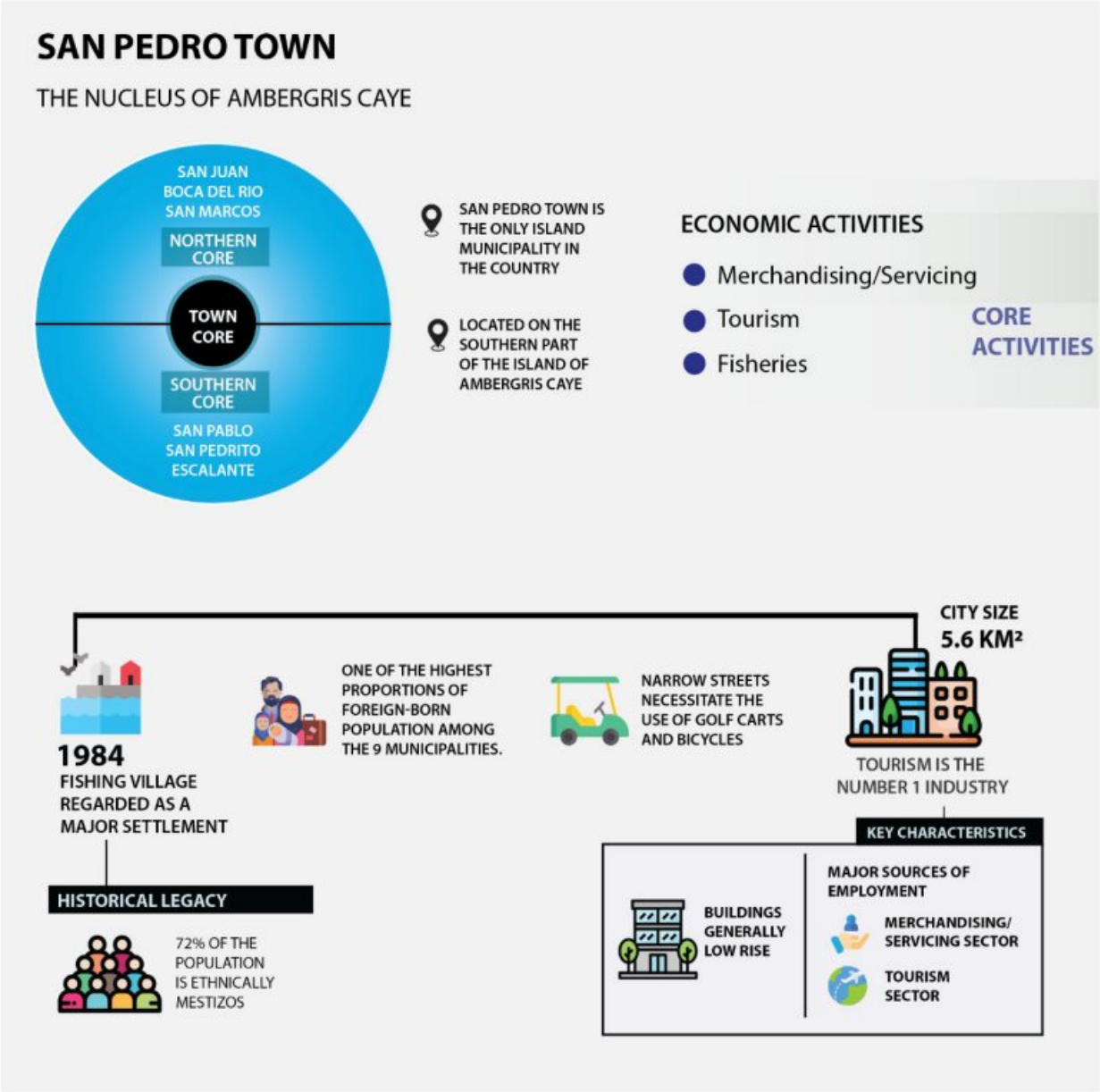

Figure 4: A Summary Illustration of San Pedro Town

ECONOMY: Prior to the present tourism driven economy of San Pedro, this was a vibrant fishing village. While this is still an occupation for several households, its significance has greatly decreased, but nonetheless remains important. Tourism is now the number one industry with San Pedro having the highest concentration of visitor accommodations in all of Belize. Retail, merchandising and restaurants are also significant aspects of the economic matrix.

2.2 FISHERIES SECTOR IN BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO

CONTEXT: Belize City is characterised as the distribution hub for the fisheries sector. Here the majority of the fish catch are landed after which it is either wholesaled or retailed into the consumptive sectors via cooperatives and/or individually.

Dangriga Town has a long tradition of harnessing the marine resources dating back to when the Garifuna settled there. Today it remains a vibrant entrepot for fishermen utilising the fishing grounds off the coast of Dangriga such as Glover Reef. WABAFUWAFABU Fishermen Association is the cooperative where fishermen would sell their catch, if not retailed individually. The South Stann Creek River which carries nutrients from inland to the coast plays a major role in Dangriga's rich fishing history[4].

San Pedro Town lies in close proximity to the Mesoamerican barrier reef and has a long history in the fisheries sector. Among the three sites studied, San Pedro has shown evidence of diversified fisheries. This includes the traditional supply chain for food in the households and businesses to the more tourism related activities such as tournaments, day tours and fishing expeditions. The Caribena Fisher's Cooperative, previously in operation for the fishers of the island, closed in 2010. Now fishers sell their catch locally or to the National Fishermen Producers Co-operative Society Limited, in Belize City.

Fishers in San Pedro are artisanal or small-scale and tend to use multiple gear types. The main fishing methods for fishers are the line fishing, free diving (e.g., for lobster) and trap fishing (either for fish or lobster) (Peterson et al 2014).

The Garifuna dominates the fisheries in Dangriga and are also small scale artisanal who traditionally used dories (wooden canoes) to harvest no more than a few miles offshore. This tradition continues today as can be seen by the numerous small dories pulled up on shore all along the beaches of Dangriga. While outboard motors and skiffs[5] with modern gear allow fishing from further away today, the dory is still the preferred means of transportation for the older fishermen to harvest close by. Fisherfolks in Belize City tend to prefer the skiffs.

INFRASTRUCTURE: The sector is regarded as being commercially artisanal where fishers operate from an artisanal fleet of open boats or skiffs, sail sloops, and canoes ranging from 5 to 10 m in length, some with outboard engines up to 75 hp. Skiffs are the main vessel type used by fishers, followed by sailboats. Other vessel types such as dories and canoes are in the minority. Fishing methods in the sector include lobster traps, casitas (lobster shades), handline, free diving and gillnets.

As of August 2022, there were a combined total of 327 skiffs and 6 sailboats registered among the fisherfolks in Belize City, Dangriga Town and San Pedro Town. 50 % of the total are registered in Belize City followed by 34 % in San Pedro and the remaining 16% for Dangriga Town. Sailboats used in the sector are rare with only a total of 4 registered for all of the study sites.

[4]Gathered from the consultation process, and further clarified using a blog accessed at https://www.pelicanbeachbelize.com/dangriga/artisanal-fishing-town on 23/12/2022.

[5]Skiffs are open boats, usually with outboard power, which have little more than a hull, a power plant, and some seats. They're often used for activities like fishing, crabbing, clamming, or just puttering around small bays and tributaries (Boats, 2022).

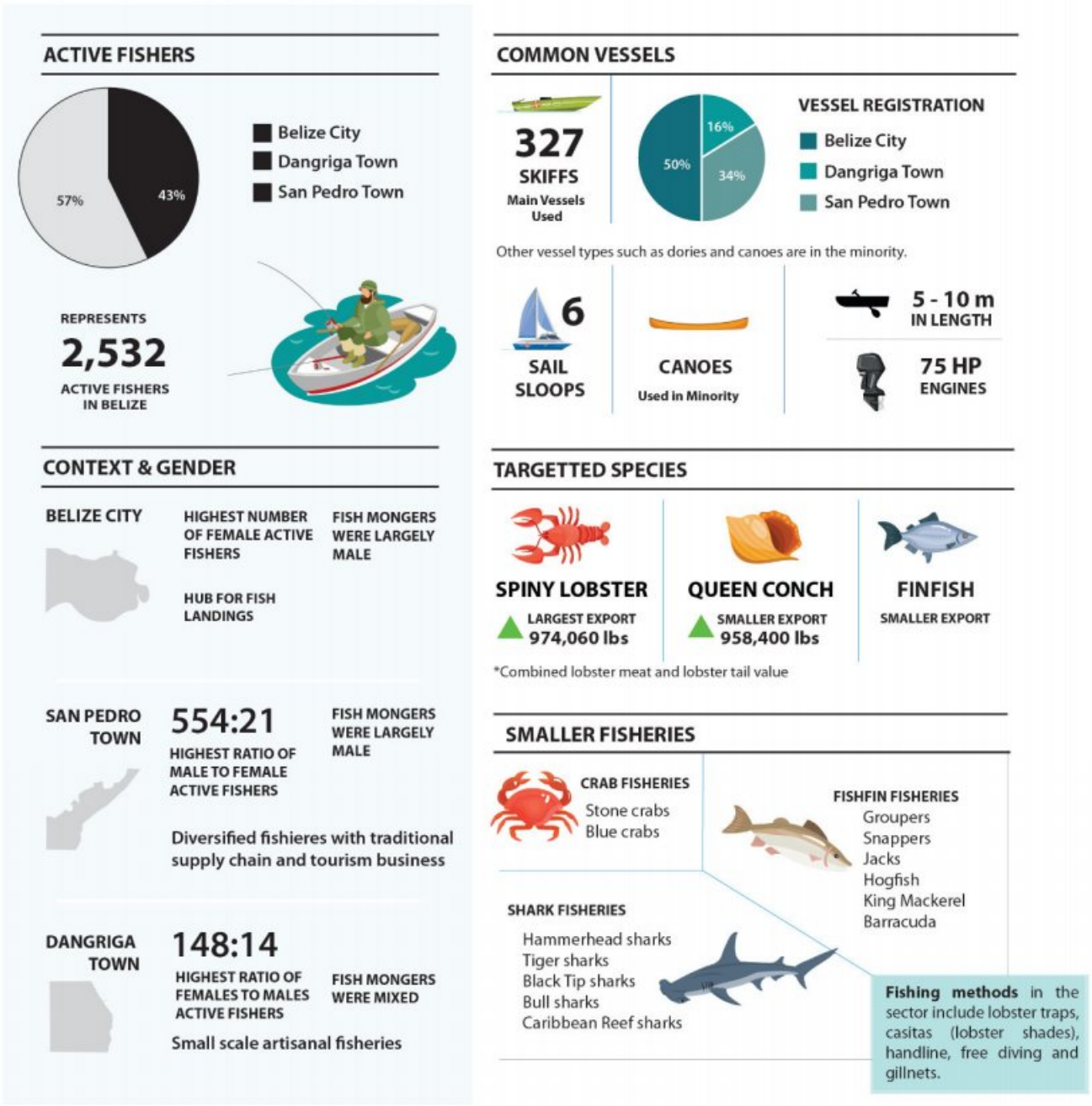

Figure 5: A summary Illustration of the Fisheries Sector in the Selected Study Sites

TARGETED SPECIES: Fishing effort is focused on the capture of spiny lobster and the queen conch representing the largest fisheries within the industry. Finfish is also targeted for local consumption and export, including groupers, snappers, jacks, hogfish, King Mackerel and Barracuda. There is a small shark fishery that targets three (3) species of Hammerhead. Tiger sharks, black tip sharks, bull sharks and Caribbean reef sharks are also targeted species. A small-scale fishery for the stone crab (*Mineppe sp.*) and the blue crab (*Callinectes sapidus*) also exists. Spiny Lobster (*Panulirus argus*) is the largest fishery export of Belize but also Queen Conch and Finfish are exported, although at a smaller scale.

EMPLOYMENT: Gender recognition in fisheries is a core area of interest, and in the selected sites, there is a growing trend of more female fisherfolks entering the workforce. According to the Fisheries Department[6] (UNCTAD 2020), there are 2,500 active fishers. Belize City, Dangriga Town and San Pedro Town account for 43% of that total, with 1,071 active fishers. Compared to the active fishers among the three sites, Belize City has a 54 % proportion followed by San Pedro Town with 31%. Belize City has the highest number of females among the active fisherfolk with a ratio (male to female) of 554:21. However, Dangriga Town has the highest ratio of females to male, with 148:14 compared across the study sites.

In Dangriga Town, the fish market is in the Dangriga Central Market along the riverbanks in the middle of town. Belize City also has several of these retail depots including Conch shell Bay and Vernon Street. There is one seafood market in San Pedro Town operated by the National Fisherman Co-Op Seafood Market. Based on observations, the fish mongers are dominated by males in Belize City and San Pedro Town with mixed gender in Dangriga Town. Belize City has an added tier of the value chain in which mostly women served as cleaners, a service which is sought by locals upon the purchase of the fish.

[6]Data provided by the Belize Fisheries Department to the consultant.


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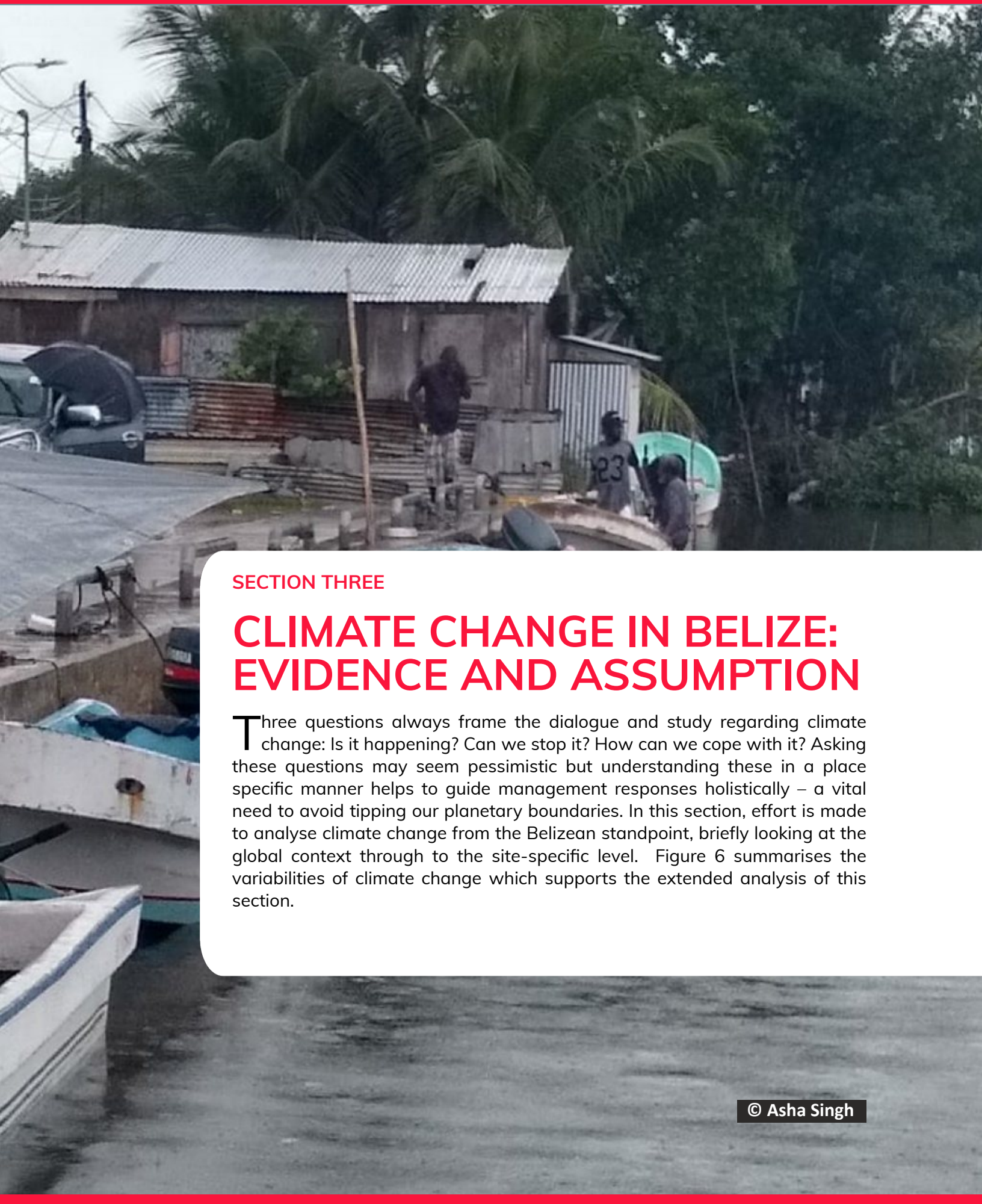
Section Summary

- Belize City, Dangriga Town and San Pedro Town are all vibrant townships which are home to several economic activities.
- While the level of activities varies, the contribution to the economic, social and cultural fabric of Belize is unequivocally important.
- The Fisheries sector in these communities is largely artisanal, but significantly plays a crucial role in Belize's food security, employment and its service sectors vis a vis hotel and restaurant.
- While the sector is male dominated, women occupy many niche roles of the industry.



SECTION THREE

CLIMATE CHANGE IN BELIZE: EVIDENCE AND ASSUMPTION

Three questions always frame the dialogue and study regarding climate change: Is it happening? Can we stop it? How can we cope with it? Asking these questions may seem pessimistic but understanding these in a place specific manner helps to guide management responses holistically – a vital need to avoid tipping our planetary boundaries. In this section, effort is made to analyse climate change from the Belizean standpoint, briefly looking at the global context through to the site-specific level. Figure 6 summarises the variabilities of climate change which supports the extended analysis of this section.

3.1 CLIMATE CHANGE VARIABILITY

THE GLOBAL CONTEXT: Climate change, manifested from greenhouse gas accumulation and global warming, is resulting in several noted shifts to the global climatic system. Atmospheric concentrations of the three major greenhouse gases have reached new record highs in 2020 and increasing into 2022 based on real -time data from specific locations such as Mauna Loa (Hawaii) and Cape Grim (Tasmania). In 2020, levels of carbon dioxide (CO_2) stand at 413.2 ± 0.2 parts per million (ppm), methane (CH_4) at 1 889 ± 2 parts per billion (ppb) and nitrous oxide (N_2O) at 333.2 ± 0.1 ppb. Respectively these are 149%, 262% and 123% of pre-industrial (before 1750) levels. However, other influences have provided some reprieve, for example, the global annual mean temperature in 2021 was 1.11 ± 0.13°C above the 1850-1900 pre-industrial average – less warm than in the most recent years owing to cooling La Niña conditions at the start and end of the year.

THE CENTRAL AMERICAN CONTEXT: Increasing greenhouse gas concentrations lead to an accumulation of heat in the climate system, much of which is stored in the ocean (WMO 2022). It is estimated that by 2030, Central America will still produce less than 0.5% of greenhouse gas (GHG) emissions on the planet, yet it is already one of the regions that is most vulnerable to climate change (Ramirez. 2013). This is expected to continue long into the foreseeable future.

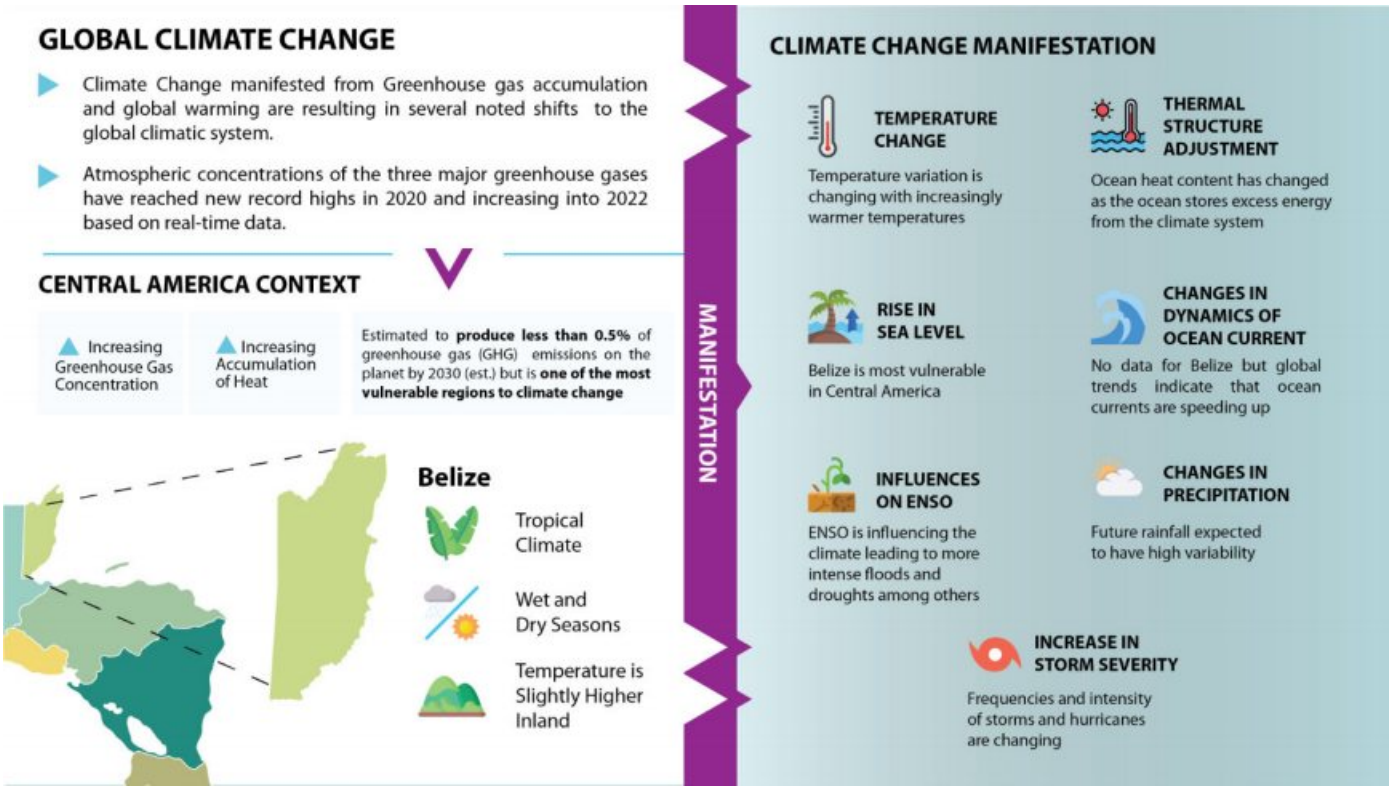


Figure 6: A summary Illustration of Climate Change Variabilities*

*The map in Figure 6 is a graphic depiction of Belize and its surrounding area. It is not geographically accurate.
The boundaries and names shown and the designations used on these maps do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

3.1.1 CHANGING TEMPERATURE

Belize has a tropical climate with pronounced wet and dry seasons, although there are significant variations in weather patterns by region. Temperatures vary according to elevation, proximity to the coast, and the moderating effects of the northeast trade winds off the Caribbean. Average temperatures in the coastal regions range from 24 °C (75.2 °F) in January to 27 °C (80.6 °F) in July[7]. Temperatures are slightly higher inland, except for the southern highland plateaus, such as the Mountain Pine Ridge, where it is noticeably cooler year-round.

BELIZE CITY: Figure 7 shows a steady trend increasing over the 30-year period of 1991 to 2021. There were some minor fluctuations along the period; however, there was a noted downward trend for the strong La Nina periods from 1998 – 2000 and 2010- 2011 and the spike in 2015 – 2016 for El Nino. Overall, there is a noticeable upward trend line of the temperature.

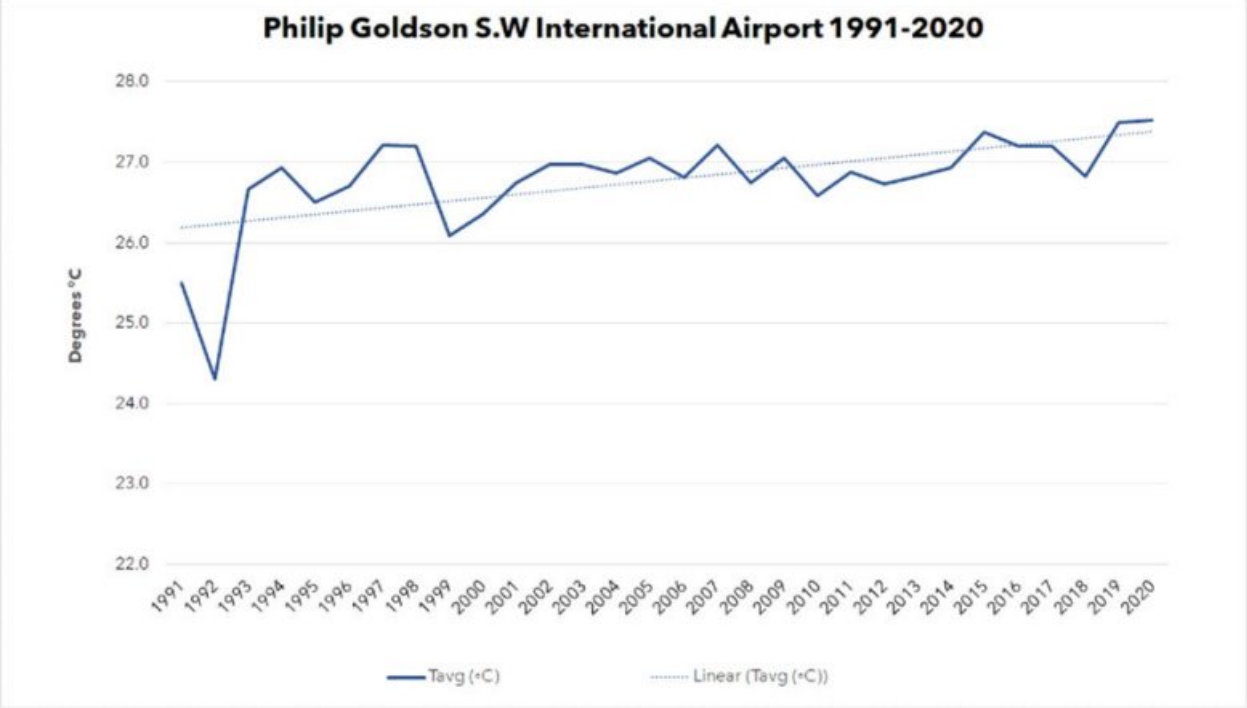


Figure 7: Temperature Trend for Belize City for 1991-2021. Developed using data from the Belize Meteorological Service.

[7] https://belizeproject.weebly.com

DANGRIGA TOWN: Figure 8 represents the temperature data collected near Dangriga Town. There are fluctuations in the early 90s, especially 1995 – 1996 where a significant dip in the temperature is observed. This is perhaps due to a moderate La Nina period that took place during this time. This is followed with a slight steady uphill average trend of 26.2 as seen on Figure 7. Overall, the trendline is moving upward as well.

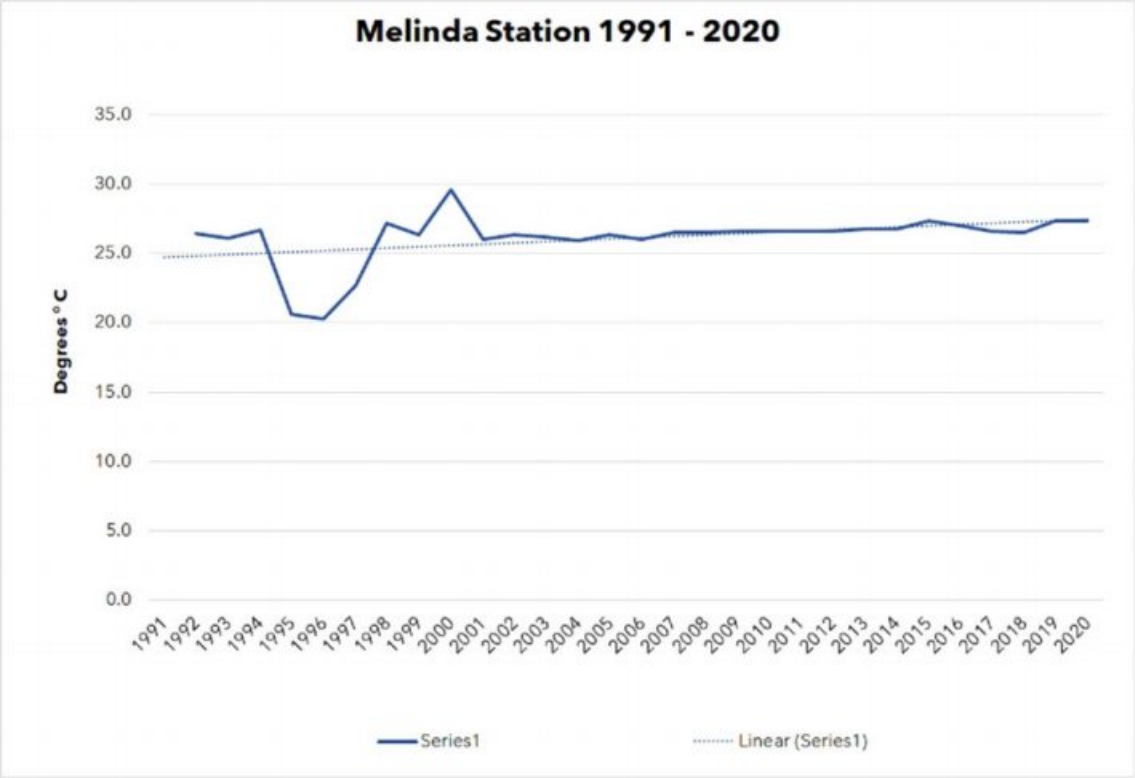


Figure 8: Temperature Trend for Dangriga Town for 1991-2021. Developed using data from the Belize Meteorological Service.

SAN PEDRO: While no empirical data is available to assess the temperature in San Pedro, there is an overwhelming response from the workshop feedback of hot days and unbearable temperature which seems more than the norm. This anecdotal information seems to correlate with the other sites where data is available.

In summary, based on the data, the year 2021 was between the 5th and 7th warmest years, with the past seven years, 2015 to 2021, being the seven warmest years. The year 2016, which started during a strong El Niño is one of the warmest years. These observations align with the trend noted for Belize according to WMO (2022). Further, the upward trending of the temperature for the period studied correlates with the global narrative on temperature rise. According to IPCC (2022), the planet continues to warm at a faster rate. In 2001 scientists using data from around the Caribbean region conducted an analysis of indices of extremes derived from daily weather observation in the region. The results of the analyses indicate that the percent of days having very warm maximum or minimum temperatures increased strongly since the late 1950s while the percent of days with very cold temperatures decreased (Peterson et al. 2002).

3.1.2 SEA SURFACE TEMPERATURE (SST)

Sea surface temperature is the mean temperature in the top few metres of the ocean. It is a vital component of the climate system as it exerts a major influence on the exchanges of energy, momentum and moisture between the ocean and atmosphere. Spatial patterns in SST reveal the structure of the underlying ocean dynamics, such as ocean fronts, eddies, coastal upwelling and exchanges between the coastal shelf and open ocean. In a warmer world, warmer SSTs lead to more frequent marine heatwaves.

Belize: SST data, when analysed below, show that SST has been increasing steadily upwards (Figure 9) with the sea surface temperature becoming progressively warmer. The spikes observed in the data are more pronounced in the oscillation events. During the 30-year period there were five El Nino/La Nina events, with two classed as very strong based on the Oceanic Niño Index (ONI), developed by the National Oceanic and Atmospheric Administration (NOAA).

Stakeholders' Reaction

Fisherfolks, Divers and Recreational Swimmers highlighted the experiences of prolonged warmer waters which are becoming a norm.

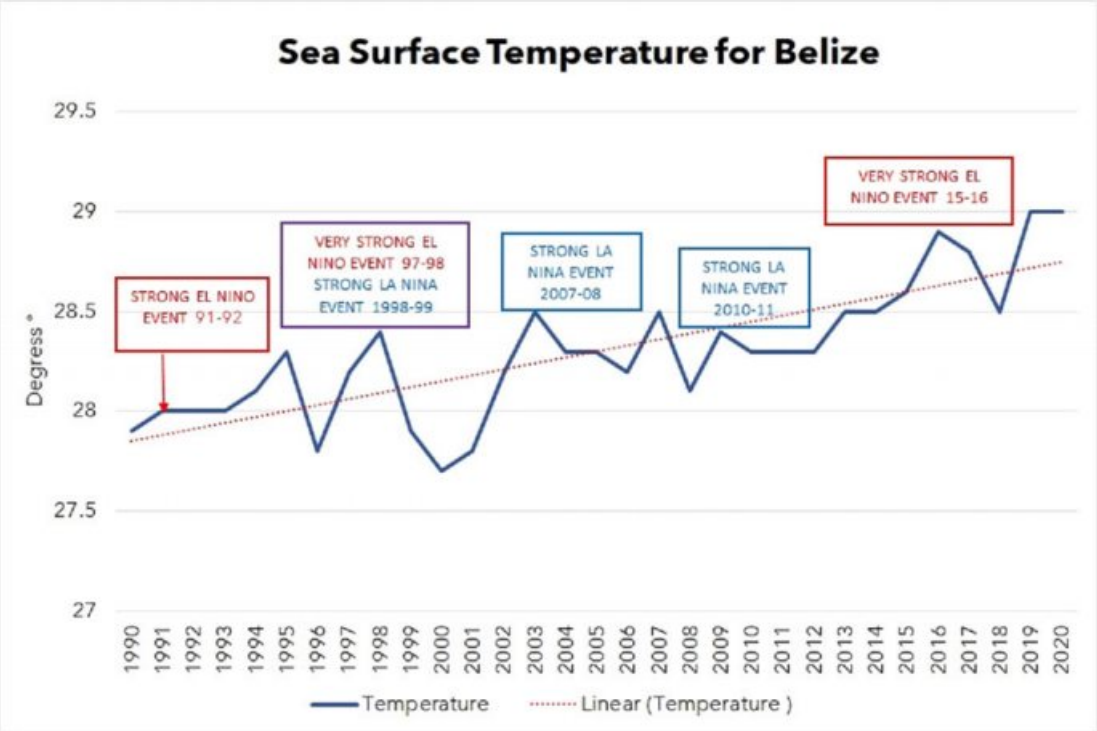
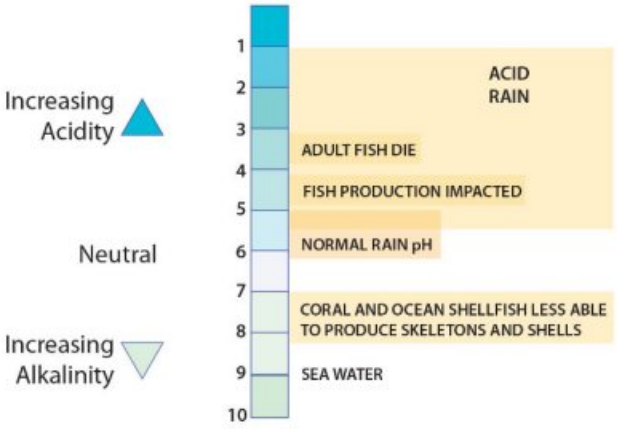


Figure 9: Sea Surface Temperatures have been steadily increasing over the period 1985 – 2022. Developed using data from the Belize Meteorological Services.

In summary, observations align with the global trend regarding sea surface temperature. According to the IPCC Sixth Assessment Report (2022), marine heatwaves have become more frequent over the 20th century and are also projected to increase around the globe over the 21st century.

3.1.3 OCEAN ACIDIFICATION

Globally, over the past two decades, evidence of ocean warming is well established, with the ocean heat content in 2021 the highest on record (Cheng 2022). The ocean absorbs about 30% of annual anthropogenic emissions of CO2 into the atmosphere. However, when CO2 reacts with seawater, the pH of the ocean lowers into a more acidic range. This phenomenon is referred to as ocean acidification which affects the structure and composition of particular organisms and ecosystems such as crustaceans and coral reefs. According to the International Atomic Energy Agency (2022), prior to the Industrial Revolution of the 18th to 19th centuries, the ocean's average pH was about 8.2. Currently, the ocean's average pH is 8.1. This means that the ocean today is about 30 per cent more acidic than in pre-industrial times[8].



Explaining OA- Adapted and modified from USEPA (2016)

BELIZE: Ocean pH monitoring is not continuous in Belize. Data gathered and provided by the Coastal Zone Management Authority and Institute of Belize is not extensive to support any analysis. However, the data shows several daily measurements (Figure 10) which are within the range where coral reefs are directly threatened (box above). A more sustained period of data collection will strengthen the arguments as to whether Belize is experiencing a more acidic ocean environment.

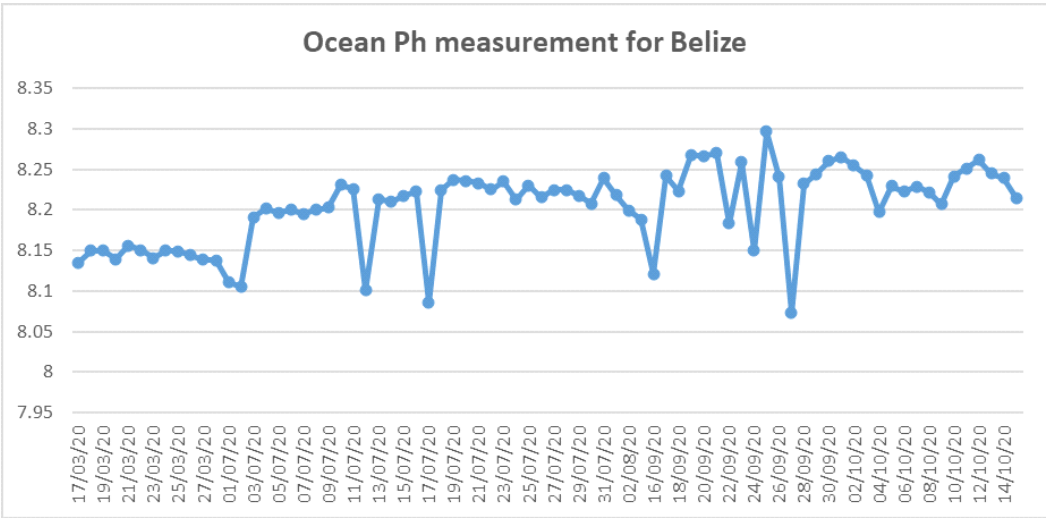


Figure 10: Daily ocean pH measurements for several days in 2020. Developed using data provided by Coastal Zone Management Authority and Institute of Belize

[8]https://www.iaea.org/newscenter/news/what-is-ocean-acidification#:~:text=The%20ocean%20is%20slightly%20basic,than%20in%20pre%2Dindustrial%20times.

In summary, ocean acidification is an established effect of climate change. According to the IPCC Sixth Assessment Report The Working Group to the Sixth Assessment Report, Climate Change 2021: The Physical Science Basis (2021), 'With the rising atmospheric CO_2 concentration, the ocean acidification has increased globally over the past four decades. Further the Assessment stated that 'In the open ocean, acidification, changes in sea ice, and deoxygenation are detectable in many areas.''

3.1.4 SEA LEVEL RISE

Most of the excess energy that accumulates in the earth system due to increasing concentrations of greenhouse gases is taken up by the ocean. The added energy warms the ocean, and the consequent thermal expansion of the water is one of the major contributors to sea-level rise. Compared to global mean sea level, over the last three decades relative sea level has increased at a higher rate in the south Atlantic and the subtropical North Atlantic (WMO 2022). From a global perspective, currently, the annual rise is approximately 3mm per year (World Bank 2022). Future changes in sea level are not expected to be geographically uniform. Data from analyses of tide gauges and thermal expansion tend to show greater trends in sea level rise for the North Atlantic Ocean than for the Indian, Pacific, or South Atlantic Oceans (Bindoff et al., 2007). According to the Caribbean Community Climate Change Center (2016), Belize is the most vulnerable country to sea-level rise in Central America.

BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO TOWN: Sea level rise data is not available for these locations, but proof exists of land subsidence based on observation and evidence (Azueta, *et al*. 2020). Predictive modelling done using topography showed that significant areas can be lost due to their topography Azueta, *et al*. 2020). Table 5 summarises the information gathered regarding sea level rise from documentations and the stakeholder engagement

Table 5: Anecdotal Evidence of sea-level rise in the study sites

Study Sites	Information Gathered from Document Review	Stakeholder Input
	Some Predicted modelling was done using topography data in lieu of SLR to assess areas in Belize's Coastal Zone susceptible to SLR.	Stakeholders identified several areas within the coastal zones that are being submerged due to SLR.
Dangriga Town	Studies on SLR in Dangriga Town are not evident.	Several stakeholders identify several areas of land subsidence. For example, Pelican Beach Resort area.
San Pedro	With a 3mm SLR, San Pedro will lose 100 % of its beach area which is calculated to be 27943.11 ft.	Many stakeholders shared accounts of higher water levels giving examples of how seawater is creeping on various infrastructure and dwellings.

In summary, there is anecdotal evidence of sea level rise in study sites, although there is no empirical data presently. According to IPCC (2021) it is virtually certain that global mean sea level will continue to rise over the 21st century in response to continued warming of the climate system, and this rise will continue to increase for centuries to millennia due to continuing deep ocean heat uptake and mass loss from ice sheets. Over the 21st century, the majority of coastal locations have a median projected regional sea level rise within ± 20% of the projected global mean sea level change.

3.1.5 STORM SEVERITY AND FREQUENCY

Belize lies in the Tropical Atlantic Hurricane Region; thus, the country is naturally susceptible to these weather-related events. Annually, the Atlantic Hurricane Season commences from June 1 until November 30 of each calendar year. While various categories of hurricane and tropical storms have made landfall in Belize, there is growing evidence that climate change is transforming the intensity and frequencies of these storms and hurricanes, in a manner where events are stronger and more recurrent. Belize is one of the countries of Central America that has been most affected by hurricanes. Since 1930, there have been 16 hurricanes, 8 of which were major hurricanes that made landfall or passed close enough to cause damage or loss of life. Eighteen systems of less intensity also made landfall in the form of tropical storms. Those events which impacts the study sites are listed in Table 6.

BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO TOWN: Hurricanes have played key—and devastating—roles in Belizean history. The study sites on several occasions were visited by hurricanes and storms. In 1931, an unnamed hurricane destroyed over two-thirds of the buildings in Belize City and killed more than 1,000 people. In 1961 Hurricane Hattie struck the central coastal area of the country including Belize City with winds in excess of 300 km/h (185 mph) and 4 m (13 ft) storm tides. In 1978, Hurricane Greta hit in the Stan Creek District including Dangriga. In 2000, Hurricane Keith, the wettest tropical cyclone in the nation's record, stalled, and hit the nation as a Category 4. In 2007, Hurricane Dean made landfall as a Category 5 event only 40 km (25 mi) north of the Belize–Mexico border. In 2010, Belize was directly affected by the Category 2 Hurricane Richard, which made landfall approximately 32 kilometres (20 mi) south-southeast of Belize City. The most recent hurricane to affect the nation was Hurricane Nana in 2020 which made landfall near Dangriga. San Pedro Town is also impacted by several hurricanes and tropical storms including hurricanes such as Hurricane Dean (H5, 2007), Carmen (H4, 1974), Janet (H5, 1955) and an unnamed storm (H4, 1933), TS Keith (2020), Alex (2010). In 2022, Hurricane Lisa drenched Belize City, San Pedro Town and Dangriga Town.

[9]Taken from https://www.caribbeanclimate.bz/blog/2016/06/10/belize-most-vulnerable-in-central-america-to-sea-level-rise/. Accessed 12/23/2020

Table 6: An inventory of the hurricanes and tropical storms which impacted the study areas (1991-2021)

Year	Hurricane/Storm	Impacts
1931	Unknown	Two-thirds of the buildings in **Belize City** affected and killed more than 1,000 people.
1933	Unnamed storm	Information not available.
1955	Janet	Information not available.
1961	Hattie	Winds in excess of 300/h (185 mph) and 4m (13ft) storm tides. The devastation of **Belize City** for the second time in thirty years prompted the relocation of the capital some 80 kilometres (50mi) inland to the planned city Belmopan.
1974	Carmen	San Pedro Town.
1978	Greta	Caused more than US $ 25million in damage in the Stan Creek District including **Dangriga**.
2000	Keith	The wettest tropical cyclone in the nation's record stalled and hit the nation as a Category 4 storm, causing 19 deaths and at least $280million in damage.
2007	Dean	Category 5 storm. Dean caused extensive damage in northern Belize including **San Pedro**.
2010	Richard	Category 2 which made landfall approx. 32 kilometres (20mi) south-southeast of **Belize City**. The storm moved inland towards Belmopan, causing estimated damage of BZ$33.8 million ($17.4 million 2010 USD), primarily from damage to crops and housing.
2010	Alex	San Pedro.
2020	Nana	It made landfall near **Dangriga**.
2020	Keith (TS)	Information not available.
2022	Lisa	Hitting Belize City as a Category 1, drenching the city and causing many areas to flood.

Tracking the storms in the study sites did not present any significant trends and observations. However, among the stakeholders consulted, there was a consensus that storm related damage are becoming more a norm than exception for many households and businesses. According to IPCC Working Group I, climate change is modifying multiple types of climate-related events or hazards in terms of occurrence, intensity and periodicity. WMO (2022) concluded that tropical cyclone rainfall rates are projected to increase in the future due to anthropogenic warming and accompanying increase in atmospheric moisture content. Tropical cyclone intensities globally are projected to increase.

3.1.6 OCEAN CURRENT VELOCITY

According to (Voosen 2022), global warming is speeding up ocean currents caused by excess heat constricting the water flow in shallow surface layers. Oceanographers have discovered that not only have oceans been warming because of human-driven climate change, but the currents that flow through them have accelerated – by some 15% per decade from 1990 to 2013. The ocean's own tendency to warm from top to bottom leads to constricted surface layers where water flows faster.

STAKEHOLDERS' REACTION

Though Belize is known to have a wet and a dry season, these seasons don't appear to be as distinct as they used to be 20 – 30 years ago.

BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO TOWN: There is no specific ocean current data for Belize or the selected sites.

In summary, Voosen (2022) suggests climate change will continue to speed up across ocean currents, potentially limiting the heat the ocean can capture.

3.1.7 PRECIPITATION CHANGES

Belize's average rainfall varies considerably, from 1,350 millimetres (53 in) in the north and west to over 4,500 millimetres (180 in) in the extreme south. Seasonal differences in rainfall are greatest in the northern and central regions of the country where, between January and April or May, less than 100 millimetres (3.9 in) of rain fall per month. The dry season is shorter in the south, normally only lasting from February to April. A shorter, less rainy period, known locally as the "little dry", usually occurs in late July or August, after the onset of the rainy season according to Merrill (1992).

BELIZE CITY: Figure 11 shows the precipitation data for Belize City where the dry and wet seasons were disaggregated for the data period 1990-2020. Here the average monthly precipitation in both the wet and dry seasons shows an increasing trend, while a similar rate is noticed for the number of rain days for both seasons. February, March and April hold as the driest months, with the wettest month being October.

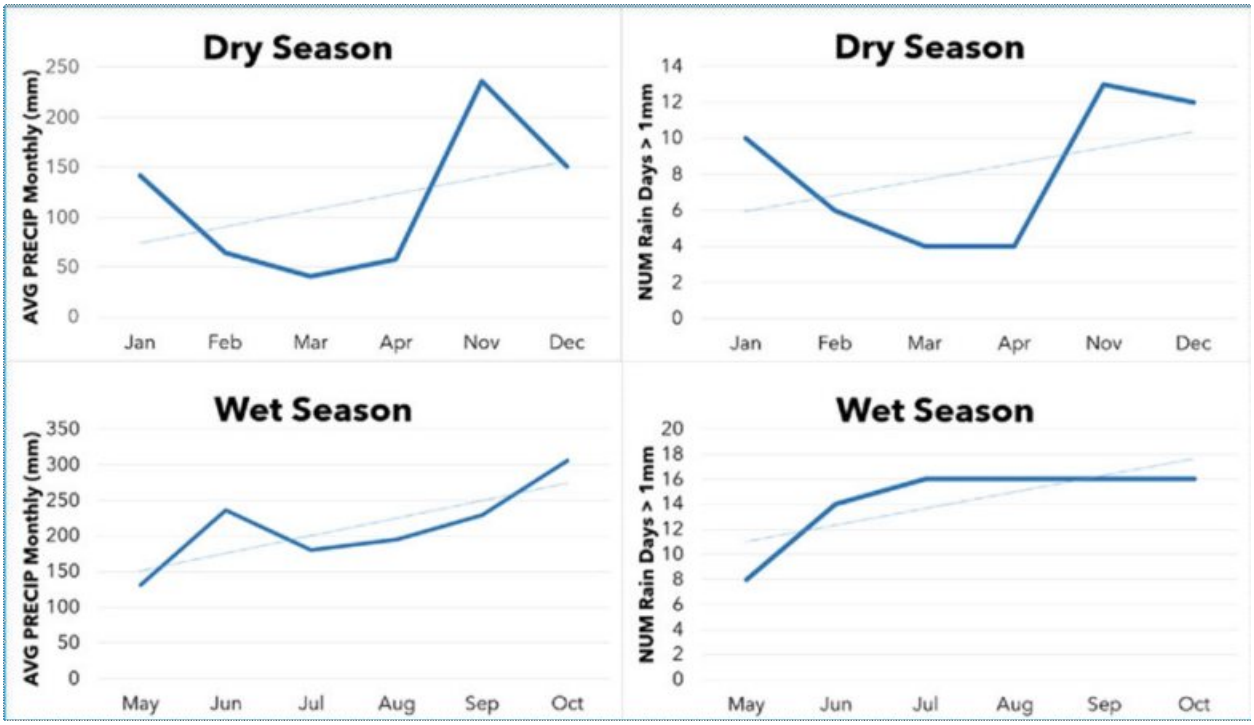


Figure 11: Average precipitation for Belize City over a 30-year period (1990-2020). Developed using data provided by the National Meteorological Service of Belize.

DANGRIGA TOWN: The data for Dangriga Town shows similar trends as Belize City reflected in Figure 11. Here the average monthly precipitation in both the wet and dry seasons shows an increasing trend, similar to the number of rain days for both seasons. On average March and April hold as the driest months with the lowest number of rain days per month while the wettest months are September and October.

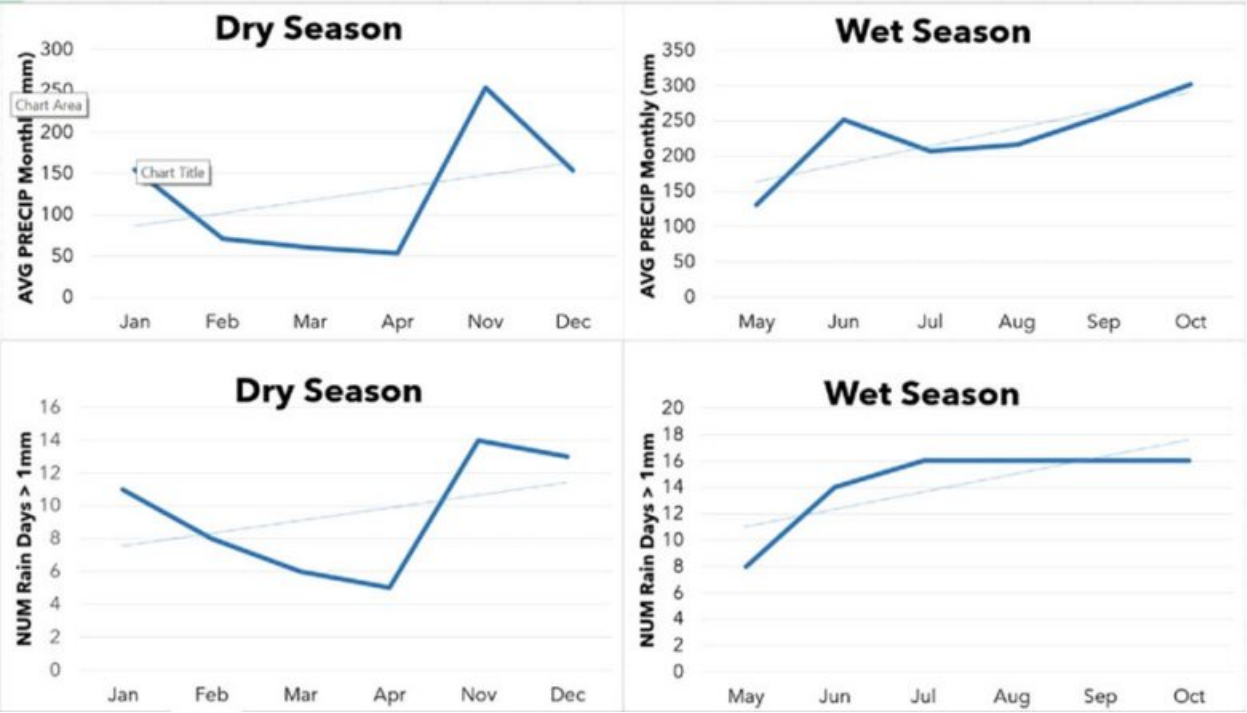


Figure 12: Average precipitation for Belize City over a 30-year period (1990-2020). Developed using data from the Belize Meteorological Service

The climate change projections done by WMO (2022) indicated that Belize will have a substantial decrease in rainfall during June, July and August, especially nearer the end of the century. There may also be an increase in the intensity and variability of rainfall in the last months of the year. Precipitation indices, despite the large and expected spatial variability, indicate that although no significant increases in the total amount are found, rainfall events are intensifyingwith the contribution of wet and very wet days enlarging. The data analysed for Belize align with findings of the WMO 2022.

3.1.8 THERMAL STRUCTURE ADJUSTMENTS IN OCEAN

Most of the excess energy stored in the climate system due to anthropogenic greenhouse gas emissions has been taken up by the oceans, leading to thermal expansion, among other factors. According to Zanna et al, (2019), The total Ocean Heat Content has changed since 1871, and is estimated at 436 ± 91 ×1021 J, with an increase during 1921–1946 (145 ± 62 ×1021 J) that is as large as during 1990–2015. By comparing with direct estimates, the authors inferred that during 1955–2017, up to one-half of the Atlantic Ocean warming and thermosteric sea-level rise at low latitudes to mid-latitudes emerged due to heat convergence from changes in ocean transport.

STAKEHOLDERS' REACTION

'The ocean water is so warm for the last few years, that I do not need a wetsuit to dive year-round; actually I now sweat underwater if I wear one'.

BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO TOWN: There are no information or studies conducted on thermal structure changes for Belize or the selected sites.
In the study sites, a significant proportion of the stakeholders, alluded to experiencing warmer waters in the ocean and coastal areas.

3.1.9 EL-NINO SOUTHERN OSCILLATION

The ENSO phenomenon is specifically characterized by a reduction in rainfall during the middle of the rainy season of July-August (Glantz. 2001). ENSO events are measured by the recordings of above normal SST and these phases (ENSO) affect Central American countries, including Belize.

BELIZE: There is no continuous ENSO tracking and recording in Belize, hence in this assessment much reliance is placed on the global database. A review of the ENSO events showed that during the period 1990 to 2020, 18 of those years would have registered a period of ENSO of varying duration. 2014 to 2016 showed the longest ENSO event for the period under study (Figure 13).

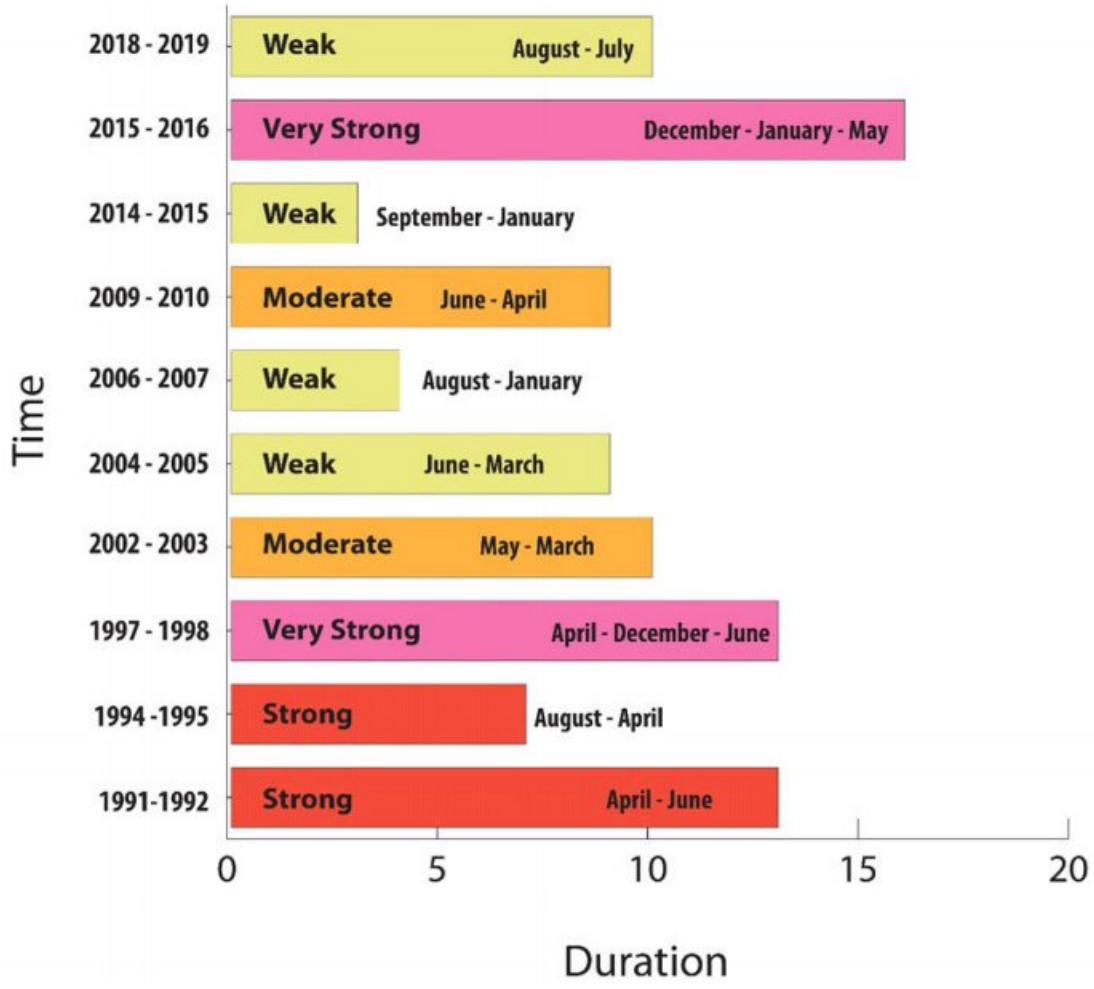


Figure 13: El Nino occurrences during the period 1990-2020. The colours represent the strength of the system using the Ocean Nino Index classification

The ENSO events have bearing on the weather systems in Belize where both El Nino and La Nina bring episodes of elevated heat in the event of El Nino, and lower temperatures in the La Nina events. Belize is fully aware of the ENSO events and usually issue drought alerts. While studies are still few regarding the influences of ENSO events on climate change, it is an emerging field. For example, Wang, B et al (2019) found that climate change is increasing the frequency of extreme El Niño events, leading to intensifying droughts, worsening floods, and shifting hurricane patterns.

[10]Available at https://ggweather.com/enso/oni.htm#:~:text=El%20Ni%C3%B1o%20and%20La%20Ni%C3%B1a%20Years%20and%20Intensities&text=The%20Oceanic%20Ni%C3%B1o,o%2D170oW).

[11]This data was accessed on 01/12/2022 at https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

3.1.10 WIND CHANGES

IPCC (2021) noted that climate change is having implications on wind and expects that in most regions, the mean wind speed will decrease as a result of climate change. Between 1979 and 2018, global mean land wind speed (excluding Australia) showed a reduction of 0.063m per second every decade. In parallel, there is a growing observation of "rapid intensification events," when a storm's wind speeds increase by at least 35 mph within 24 hours. However, the science is still emerging on what are the factors that are driving these changes. However, temperature increase causing warmer ocean conditions seem to be the two major drivers.

Belize City: Wind speed data mapped for Belize City shows a slightly downward trend as shown in Figure 13.

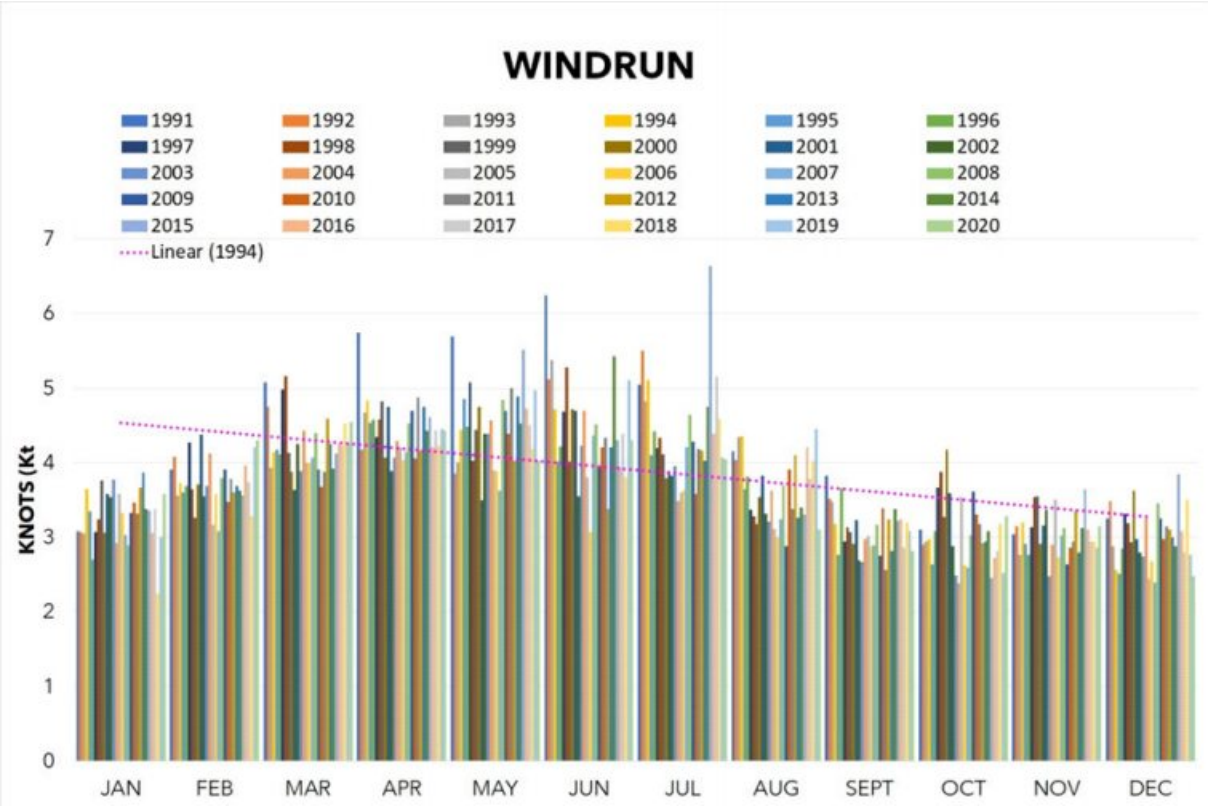
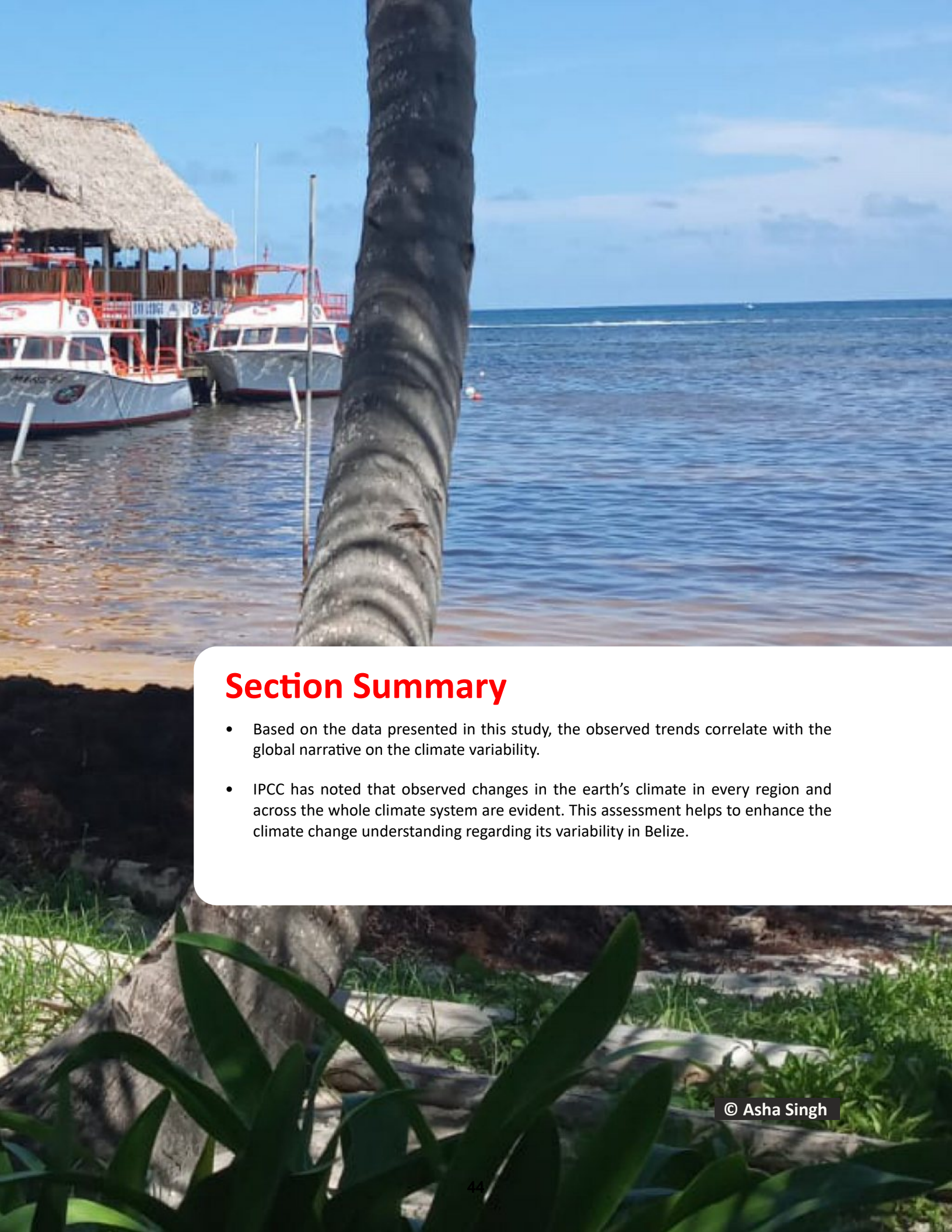


Figure 14: Average monthly wind speed 1991-2021. Developed using data from the National Meteorological Service of Belize.

The evidence of changing wind speed and its link to climate change is growing. There seems to be a correlation with the wind speed trend and that of the global findings.



Section Summary

- Based on the data presented in this study, the observed trends correlate with the global narrative on the climate variability.
- IPCC has noted that observed changes in the earth's climate in every region and across the whole climate system are evident. This assessment helps to enhance the climate change understanding regarding its variability in Belize.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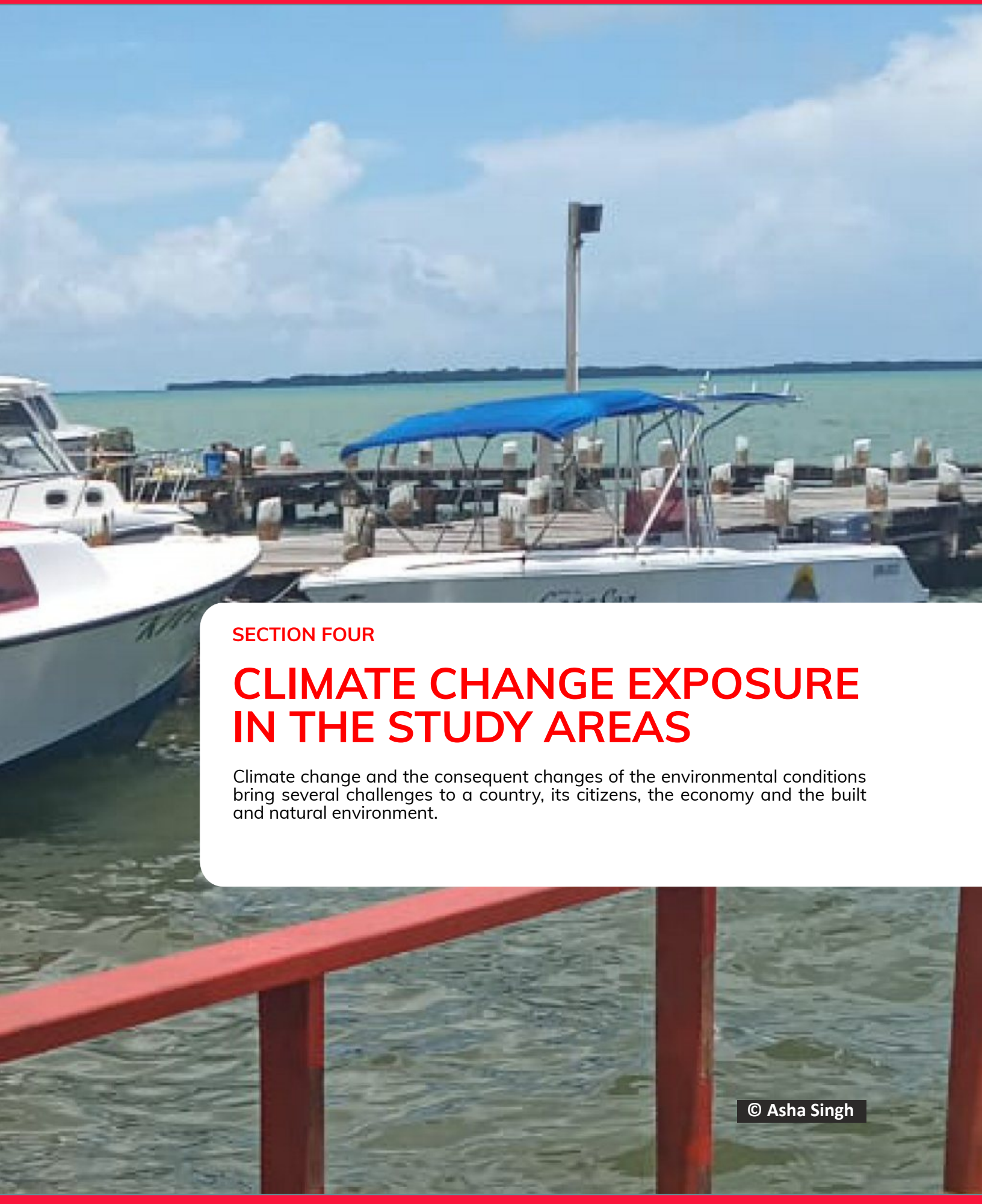


SECTION FOUR

CLIMATE CHANGE EXPOSURE IN THE STUDY AREAS

Climate change and the consequent changes of the environmental conditions bring several challenges to a country, its citizens, the economy and the built and natural environment.

In this section, the exposures are illustrated in Figure 15 and discussed below. Discussing the concept of exposure helps in understanding the vulnerabilities in a more systematic manner.

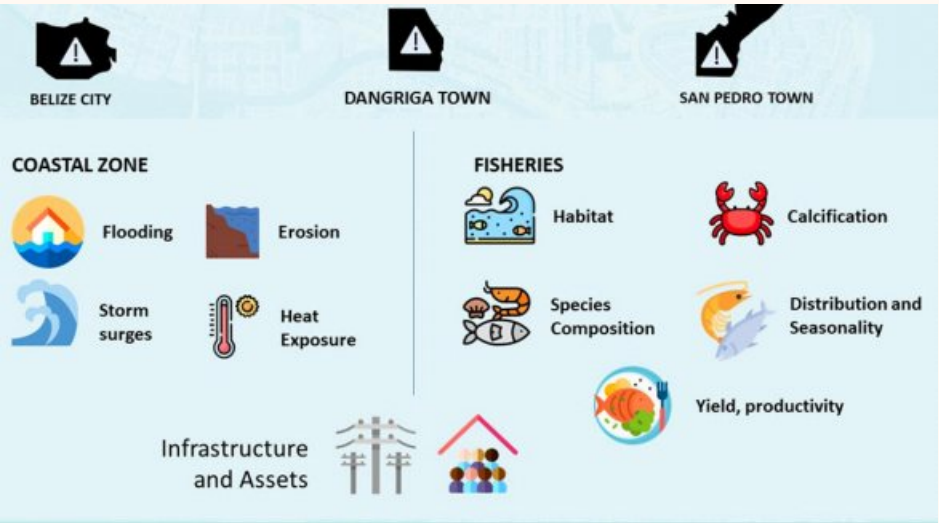


Figure 15: A summary representation of exposure in the study areas of Belize.

4.1 THE COASTAL ZONE

4.1.1: COASTAL FLOODING

BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO TOWN: There are essentially two major types of flooding: coastal and inland flooding. These may include:

(i) floods caused by high water level outside the city (in the rivers and in the ocean); and
(ii) inundation caused by heavy rainfall.

In instances of the presence of low-pressure weather systems coupled by peak high tides (higher sea levels than normal), river and coastal flooding intensifies. High tide levels may vary through the lunar and solar cycle and when superimposed upon other tidal variations, exceptionally high tides may result.

Belize City, being below sea-level, is invariably at risk of flooding even with a heavy single episode of rainfall. Dangriga Town is also flood prone, experiencing most of its flooding from heavy downpour. However, areas in close proximity to the ocean are often submerged during tidal fluctuations. Flooding of San Pedro is constant whenever there is torrential downpour. Belize's location in an active region for both hurricane and seismic activities can also compound the risk of flooding in these areas.

Belize City is exposed to and is severely affected by floods from the sea, river swelling as well as floods caused by direct extreme rainfall, in addition, to land subsidence as a result of sea level rise. As a consequence of these phenomena daily flooding during ebb and flow is a common occurrence, and inundations of a few centimetres (in the streets) are common. Data

STAKEHOLDERS' REACTION

In the consultation, several stakeholders spoke of the issue of flooding in Belize City. Some areas are more flood - prone including Belama Phase 3 and 4, Krooman Lagoon area and Gungulung among others.

NON-CLIMATE CHANGE INFLUENCED FACTORS

Poor and ineffective waste management is a significant contributor to flooding in Belize City.

on flooding are only available for 2015 to the present for Belize City. While no trend can be observed based on the recorded episodes of flood, for the period 2015- present, between eight flood events were recorded

Apart from the rainfall related flooding, coastal flooding in Belize City, Dangriga Town and San Pedro Town, is caused by higher sea levels than normal, largely as a result of storm surges, resulting in the sea overflowing onto the land. This may be influenced by the following factors, which may work in combination:

- high tide level.
- storm surges caused by low barometric pressure exacerbated by high winds especially during episodes of tropical cyclone.
- wave action influenced by wind speed and direction, local topography and exposure.
- land subsidence caused in part by sea level rise.

Low lying areas sitting over aquifers may periodically flood as ground water levels rise. Groundwater flooding occurs when the level of water stored in the ground rises as a result of prolonged rainfall to meet the ground surface and flows out over it, i.e., when the capacity of the underground reservoir is exceeded.

4.1.2: EROSION

BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO TOWN:

In the case of Belize City and Dangriga Town, two main sources of sediments on the coastline of these sites are river discharges and sediments from reefs and lagoons. In San Pedro, the sources are mainly from the parallel running reef system.

While all the coastlines in Belize are affected by storms and other natural events that cause erosion, the combination of storm surge at high tide with additional effects from strong waves-conditions commonly associated with landfalling tropical storms - create the most damaging conditions. The extent and severity of the problem is worsening with global sea level rise.

STAKEHOLDERS' REACTION

In the consultations, several stakeholders spoke of the prevalence of illegally removing sand from the beaches and referenced areas where active erosion is taking place.

[12]National Hydrological Service of Belize provided this information.

Coastal erosion/accretion can also occur from natural phenomena such as sinking and lifting of portions of the land by tectonic and volcanic activities phenomena, or extraordinary events such as storm surges (hurricanes) and tsunamis. All beaches have coastal dynamics with seasons of accumulation and loss of sediments, closely related to the marine and continental climate. Over time the beaches stabilize and preserve. The stability of beaches is due to phenomena of continuous supply of sediments mainly from rivers. These, however, can be diminished by civil constructions in the coastal zone, such as roads, railways, bridges, as well as by the damming of river flows in hydraulic works, retaining sediments.

NON-CLIMATE CHANGE INFLUENCED FACTORS

Poor land planning and lack of enforcement have contributed to ad-hoc development. For example, coastal structures (piers, breakwaters, etc.) are constructed in many instances in the absence of detailed studies of coastal dynamics. Removal of beach materials is also a factor.

4.1.3: STORM SURGES

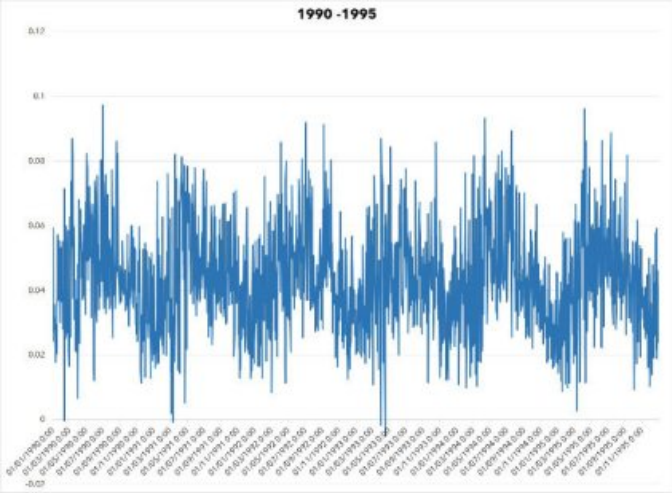
A storm surge is the name for the temporary increase in sea level at a particular location due to stormy weather conditions such as low atmospheric pressure and strong winds.

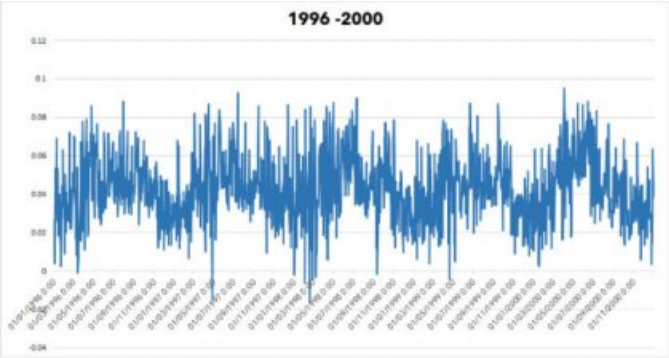
BELIZE: Belize, like other coastal countries, is at risk from storm surge depending on surge size, propagation speed and direction. The height of coastal flooding attained during coastal storms is the product of storm surge height, timing in the astronomical tidal cycle and sea level rise.

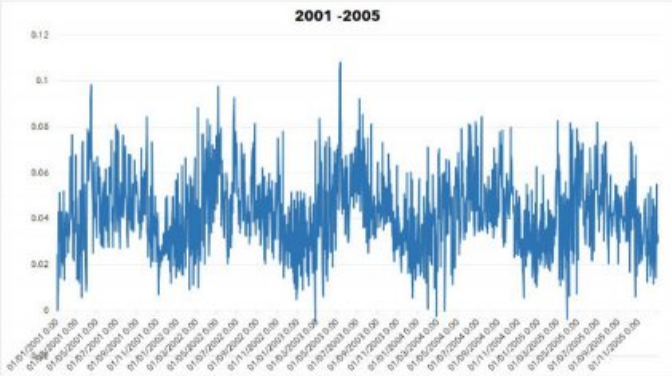
STAKEHOLDERS' REACTION

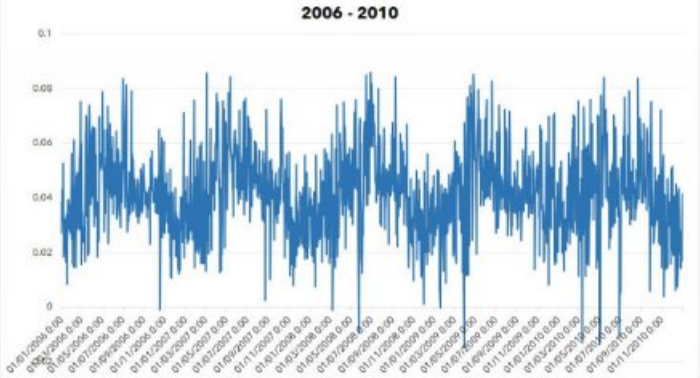
In the consultations, stakeholders spoke of higher-than-normal waves toppling over the seawall.

Rising sea levels are already increasing baseline elevations for waves and storm surge, which can dramatically amplify the impact of storms and hurricanes. A small vertical increase in sea level can translate into a very large increase in horizontal reach by storm surge depending upon local topography. There are no data collected for storm surges in Belize. However, a global database of modelled information for the period 1991-2015, seems to show higher surge peaks during the 2011-2015 period when compared to the others (Figure 16).









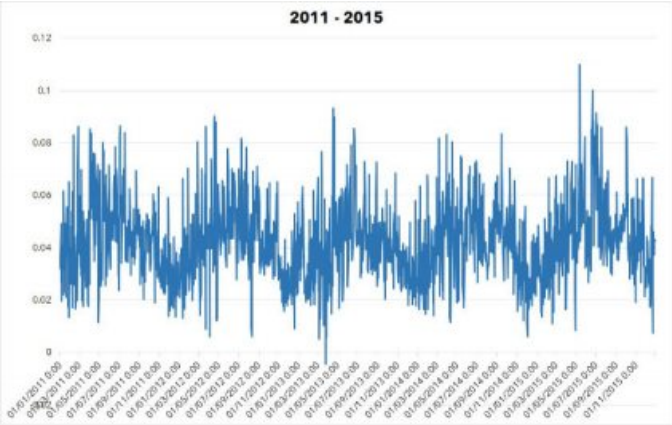


Figure 16: Average monthly storm surges for Belize for the period 1990-2015. Developed using reconstruction data from global storm surge database

4.1.4: SALTWATER INTRUSION

Saline intrusion is the phenomenon that occurs in coastal areas due to the formation of a "saltwater wedge" located below the freshwater aquifers. It is an activity of difference in water density, where the saltier water finds the lower of the less dense water, the freshwater, which explains the frequent stratification of the aquifer.

BELIZE: Water supply in Belize comes from underground water, surface water (rivers, lakes and lagoons) and desalinisation of seawater (Ambergris Caye and Caye Caulker). The focused groundwater and surface-water systems are hydrologically interconnected and function together to provide water for public, industrial, agricultural, and recreational uses.

BELIZE CITY: According to the Belize Water Services (BWS), the water which is harnessed to service Belize City is sourced from surface water in the river system. However, there is a noticeable shift of the saltwater wedge moving further upstream in the river. This is beginning to pose operational challenges for the BWS and in the future may be a threat to the City's water security. Salinity data for 2012-2021 shows that the monthly values between 2012 to 2018 are about the same for each year (Figure 17). However, since 2019 the salinity values are increasing. This aligns to the observations made by BWS. At the global level there is a noted increase in the ocean salinity due to climate change, as according to Olsen et al (2022) 'Saltier oceans result in warmer climates with less sea ice'. However, another contributing factor, although speculative in the absence of information, is the increased upstream activities and slower velocity of the river system.

NON-CLIMATE CHANGE INFLUENCED FACTORS

These aquifers tend to contain hard water in Ca-Mg. The depth at the static level is small, with the freshwater layer found a few meters deep (2-10 m). The thickness of the freshwater layer varies from 10 to 70 meters from which the salty and/or saline water layer begins. In Belize, the characteristic of coastal aquifers is that they are stratified, where the usable fresh water is located at shallow depths and under which a layer of saline water is located. The penetration of the so-called saline wedge can be up to 100 km inland as occurs in the area adjacent to Mexico (Azueta et al 2020).

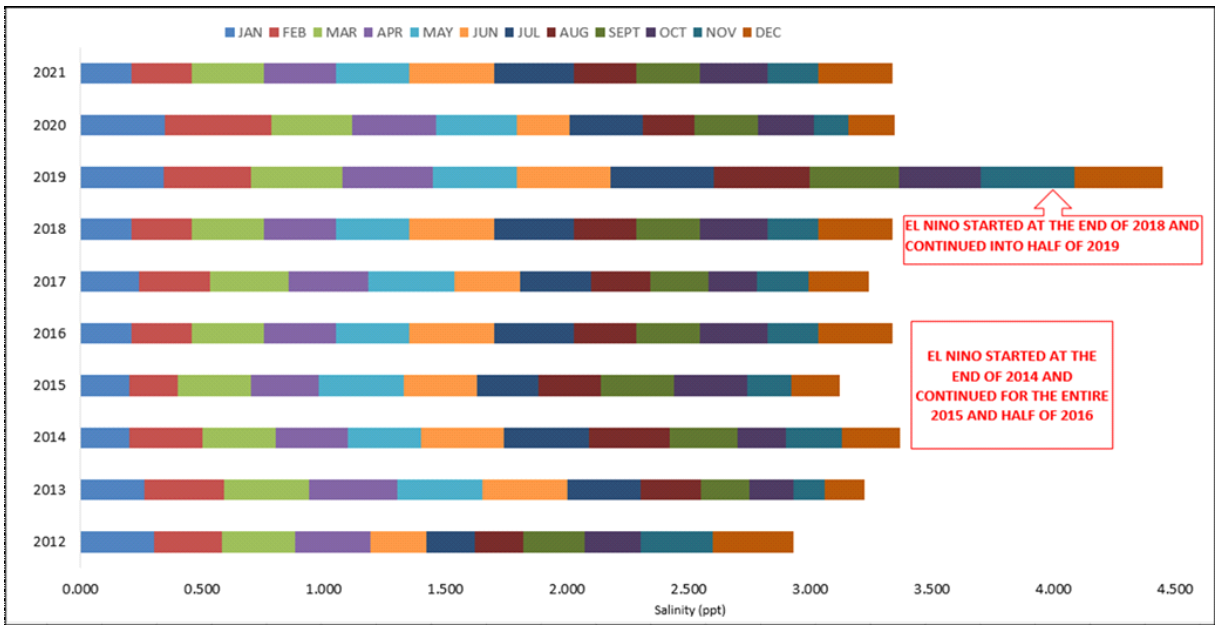


Figure 17: Monthly salinity measurements for Belize City for the period 2012-2021. Developed using data provided by the Belize Water Service.

DANGRIGA TOWN AND SAN PEDRO TOWN: Also serviced by BWS, salinity in the water supply for Dangriga Town poses no challenges given where the water is sourced. Salinity data measured for Dangriga's water source show very negligible saline content. San Pedro town has natural saline wells which are desalinated to meet the potable water demands.

4.1.5: DROUGHT LIKE CONDITIONS

Droughts are attributed to declines in rainfall, particularly in the wet season (Angeles et al. 2007, Taylor et al. 2012, IPCC 2014). They have, in recent decades, become exacerbated by increasing high evapotranspiration rates associated with increasing temperatures (Herrera et al. 2018; Dai 2013 and 2011). Both temperature and evapotranspiration are projected to increase even more in the future. Further, declines in rainfall leading to significant drought impacts are associated with the El Niño phenomenon and with cooler than normal sea surface temperatures in the Tropical North Atlantic Ocean and the Caribbean Sea (Enfield and Alfaro 1999; Giannini et al. 2000; Taylor et al. 2011).

BELIZE CITY AND DANGRIGA: Standard Precipitation Index data at 12 months were analysed for Belize City and Dangriga Town Figure 18. It shows several declared episodes of drought during the period 1990-2020. Some of these coincide with episodes of El Nino. Generally, the data seems to show longer periods of drought in the latter quarter of the data period with these two sites experiencing more abnormally dry and moderately dry periods.

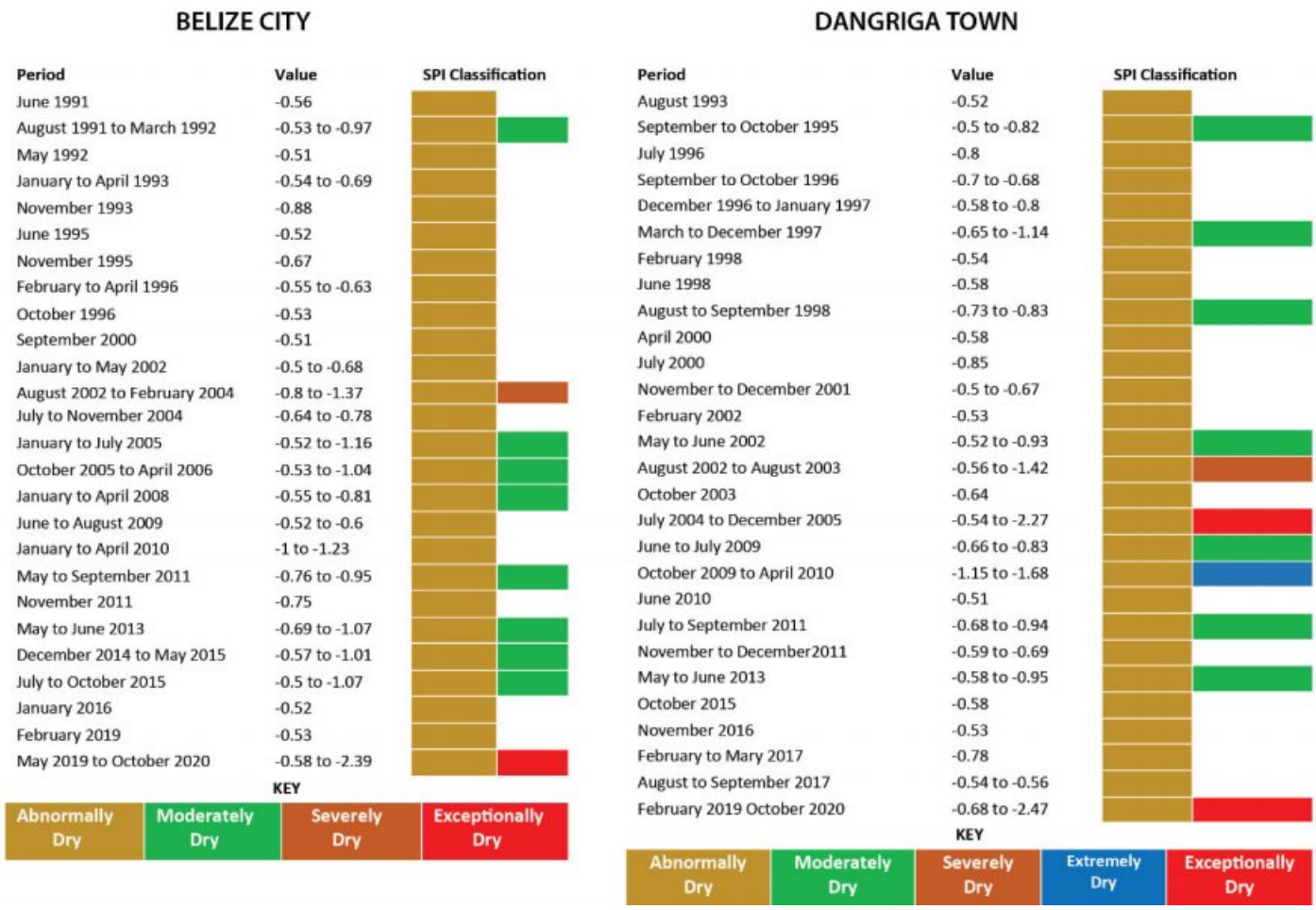


Figure 18: The drought episodes for 1990-2020 using SPI data. Developed using data provided by National Meteorological Service of Belize

4.1.6: HEAT EXPOSURE

When people are exposed to extreme heat, they can suffer from potentially deadly illnesses, such as heat exhaustion and heat stroke. Hot temperatures can also contribute to deaths from heart attacks, strokes, and other forms of cardiovascular disease. Heat is the leading weather-related killer. There is no data being collected in Belize on weather related mortality.

4.2 EXPOSURE IN THE COASTAL ZONE: BUILT ENVIRONMENT AND LIVELIHOOD

The infrastructure and assets in the Coastal Zone in Belize City, Dangriga Town and San Pedro Town are subjected to exposures in varying degrees. These climate change manifestations could increasingly directly and indirectly disrupt critical systems. The assets' exposures are mapped below in Table 7.

Assets Infrastructure	EXPOSURE							
	Water Related				Temperature Related		Wind Related	
	Tidal and or Pluvial	Storm Surges	Saline Intrusion	Erosion	Drought	Heat Exposure	Reduction	Hurricane
Transportation Infrastructure								
Airports								
Seaports & Jetties								
Roads								
Rivers								
Telecommunication Installations								
Wireless								
Fixed								
Energy Systems								
Transmission Lines								
Transmission & Distribution								
Substations and Towers								
Water and Sewerage System								
Drinking Water								
Water Treatment								
Wastewater Treatment								
Residents								
Homes								
Health and well-being								
Safety								
Livelihood								
Business Infrastructure								
Business Operation								
Employees (job security)								
Income Generation								

4.3 FISHERIES SECTOR

4.3.1: HABITAT

Climate change manifested through rising ocean temperature further exposes the fragile yet delicately balanced marine system which functions as a unit. Coral reefs ecosystems, littoral forest, mangroves systems and seagrass mats all found in Belize host a wide variety of marine life. These ecosystems are the foundation to Belize's fisheries sector. Exposure to marine heatwave and changes in the pH are the leading climate change related challenges. If water temperatures persist above a threshold of between 1°C–2°C above the normal range, the reef system is exposed to coral bleaching.

BELIZE: There is evidence that coral bleaching has occurred in Belize. According to Searle et. al. (2014), bleaching was first recorded in Belize in 1995 and thereafter, several episodes have been recorded such as 1998,2005,2008,2009,2010,2011 and beyond. Mangroves habitats in Belize are crucial spawning ground for several species of fish of commercial importance or for local consumption.

NON-CLIMATE CHANGE INFLUENCED FACTORS

Land based activities are negatively impacting these ecosystems adding further stress thereby increasing their vulnerability to damage and loss. Among the issues are land-based sources of pollution, illegal removal of beach sand, marine litter pollution, inland dredging infilling of mangroves and unregulated, poorly enforced coastal planning.

4.3.2: SPECIES COMPOSITION, YIELD AND PRODUCTION

According to IPCC (2019) mobile species, such as fish, are being exposed to heightened changes in the ocean dynamics. Consequently, further studies have shown that several species are already moving to more favourable regions, with populations shifting poleward or to deeper water to find their preferred range of water temperatures or oxygen levels (Perry et al, 2005). As a result, projections of total future fishery yield under different climate change scenarios only show a moderate decrease of around 4% (~3.4 million tonnes) per degree Celsius warming (IPCC, 2019). While much of these studies are outside of the region and Belize specifically, regional variations may exist owing to the ocean dynamics. However, IPCC (2019) noted that fisheries in tropical regions could lose up to half of their current catch levels by the end of this century.

NON-CLIMATE CHANGE INFLUENCED FACTORS

Sustainable stock management and extraction remains a challenge for Belize.

The oceans and seas are home to a rich diversity of life, from tiny plankton to fish, and seafloor invertebrates. Their complex interactions give rise to our fisheries sector. However, these can be altered (if they have not already) if new warmer-water species extend their ranges as sea temperatures rise. The effects of acidification on shelled organisms, as well as increased human activities are amplifying these disruptions.

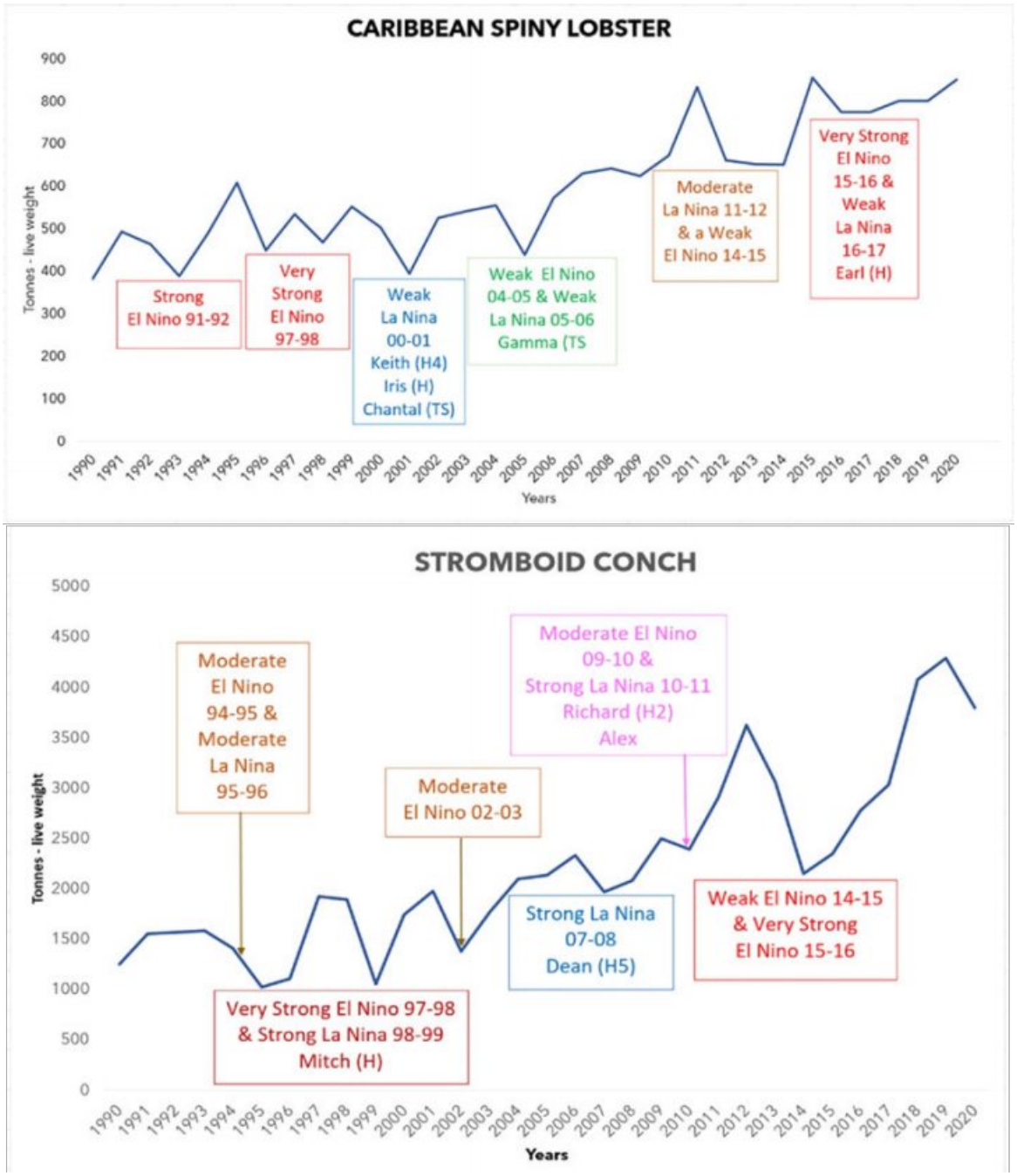


Figure 19: Annual lobster (top) and conch production (bottom) for the period 1990-2020. Developed using data from FAO.

4.3.3: DISTRIBUTION AND SEASONALITY

While there are no specific studies on Belize fisheries in this regard, it is well established that pelagic fish stocks exhibit unique spatial and temporal distribution patterns related to their bioclimatic niche. Climate changes and the associated shifts in primary and secondary production have therefore impacted on the distribution range, migratory habits and stock size of many marine fish species (IPCC, 2019). However, few are affected as dramatically as the straddling pelagic stocks – like herring, mackerel, capelin, blue whiting, sprat, anchovy and sardine according to the findings of the Climefish Project[14]. They provide an interesting showcase of extreme changes, where climate induced fluctuations affect important biological processes such as reproductive success, population dynamics, migration patterns and interactions between fish populations.

4.3.4: CALCIFICATION

The rising ocean temperature and increased acidity make it more difficult for marine organisms such as shrimps, oysters, or corals to form their shells – a process known as calcification

Many important animals, such as zooplankton, that form the base of the marine food chain also have calcium shells. The entire marine food web is being altered and may result in 'cracks in the food chain'. As a result, the distribution, productivity, and species composition of global fish production are changing, generating complex and inter-related impacts on oceans, estuaries and sea grass beds that provide habitats and nursery areas for fish.

STAKEHOLDERS' REACTION

Fisherfolks in Belize spoke of lobsters and conch moving further out into the sea, as a major contributor to a low season.

BELIZE: Using data on stone crabs, it was found that there is a low production as shown in Figure 20. While, it is not a species of significant commercial value, it is utilised locally. However, many of the fisherfolks alluded to the reduced abundance of crabs in general. Crabs are of significant cultural and religious value to the Garifuna in Belize, and their absence is well noted in the community and the impact on their religious practices.

[14]Accessed on 23/12/2022 through https://climefish.eu/virtual-fact-sheets/

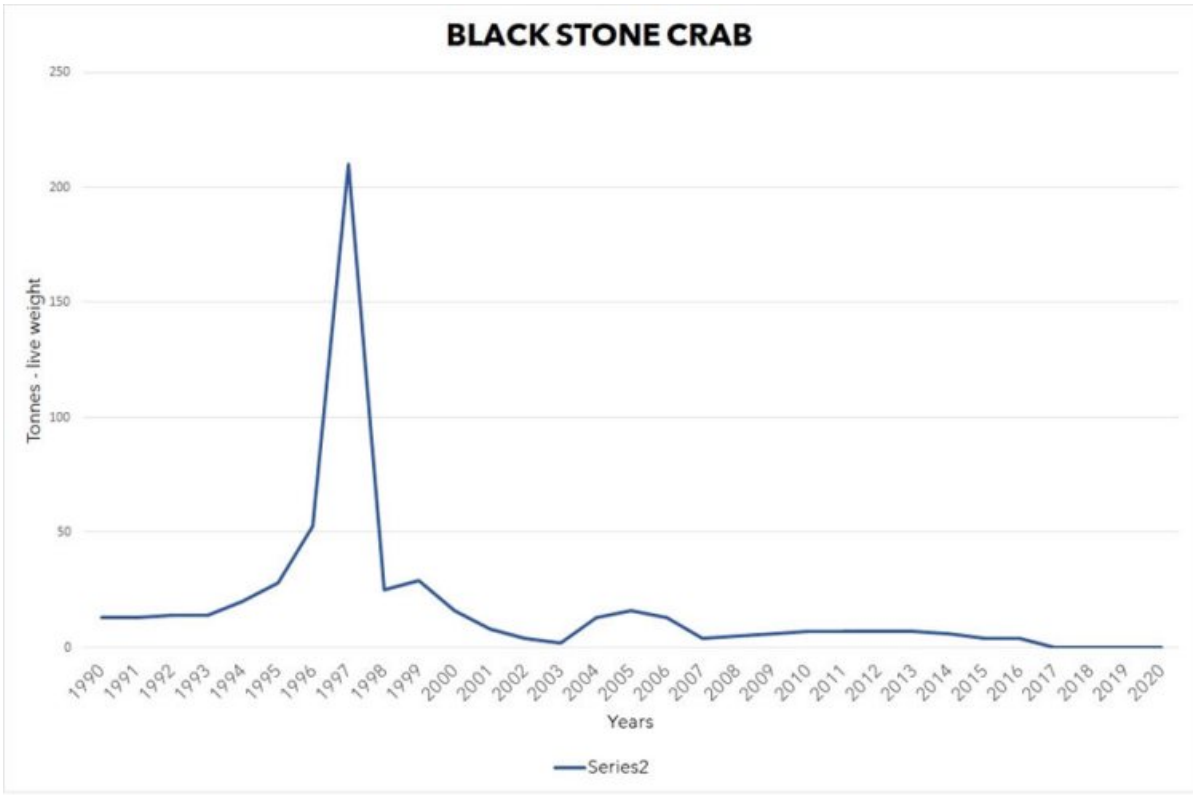


Figure 20: Annual stone crab production for Belize for the period 1990-2020. Developed using data from FAO.

4.4 SENSITIVITY IN THE FISHERIES: LIVELIHOOD

The fisheries sector infrastructure, assets, fisherfolk in Belize City, Dangriga Town and San Pedro Town are subjected to exposures in varying degrees. The exposure of these assets is mapped below in Table 8.

Table 8: A summary assessment of the study areas' fisheries sector and the varying exposures to climate change

Assets and Infrastructure	EXPOSURE								
	Water Related				Temperature Related		Wind Related		Resource Related
	Tidal and/or Pluvial	Storm Surges	Saline Intrusion	Erosion	Drought	Heat Exposure	Reduction	Hurricane	Calcification
Infrastructure and Asset									
Fishing Vessels									
Landing Sites									
Fish Depot									
Natural Resources									
Marine Habitats									
Living Resources									
Fisherfolks									
Homes									
Health & wellbeing									
Safety (home and at sea)									
Job security									
Income Generation									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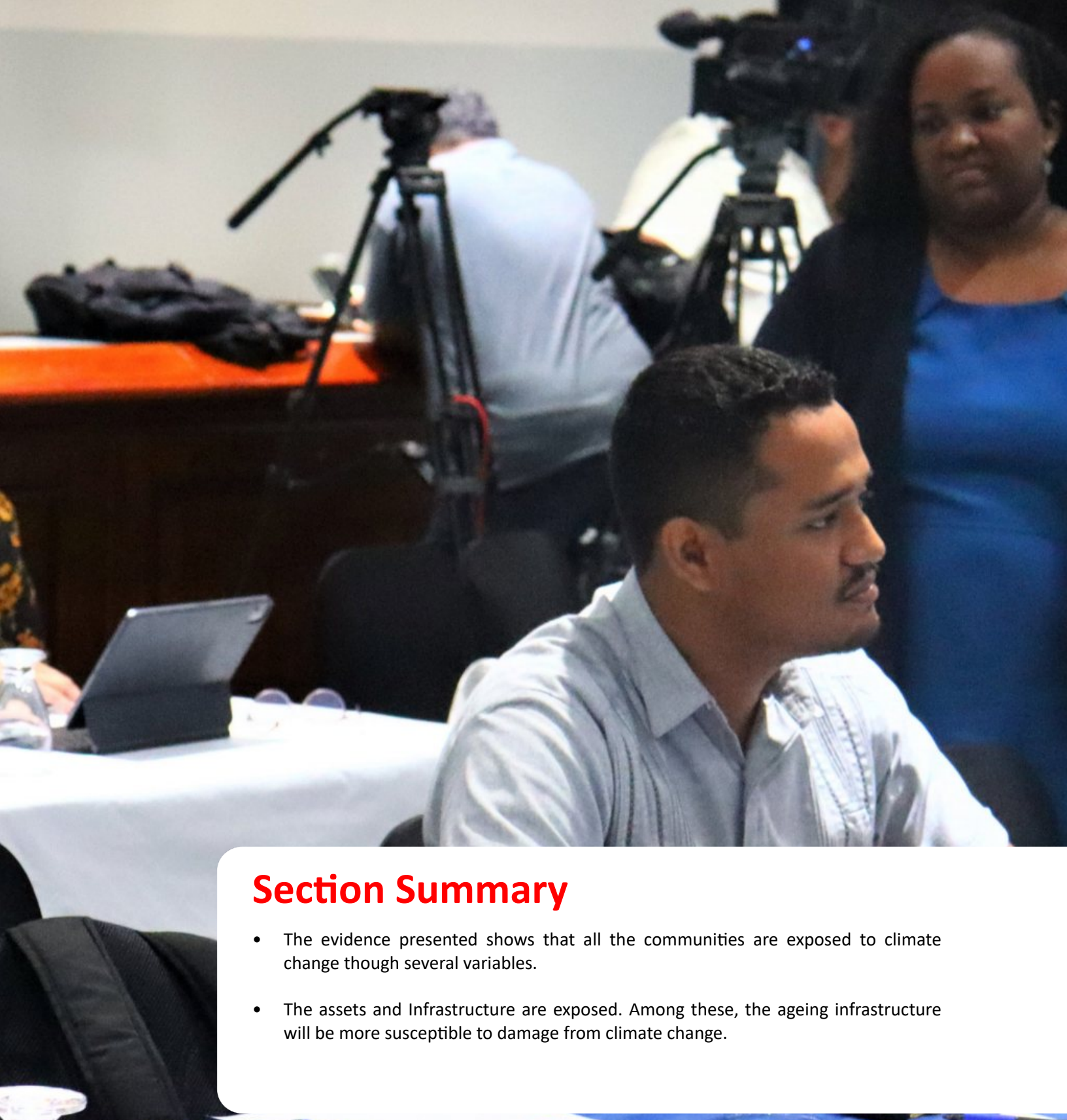

Section Summary

- The evidence presented shows that all the communities are exposed to climate change though several variables.
- The assets and Infrastructure are exposed. Among these, the ageing infrastructure will be more susceptible to damage from climate change.


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SECTION FIVE

CLIMATE CHANGE SENSITIVITY IN THE STUDY AREAS

Every Belizean faces a risk associated with climate change. Some people, however, face higher risks than others because of the differences in the exposure and their sensitivity to this variability of climate change.

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In this section, sensitivity is discussed from four perspectives as illustrated in Figure 21.

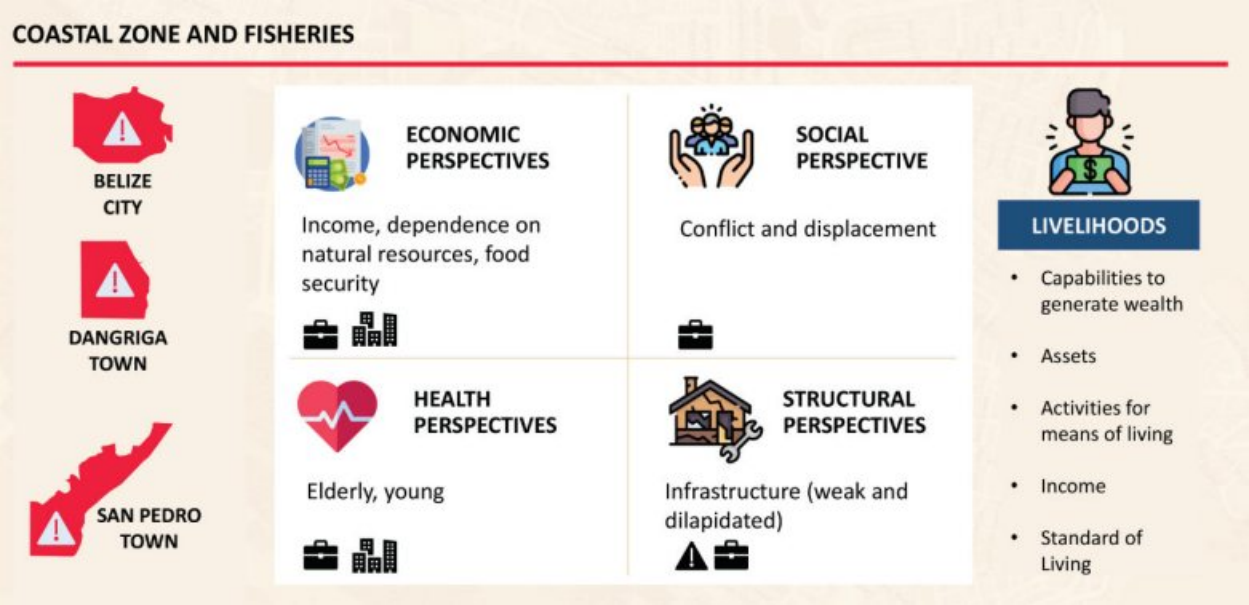


Figure 21: A summary representation of sensitivity in the study areas of Belize.

5.1 COASTAL ZONE IN BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO TOWN

5.1.1 ECONOMIC: In these communities, much of the critical infrastructure is at risk from flooding. This could potentially cause (if it hasn't already) a loss of value of assets. Loss from damage to housing and other infrastructures is already a reality. Heavy precipitation and the intensity of extreme weather are requiring more maintenance and repair for roads and other infrastructure. The communication systems are also sensitive, especially utility poles which are prone to damage especially from heavy winds or waterlogged conditions.

Already, Belize like many Caribbean destinations faces reduced tourism revenue during the hurricane season. However, more economic bleeding from intense weather-related events continues to be an economic cost. There are also indirect costs, which can be harder to measure. After an event, businesses experience a slowdown in economic activity due to interruption, disrupted transport networks (for example flooded roads or collapsed bridges) and disrupted supply chains. These impact livelihoods of not only the owners, but also the employees. In addition, as water temperatures increase, more intense sargassum blooms are landing on the shores, thus curtailing recreational water activities and impacting fishing. More frequent and severe sargassum annually worsens air and water quality and discourage tourism. There are also macroeconomic impacts, whether increases in government debt, or declines in GDP. Overall, the economies of Belize and moreso of these specific communities continue to be sensitive to these exposures of climate change and are becoming an increasing burden to fix.

Research even shows that high temperatures reduce workers' productivity. Put simply, when

daily maximum temperatures get too hot (over 32°C), workers in 'outdoors' industries, like construction, go home early or are likely to suffer from heat exhaustion. This becomes an economic burden over time, not to mention the health implications. While there is no data for Belize on the economic implications, anecdotal evidence from stakeholders lamented about the heat and challenges to operate in such an environment.

5.1.2 STRUCTURAL: Housing in these study sites is a mixture of wooden or concrete structure with zinc metal or concrete roofing. In newer homes or building, the use of masonry construction for walls is on the increase, while the use of metal sheet for roofs remains prevalent. While homes are being built to be more resilient to extreme events, there are several dwellings which are old or poorly constructed. These housing or dwellings are very sensitive to damage from exposure to the variability of climate change.

5.1.3 HEALTH: Climate change has major and costly health impacts that put healthcare systems under further strain. While no data is available on hospitalization due to extreme heat and fatigue, there is a recognition of the health challenges of increased exhaustion faced by the aged population. Flooding is another major health risk. It presents immediate threats in the form of drowning or loss of possessions, for example, and the trauma brought by flooding has been associated with heightened risk of mental health symptoms such as stress. Some of the stakeholders engaged for this study spoke of the heightened emotional stress when there are heavy downpours wondering about safety and their material belongings.

5.1.4 SOCIAL: Displacement (physical or economic) and the interplay with crime and conflicts as a result of climate change are not of any crisis proportion or trigger any cross-border mobility. However, there are softer levels of internal displacement which are being triggered by disasters. These may enlarge marginalized communities resulting in land conflict, especially if squatting regulations are not being enforced.

5.2 FISHERIES IN BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO TOWN

5.1.1 ECONOMIC: Fisheries in Belize, is labour-intensive harvesting strategies, relatively small fishing vessels, short fishing trips, close to shore, low relative catch per vessel and limited capital investment. The majority of the fisherfolks in Belize City, Dangriga Town and San Pedro Town rely on this occupation for their economic livelihoods of which mostly are small scale fisherfolks. Hence any shift and negative signals which may affect production level have immediate and significant livelihood impact. This is most challenging to fisherfolks who are older, making them particularly sensitive. In comparison, this heightening level of sensitivity, while still present, may be tempered as many of the younger generation of fishers usually serve as tour operators thereby allowing for a dual income.

5.1.2 STRUCTURAL: Fishermen mostly operate skiffs to undertake their fishing activities. Although these are structurally sound, they may not be able to withstand the onslaught of storm surges and other weather-related events which are predicated to increase due to climate change. Many fisherfolks spoke of more boat repairs now than in the past and the cost and time. Similarly, the jetties used for fish landings are also now subjected to greater wave action which can compromise the structures.

5.1.3 HEALTH: Recalling that fisheries in these communities are centered around labour intensive harvesting, fisherfolk are more prone to heat exhaustion. In addition, with increasing swells due to climate change, safety at sea is becoming riskier. In other words, life at sea for fisherfolks is truly becoming one of the most dangerous occupations in a world of changing climate.

5.1.4 SOCIAL: With migration of species and low yield in some seasons, many fisherfolks are observing/experiencing an increase in piracy of yield. Many complained of fish traps that are raided frequently. Apart from an added economic loss, it is also becoming dangerous for fisherfolk given the growing prevalence of crime on the sea.

In summary, as climate change increased in its magnitude, so will be the sensitivity to the exposures which ultimately will pose a major threat to people living on Belize's coastlines and the fisherfolks, as no one is spared as illustrated in Table 9.

Table 9: A summary assessment of the Study Area's Demographics Sensitivity to climate change

Demographics	SENSITIVITY							
	Socio-Economic				Physical		Health	
	Increased cost due to repairs	Loss of Income	Conflict	Fiscal Burden	Damage to buildings	Damage to utility services & equipment	Heath Exposure	Emotional Distress
Homeowners								
Residents								
Elderly								
Working Population								
Youth								
Owners								
Employee								
Self Employed								
Fisherfolks								
Policy Makers								

Section Summary

- Every citizen in the study area faces some level of sensitivity associated with climate change.
- The fisherfolk demographic is sensitive to a wider range of issues related to climate change. This has significant implications for their vulnerability, but more importantly their well-being.

SECTION SIX

ADAPTIVE CAPACITY TO CLIMATE CHANGE IN THE STUDY AREAS

Assessing the ability of individuals to anticipate and respond to changes, or to cope, reduce and recover from the effects of climatic stressors is critical to building resilience to climate change. Low adaptive capacity would make it difficult to adapt to the change in climate variability or in harnessing the opportunities that climate change may create in the availability of resources and services. In this section, the analysis is focused on the enabling conditions to build adaptive capacity in the study areas under focus in this assignment.

The perspective of assessing adaptive capacity is summarised in Figure 22.

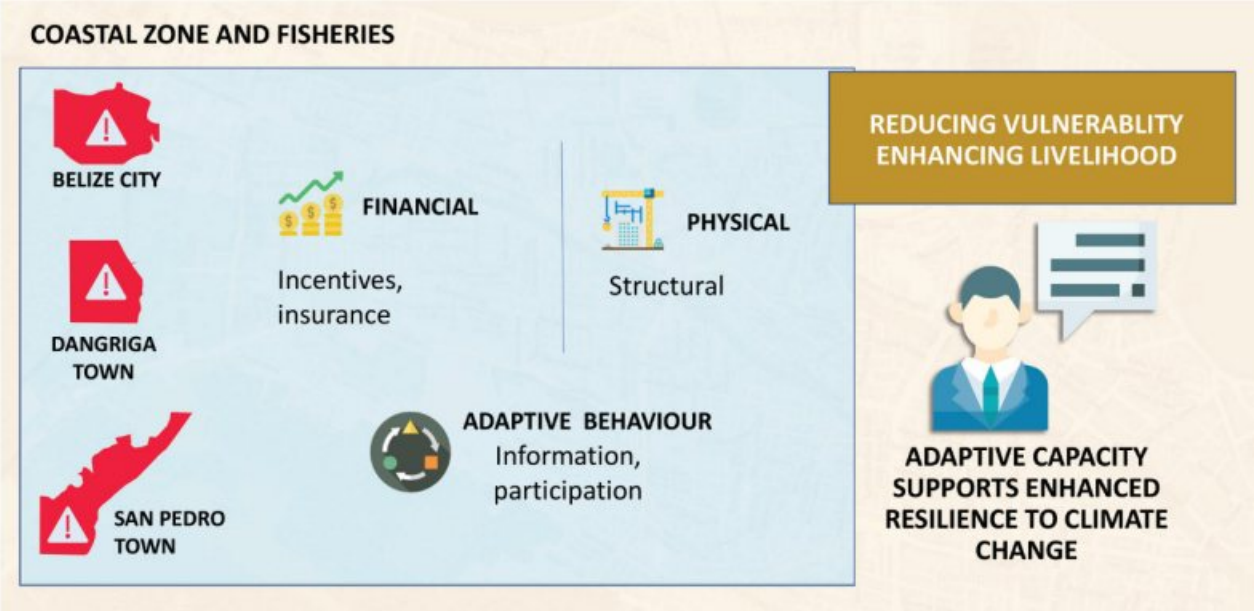


Figure 22: A summary representation of adaptive capacity in the study areas of Belize

FINANCIAL CAPITAL: Climate finance seeks to support mitigation and adaptation actions that will address vulnerability to climate change. Climate finance is important for adaptation, as significant financial resources are needed to adapt to the adverse effects and reduce the impacts of a changing climate. Apart from donor driven financing or government accessed financing under mechanisms such as Green Climate Fund which address climate change, financing access via incentives is one of most critical areas to reduce vulnerability. Therefore, there must be mechanisms that allow for that access. In addition, climate-based insurance schemes are also a means of enhancing resilience.

DESIGNATED CLIMATE FINANCING: A review of financing available in Belize revealed that most financing are offered from the private sector driven banking institutions. There is no designated climate financing loan scheme. Hence loans are offered for activities such as repairs, which can be used indirectly to address climate related activities. There is no loan scheme to support the fisheries sector, even less so for the fisherfolks.

INCENTIVES: No climate change related incentives are identified to be operating in the sectors or the sites studied.

INSURANCE: There is a growing plethora of non-parametric type of climate insurance already operational in many parts of the world. However, there are none presently operating in Belize that focus on climate resilience building.

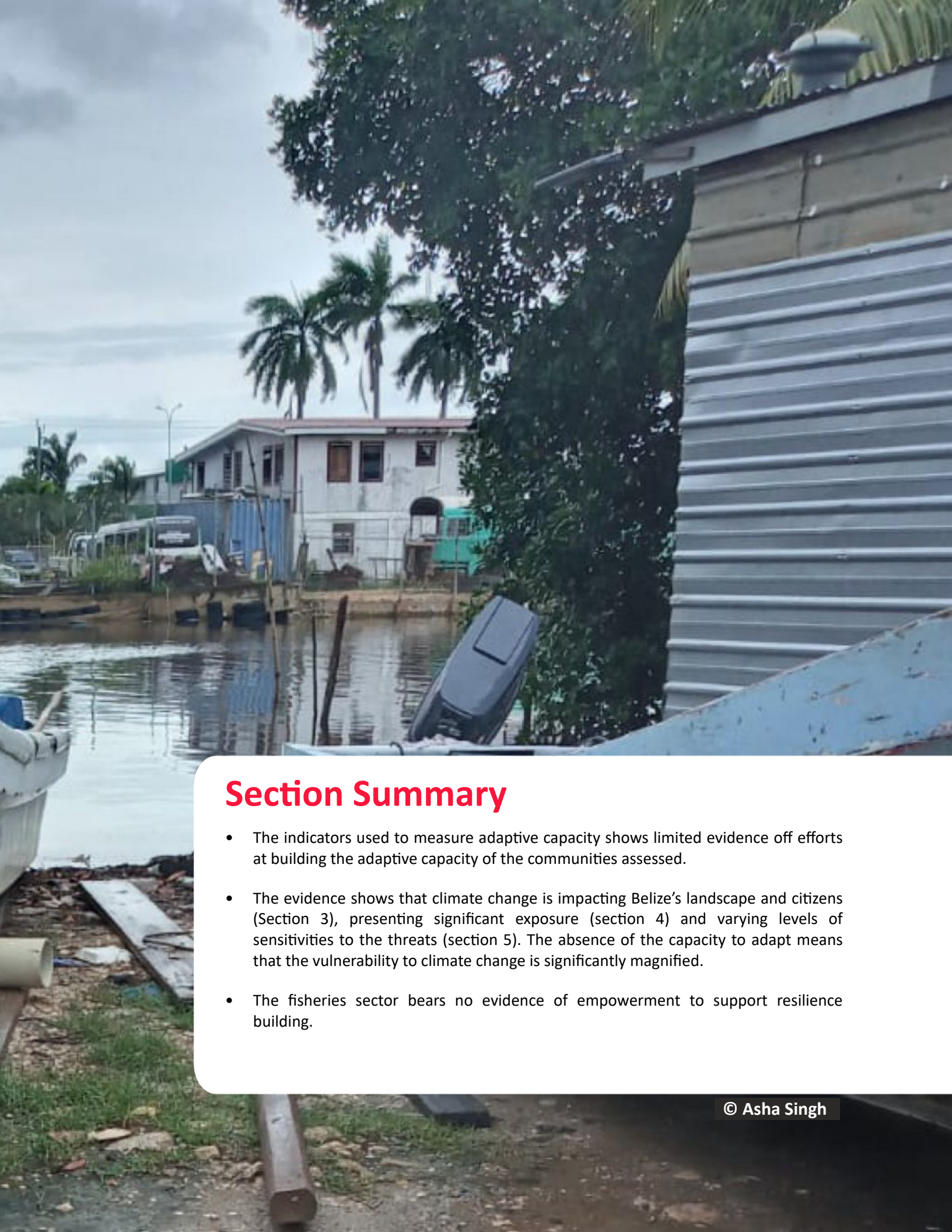
PHYSICAL: Climate proofing is a process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects or retrofitting. There is evidence of newer buildings using more concrete based materials. However, based on information received from the stakeholders and a cursory analysis of the governance mechanisms operating within the study areas, it is evident that the permitting processes, building code, engineering standards and resource management have not, in any significant noticeable degree, mainstreamed climate change consideration in their prescriptions. There is no shift in the required degree to support effective adaptation to climate change.

ADAPTIVE BEHAVIOUR: The growing need for people to learn to live with the effects of climate change has spurred scholarly work in adaptation. Recently, scholars have extended psychosocial frameworks of individual behavioural responses to natural hazards and human health risks to the domain of climate change. There is a recognition that climate change is occurring in Belize, but many (though there are several exceptions) are of the opinion that it is the responsibility of the State. Some do not know how they can contribute. Overall, the required behaviour at the individual and community levels does not seem well communicated or understood.

In summary, there is limited evidence to link adaptive capacity to climate change in the areas studied. While some elements may be present, several factors restrict access, one being the ability to pay for services. A situation analysis is presented in Table 9.

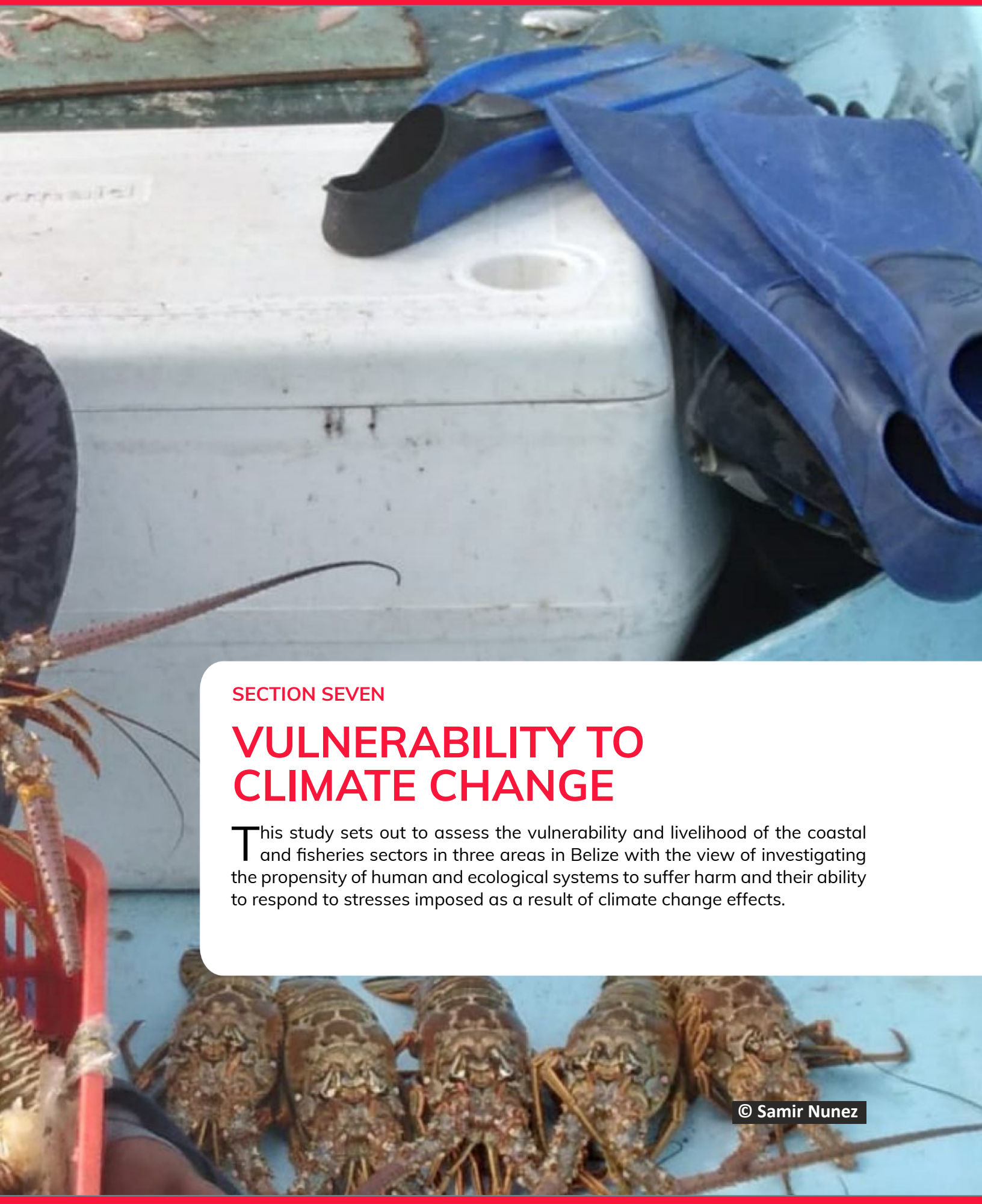
Table 10: A summary assessment of the Study Area's Demographics Sensitivity to climate change

<table>
<tr><th rowspan="3">Demographics in the Study Areas</th><th colspan="5">Adaptive Capacity</th></tr>
<tr><th colspan="2">Finance</th><th colspan="2">Physical</th><th>Adaptive Behaviours</th></tr>
<tr><th>Insurance Access</th><th>Climate Loans</th><th>Incentive for Climate Retrofitting</th><th>Mainstreaming Climate change in the Governance</th><th>Awareness</th></tr>
<tr><td>Homeowners</td><td>There are general insurance schemes. Based on the engagement, many spoke of the inability of many residents to afford them.</td><td rowspan="4">No designated Climate Financing available in the Belize Financial Sector.</td><td rowspan="3">No evidence of such.</td><td rowspan="4">Limited evidence of such.</td><td rowspan="4">While many heard of climate change, the level of awareness still seems murky at best based on the consultations.</td></tr>
<tr><td>Residents/Citizens</td><td>N/R</td></tr>
<tr><td>Business Owners</td><td>There are general insurance schemes available which are taken up by business owners. However, how businesses are insured in the study areas could not be ascertained.</td></tr>
<tr><td>Fisherfolks</td><td>No schemes available for the fisheries sector.</td><td>No evidence of such for fishing equipment.</td></tr>
</table>



Section Summary

- The indicators used to measure adaptive capacity shows limited evidence off efforts at building the adaptive capacity of the communities assessed.
- The evidence shows that climate change is impacting Belize's landscape and citizens (Section 3), presenting significant exposure (section 4) and varying levels of sensitivities to the threats (section 5). The absence of the capacity to adapt means that the vulnerability to climate change is significantly magnified.
- The fisheries sector bears no evidence of empowerment to support resilience building.



SECTION SEVEN

VULNERABILITY TO CLIMATE CHANGE

This study sets out to assess the vulnerability and livelihood of the coastal and fisheries sectors in three areas in Belize with the view of investigating the propensity of human and ecological systems to suffer harm and their ability to respond to stresses imposed as a result of climate change effects.

Figure 23 brings together the components of the assessment supported by a qualitative assessment of the vulnerabilities in this section.

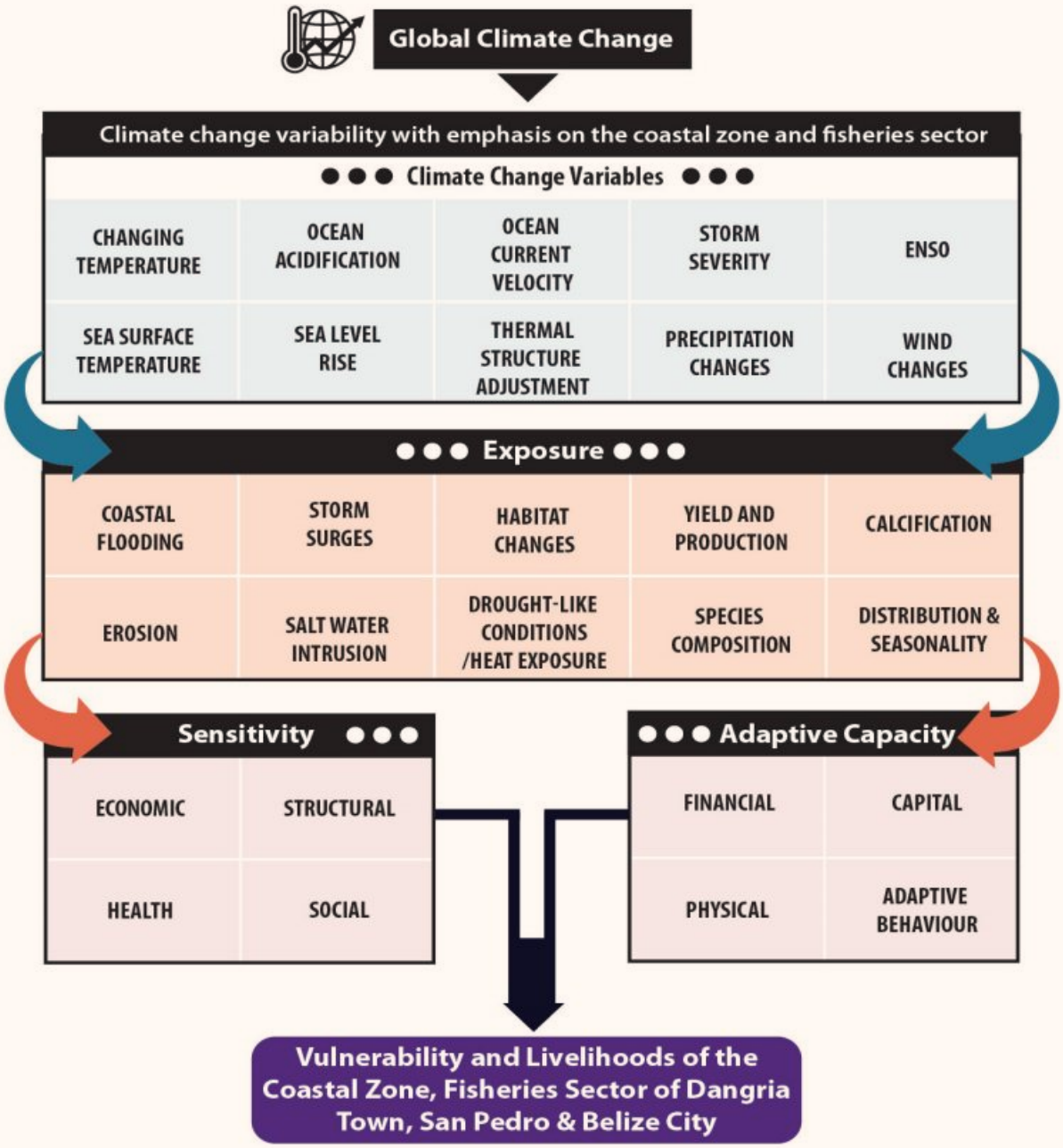


Figure 23: A summary representation of vulnerabilities in the study areas of Belize.

ENVIRONMENTAL AND ECOSYSTEM VULNERABILITIES: Belize's natural occurring ecosystems and geophysical characteristics provide several ecosystem services (regulating, provisioning, cultural and supporting services). Belizean wellbeing is intricately linked to the environment and climate change, unfortunately, is impacting deleteriously with this relationship.

COASTAL ZONE AND FISHERIES SECTORS OF BELIZE CITY, DANGRIGA TOWN AND SAN PEDRO: Whether the exposure to climate change is from excessive heat, changes in precipitation, or pH changes, the environmental assets of Belize are sensitive to the shifts brought on by climate change which are impacting their survival and ability to provide their services to humanity. Added to this is the additional anthropogenic activities such as pollution, sedimentation and over-exploitation which are contributing to the stress on these systems. Overwhelming, the vulnerability of these system is high.

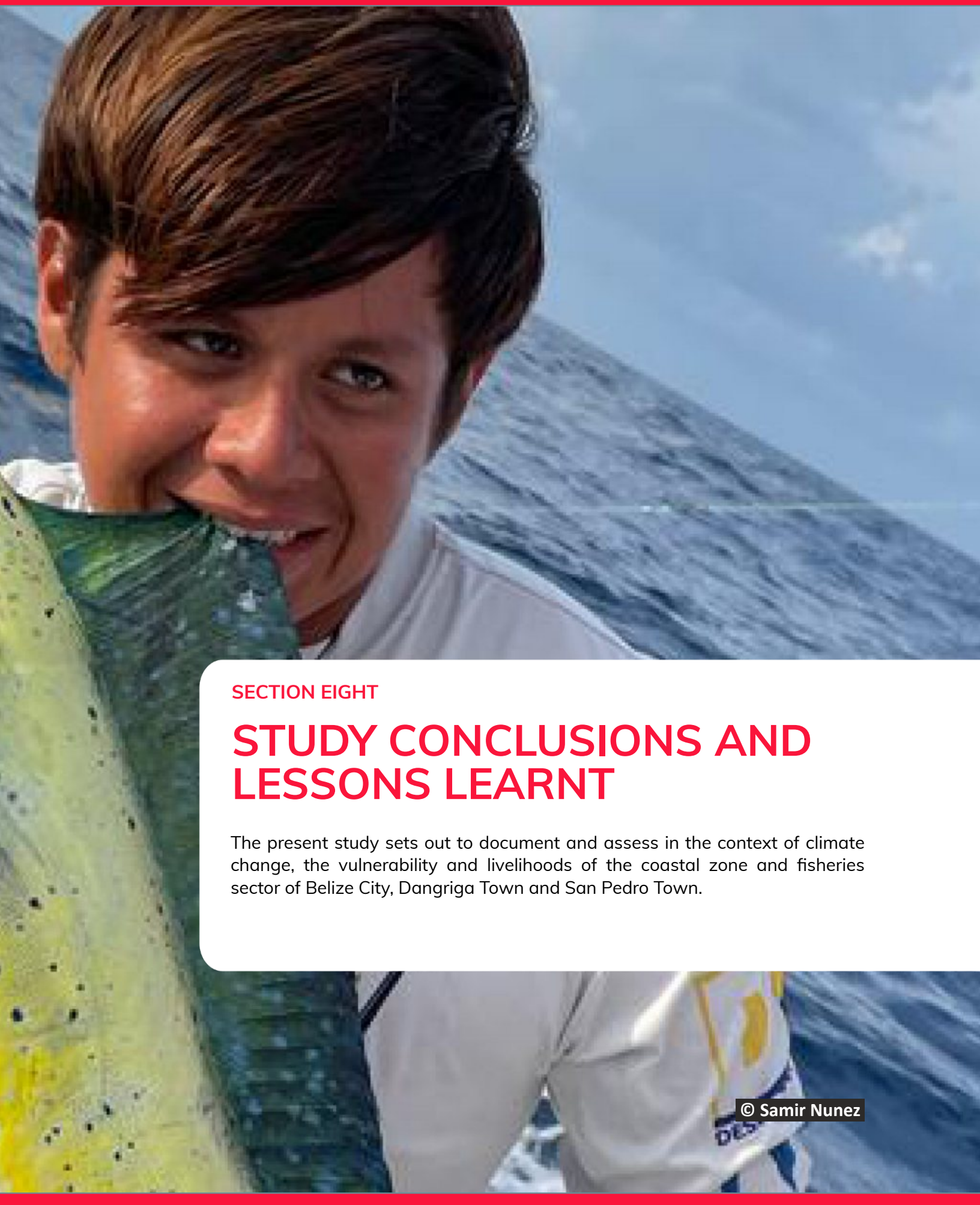
ECONOMIC VULNERABILITY AND LIVELIHOODS: The assessment shows that climate change is playing a significant role in determining the economic growth and prosperity of the communities under focus in this study.

BELIZE CITY COASTAL ZONE AND FISHERIES SECTOR: Belize City is the largest population hub, business concentration and location of critical infrastructure. It faces exposure to climate change through flooding, storm surges, and erosion, among others. A large percentage of the working class does business or work in Belize City which, by virtue of its location, makes the sensitivity to climate change high. It is the hub for landing and marketing of products.

DANGRIGA TOWN COASTAL ZONE AND FISHERIES SECTOR: Home to the Garifunas, this town is home to a vital component of Belizean cultural tapestry, manifested in the food, customs, and religious practices. Many of its residential buildings are poorly constructed. Flooding is one of the significant exposures faced by residents and businesses. The economy is centered on farming with limited diversification. Several of the fisherfolks are the sole generators or the most crucial source of income for a household, and for many of the fisherfolks, their only occupation.

SAN PEDRO TOWN COASTAL ZONE AND FISHERIES SECTOR: One of the largest tourist-based destinations in Belize, it is a thriving economic hub centred on tourism related services. Its economic prosperity is evident in the infrastructure being more suitably built to withstand some of the variabilities of climate change. Many of the fisherfolks have dual occupations working in the tourism sector as well as the fisheries sector.

In summary, vulnerability varies among communities and households, mainly due to the differences in their dependence on the various economic sectors. However, this assessment has revealed significant evidence that vulnerabilities in the fisheries sector are more consequential to livelihoods and human wellbeing when compared to the other sectors operating in the coastal zone of Belize. This is caused mainly by high exposure, sensitivity and limited adaptive capacity.



SECTION EIGHT

STUDY CONCLUSIONS AND LESSONS LEARNT

The present study sets out to document and assess in the context of climate change, the vulnerability and livelihoods of the coastal zone and fisheries sector of Belize City, Dangriga Town and San Pedro Town.

8.1 KEY CONCLUSION RELATED TO THE PRINCIPAL STUDY PURPOSE

The major conclusions are as follows:

STRENGTHS

- The activities within, and by extension the Coastal Zone and Fisheries sectors, are key underpinnings to providing livelihood options in several forms including means of earning a living, long-term employment, survival, support and quality of life.

- The fisheries sector serves as a key employer as a key section of the Belizean society is engaged as full-time, part-time, occasional or unspecified workers.

- Belize City, Dangriga Town and San Pedro Town, while being centres of livelihoods, are refuge for dwelling, raising families, creating communities and serving as recreational areas which are all supportive of human wellbeing.

WEAKNESSES

- These attributes identified above are being eroded due to the challenges emanating from climate change, whereas livelihoods are threatened, recreational assets are being lost and places of dwelling are being impacted.

- While climate change is inserting itself in everyday lives and activities, one of the major challenges is the paucity of adaptation support to minimise the concerns posed by the increasingly disruptive phenomenon.

- Climate change as a phenomenon, its impacts as it relates to the specific stakeholder groups, and options to adapt are not communicated or information not accessible for easy understanding. These make climate change seem as solely a problem which cannot be overcome as evident by stakeholders' views (Figure 24)[15].

OPPORTUNITY

- Options to stem the negative influences of climate change offer opportunities to ensure the continued harnessing of and use of the natural resources, the ecosystem services and established infrastructure, and amenities to enhance human well-being vis a vis enhancing the resilience to climate change.

THREAT

- The absence of support and incentives to make the gradual and necessary shift required is leaving the businesses and livelihoods to very high exposure and significantly vulnerable to the effects of climate change. This is a recurring observation, albeit in varying magnitude in sites studied in this assessment.

[15] In the consultations, participants were asked to describe what is their understanding of climate change using a maximum of three words or less. Figure 24.

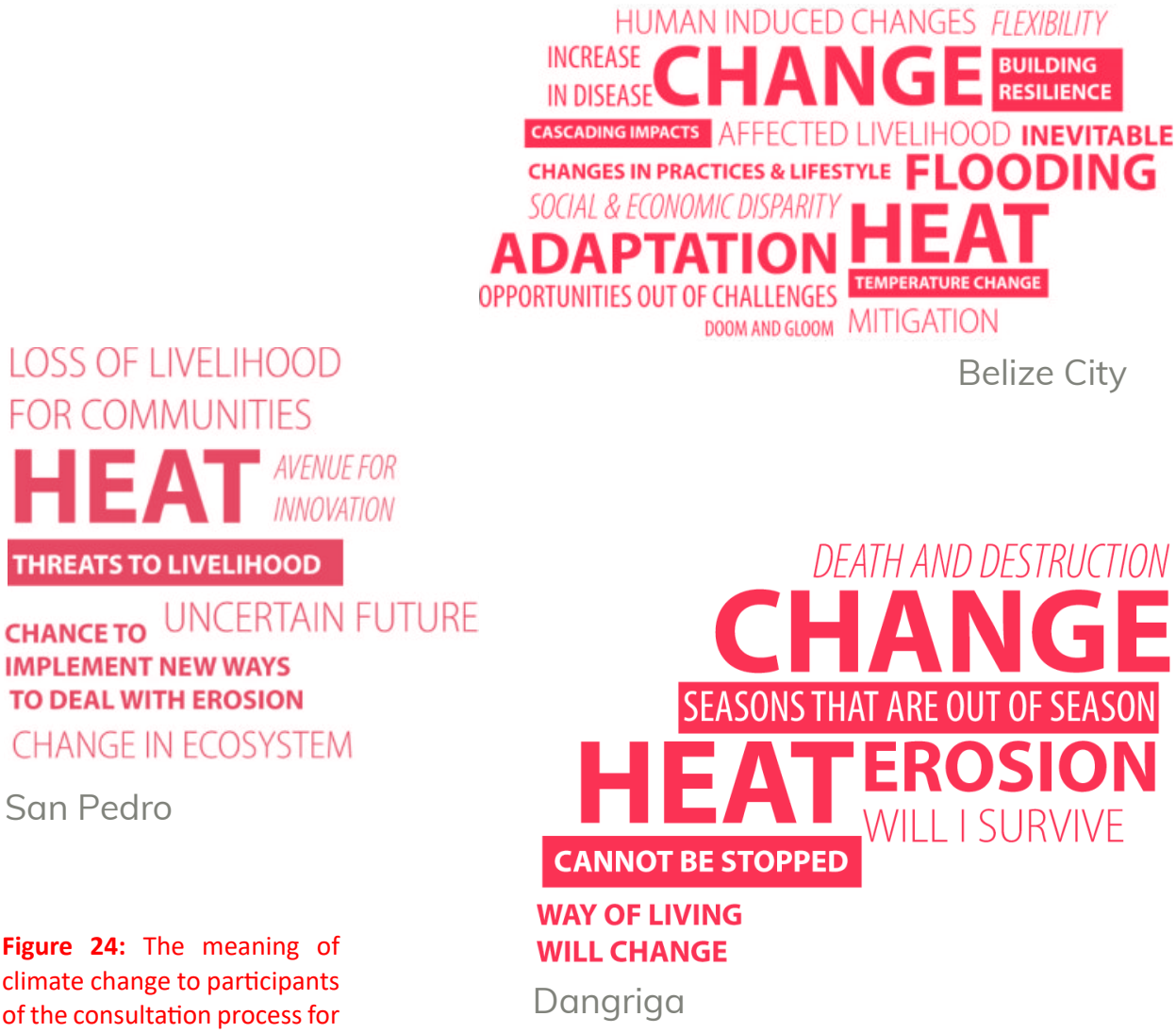


Figure 24: The meaning of climate change to participants of the consultation process for this assignment.

8.2 LESSONS LEARNT ON IMPLEMENTING LIVELIHOOD FOCUSED INTERVENTIONS

An understanding of the complexity and integrated nature of livelihoods allows for a better understanding of their vulnerability to shocks and stresses with respect to climate change. The lessons learnt in this subsection are aimed to help guide interventions focused at enhancing, sustaining and or creating new livelihood options in the coastal zone and fisheries sector in Belize.

LESSON LEARNT #1:

Diversifying livelihood options by moving from a specific focus on a single sector to a broader emphasis on communities will enhance and hasten the adaptation to climate change.

THE ADVANTAGE OF THIS APPROACH: Using such an approach will help to gradually shift the dynamic of relying on a single activity for income to a more multi-source basis. It will also help to shift households that would rely on a single individual in a household as the 'breadwinner' to multi-earners. This will enhance women and youth participation.

AN EXAMPLE OF HOW THIS CAN BE APPLIED: In Dangriga Town, an overwhelming majority of the participants in the consultation spoke of being fisherfolk and the sole breadwinner with large families. In the off season (i.e., no lobster and conch season), it becomes financially difficult to sustain a family. Therefore, if more options can be created for employment (with a view of utilising the existing skillset) then this can in the long-term enhance resilience. For example, Dangriga is a known agricultural hub with a significant level of traditional knowledge which can be reinvigorated to a more vibrant income stream.

THE REQUIRED ENABLING TOOL: Revisiting livelihood-focused interventions using a community-based approach involving holistic planning with all sector agencies and stakeholder involvement is key to success.

LESSON LEARNT #2:

Tailored training and ongoing capacity building for vulnerable stakeholder groups to be empowered.

THE ADVANTAGE OF THIS APPROACH: Empowerment through knowledge and understanding is critical to hastening adaptation, build resilience, enhance entrepreneurship and accepting change concerning harmful practices which are counter-productive to sustainable resource management.

AN EXAMPLE OF HOW THIS CAN BE APPLIED: The fisherfolks who were engaged in the consultation process for this assignment have overwhelmingly identified the need for more information. Many alluded to lack of information specially geared to the fisheries. In addition, many felt a disconnect with the relevant authority.

THE REQUIRED ENABLING TOOL: A strengthening outreach programme within the Belize Fisheries Department will be key to such an empowerment agenda among the fisherfolks.

LESSON LEARNT #3

Long-term financial support mechanisms are needed in delivering sustainable livelihoods

THE ADVANTAGE OF THIS APPROACH: Having access to loans, grants and insurance coverage are some of the crucial elements to building resilience.

AN EXAMPLE OF HOW THIS CAN BE APPLIED: For example, insurance can be a key tool in reducing vulnerability and promoting resilience. Access to and uptake is a step away from crisis and a move towards risk management, thereby strengthening socio-economic resilience under a changing climate.

THE REQUIRED ENABLING TOOL: In creating a sound financial environment, a multipronged approach will be helpful by (a) fostering the building of strategic partnerships between stakeholders and relevant public sector agencies; (b) developing or facilitating access to sustainable financing initiatives; and/or (c) building the capacity of stakeholder organisations to access grants and other types of funding which may be available.

LESSON LEARNT #4:

Implementing livelihood focused interventions require prioritization of monitoring and evaluation into programming.

THE REQUIRED ENABLING TOOL: Monitoring and evaluation need to be built into interventions. However, they should not be too complex, given that they can be important mechanisms for learning from stakeholders.

THE ADVANTAGE OF THIS APPROACH: Participatory feedback mechanisms (involving beneficiaries and technical liaisons). These approaches provide a framework for learning by doing and avoiding mistakes.

AN EXAMPLE OF HOW THIS CAN BE APPLIED: This is critical to every sector and stakeholders if sound participatory approaches are to be normalised as part of the pathway toward country-wide adaptation planning.

LESSON LEARNT #5:

Should livelihood focused interventions include alternative or additional livelihoods, then the latter design and implementation should be based on suitability for intended target group and designed in communication with the intended target group.

THE ADVANTAGE OF THIS APPROACH: Alternative or additional livelihood initiatives can present new opportunities if they are suitable. However, if alternative livelihood is unsuitable, for example in the fisheries sector, the potential of alienation due to the inability to adapt can lead to loss in interest in participating, resulting in failure.

AN EXAMPLE OF HOW THIS CAN BE APPLIED: Already there is evidence of additional livelihood options in the fisheries and tourism sectors in Belize, many of which indicate positive signs of economic benefits. The applicability of such options is very relevant in many of the low mechanised resource extraction sectors and employment generation areas.

THE REQUIRED ENABLING TOOL: It is also important to ensure that market opportunities for alternative livelihoods exist, coupled with strong endorsement at the decision-making level, governance mechanisms tailoring to support growth and financing access.

8.2 COVID 19 RECOVERY FOR LOCAL COMMUNITIES

The COVID-19 pandemic that was declared as a global emergency in March 2020 affected countries on all continents. The majority of countries, including Belize, instigated strict interventions (some forms of lockdown) and border closure to slow down the spread of SARS-CoV-2. During that period, several sectors completely shuttered their operation, while others moved to a remote working modality with the exception of the fisheries sector which had access, albeit limited. Belize City, Dangriga Town and San Pedro Town were spared no exception in the lockdown. One of the most identifiable challenges is the unprecedented economic hardship this pandemic brought to several households in these areas. While fisherfolks spoke of limited disruption to their occupation, it was still a significant level of hardship as residents were unable to purchase seafoods. However, at the completion of this assessment, the economic challenges which were present during the pandemic have now subsided as Belizeans in these communities return to some level of normalcy. Having now a retrospective view, it gives an opportunity to consider options for reducing the livelihood impacts should there be another similar situation. These options are discussed in the proceeding section.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SECTION NINE

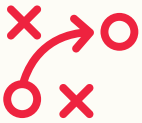
RECOMMENDATIONS TO REDUCE VULNERABILITY AND BUILD RESILIENT LIVELIHOODS

Although the people and businesses in these communities are heterogeneous and operate within varying rationalities, the types of vulnerabilities they face are common to a large extent. Therefore, enhancing adaptation through supporting schemes can serve to empower them as agents of change, which over time, will continually shift the paradigm towards the required transformative change to enhance climate resilience.

The proposed recommendations were supported by input from the stakeholder engagement process. Perhaps, these can be mainstreamed into national sector-based adaptation strategies. In addition, the lessons learnt which were provided in the preceding section can also be used to support action in livelihood interventions.

PRIORITIZE PROTECTION AND DEFENCES TO SAFEGUARD ASSETS AND INFRASTRUCTURE IN THE COASTAL ZONES: Efforts must continue to safeguard shoreline and coastal areas in order to protect public and private investments, assets, and services, especially in Belize City. Underlying this effort would be the need to energise urban and land use plans to influence development and avoid or restrict development in high-risk areas.

STRENGTHENING FINANCIAL RESILIENCE VIS-A-VIS AFFORDABLE INSURANCE AND LOANS: Insurance can be a key tool in reducing vulnerability and promoting resilience. Access to and uptake of finances are only a step away from crisis and a move towards risk management, thereby strengthening socio-economic resilience under a changing climate. While this can be a private sector offering, the enabling environment must be created by the government to attract these types of investments in Belize.



CONSIDER SOFT RETREAT STRATEGY AS AN OPTION FOR LONG TERM ADAPTATION: Managed retreat is a powerful tool to adapt to climate change effects. In particular, consideration should be given to "setbacks" that either require new development to be a minimum distance from the shore or restricted in density. Building better should be at the forefront of new investments.

BOOST ADAPTIVE CAPACITY WITH INFORMATION AND COMMUNICATION: Stakeholders need help in overcoming obstacles to adaptation arising from a lack of information on climate change at all levels. Creating targeted messages is vital to providing the incentives to adapt. Tools such as early warning systems are important adaptive measures for climate change. Their use of integrated communication systems has proven to be effective in saving lives, infrastructures, and supports long-term sustainability planning.

STRENGTHEN THE MECHANISM FOR INFORMATION SHARING AMONG THE PRIVATE SECTOR: Given the high level of exposure of businesses, more effective cohesion among the Chamber of Commerce, business entities, and associations can help build greater awareness and stronger advocacy to support growth and climate proofing in the sector. To facilitate such, one avenue is to strengthen the flow of information between businesses and relevant ministries, perhaps via the Chamber of Commerce.

INCENTIVISE CLIMATE CHANGE ADAPTATION: Reducing vulnerabilities in the coastal zones of Belize means that the multitude of businesses continue to take measures to climate proof their investments. In this regard, the government can provide incentives for businesses wishing to enter or increase their share in the supply, installation, or maintenance of adaptation commodities by revisiting the import tariffs of products that support climate change adaptation or by providing concessions.

DEVELOP A STRATEGY FOR RESEARCH AND DEVELOPMENT TO INCREASE PRIVATE SECTOR INVOLVEMENT IN CLIMATE CHANGE ADAPTATION: Providing evidence-based approaches to support investments or scaling up investments can help to better guide the targeted intervention that is necessary. Information, whether absent, weak, or poorly disseminated, hinders the private sector scale-up or the entry of SMEs into ventures that support climate change-related goals. The private sector will invest where they see opportunities to increase efficiency, lower costs, or improve the value that they provide to customers. Hence providing information can help, for example, by providing evidence-based information on energy audits. Providing energy audits to firms can identify the need for savings and trigger investments in energy-saving equipment that in turn support climate change actions. Documenting these measures can assist with knowledge transfer and uptake elsewhere.

EMPOWER THE PRIVATE SECTOR IN IDENTIFYING CLIMATE CHANGE RISKS, RESPONSE MEASURES, AND ADAPTATION NEEDS: This will catalyse greater investment in vulnerability reduction and accelerate the replication of climate-resilient and smart technologies and services into the development sector. The private sector can be disaggregated based on the firm size, capabilities, etc., alongside a modality of how the government supports them.

COMMITTING TO A MORE SUSTAINABLE MANAGEMENT REGIME IN THE FISHERIES SECTOR: Recognising the several efforts already in place in the sector, the management regimes should be further enhanced to reduce anthropogenic pressures on the sectors. The following are proposed:

- Improve data collection to better inform management and enforcement. Consider the use of citizen science to support data collection.
- Undertake periodic stock assessments to scientifically determine limits on the total number of conch and lobsters caught and landed in an effort to stabilize stock and decrease chances of potential over-exploitation.
- Enhance trained staff, data collection and evaluation mechanisms to ascertain existing fisheries resources.
- Consider the extent to which specific and general sustainability principles and standards can be used to replenish depleted fish stock.
- Consider expanded financial products to support fisheries management such as performance bonds and fees for inspections and observers.

PROVIDE SHORT TERM SUBSIDIES TO SUPPORT COVID-19 RECOVERY: Recognising that the level of normalcy is slowly returning, the recommendations outlined in 1-8 will indirectly help to build stronger economic resilience which in turn support COVID 19 recovery. However, some additional support is proposed below:

- Consider short term subsidies to help alleviate household income shortfall.
- Where heads of households would have died from COVID-19, consider providing grants for a period of time.

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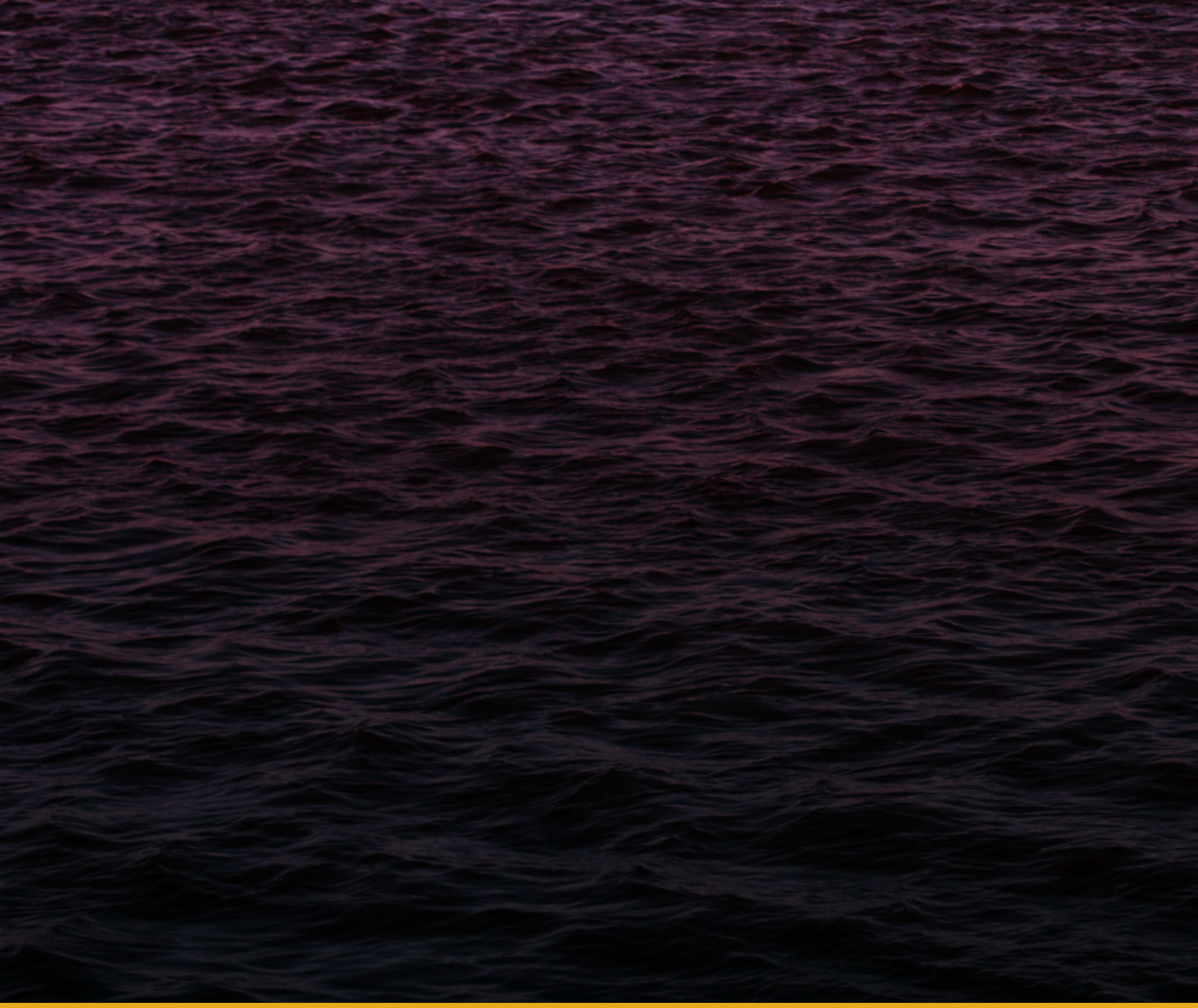

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