Evaluation of spatial fragmentation of protected areas using the Spatial Assessment for Coastal Protected Areas in Caribbean Small Island Developing States

Volume 1

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Acknowledgments

“It takes a village” – African Proverb

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This thesis is presented as an original contribution based on Doctor of Philosophy research at University of Salford, Salford, United Kingdom and has not been previously submitted to meet requirements for an award at any higher education institution under my name or that of any other individuals. To the best of my knowledge and belief, the thesis contains no materials previously published or written by another person except where due reference is made.

Signature; ....

Date 2/11/2020

LIST OF ABBRIEVATIONS

Belize MEE	Belize Management Effectiveness Evaluation
BIOPAMA	Biodiversity and Protected Areas Management
C3A2	Community Climate Change Adaptation Assessment
Catalonia MEE	Catalonia Management Effectiveness Evaluation
CATIE	Agricultural Center of Tropical Investigation and Teaching
CONANP	National Commission of Protected Areas of Mexico
CSD	Conservation Subdivision Design
CSO	Combined Sewer Outflow
CURSA	University Consortium for Socioeconomic and Environmental Research
CVA	Coastal Vulnerability Assessment
CVC	Climate Variability Change
CVI	Coastal Vulnerability Index
DHL	Dalsey, Hillblom and Lynn
DOPA	Digital Observatory for Protected Areas
Ecuador MEE	Ecuador Management Effectiveness Evaluation
EOH	Enhancing Our Heritage
Finland MEE	Finland Management Effectiveness Evaluation
Galapagos MEE	Galapagos Management Effectiveness Evaluation
GIS	Geographic Information Systems
ICZM	Integrated Coastal Zone Management
Indian MEE	Indian Management Effectiveness Evaluation
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LC-IMPACT	Life Cycle Impact Assessment
LCZ	Local Climate Zone
LUISA	Land-Use based Integrated Sustainability Assessment
LULC	Land Use Land Cover
MARIPA-G	Monitoring and Assessment with Relevant Indicators of Protected Areas
MEMS	Metodología medición de la efectividad del manejo
METT	Management Effectiveness Tracking Tool

MEVAP	Monitoring and Evaluation of Protected Areas
Mexico SIMEC	Mexico System of Information, Monitoring and Evaluation for Conservation
MPA	Marine Protected Area
MSP	Marine Spatial Planning
MSW	Municipal Sewer Waste
MTT	Marine Tracking Tool
PA	Protected Area
PAPs	Protected Area Practitioners
PASSA	Participatory Approach for Safe Shelter Awareness
PiP	Parks in Peril
PROARCA	Programa Ambiental Regional para Centroamérica
Qld Park Integrity	Queensland Park Integrity
RAPPAM	Rapid Assessment and Prioritization of Protected Area Management
RIS	Reference Information Systems
RMETT	Ramsar Management Effectiveness Tracking Tool
SACPA	Spatial Assessment for Coastal Protected Areas
SIDS	Small Island Developing State
SLR	Sea Level Rise
SNAP	National System of Protected Areas
SPNG	Servicio Parque Nacional Galapagos
SPSS	Statistical Package for Social Science
SVI	Social Vulnerability Index
T&T	Trinidad and Tobago
TNC CAP	The Nature Conservancy Conservation Action Planning
UHI	Urban Heat Island
USAID	United States Agency for International Development
WCPA	World Commission on Protected Areas
WIO MPA	West Indian Ocean Marine Protected Area
WMO	World Meteorological Organization

ABSTRACT

Climate change empirical evidence points towards anthropogenic practices, coupled with natural processes causing heighten human exposure to hazardous climatic conditions. Caribbean Small Island Developing States (Caribbean SIDS) represent a distinct group of developing countries where populations are regulated to living in coastal zones due the geographic size of the islands. The disaster risk implications to communities in coastal zones is greater due to the climate change consequences of sea level rise along with the increase frequency and intensity of storms. Although there is substantial research to support the retention of contiguous coastal ecosystems as a response to disasters, coastal ecosystems in Caribbean SIDS are plagued with the continued human encroachment. Resulting in heighten vulnerabilities for burgeoning coastal communities.

Of particular concern to this research is the persistent increase of human settlements fostering the fragmentation of protected coastal ecosystems as existing studies to monitor the spatial fragmentation on protected coastal ecosystems in the Caribbean SIDS is limited. The Spatial Assessment for Coastal Protected Areas (SACPA) aims to address this research gap through a theoretical supported, open science approach that determines the extent of loss of natural habitat in coastal protected areas and reports on the context specific conditions that foster this trend. As a new contribution to research, the SACPA provides this necessary insight utilizing open science practices to ensure that the approach can be conducted with minimal technical proficiency. This research promotes accessibility to research in protected areas through an approach where data can be collected and analyzed by community stakeholders. Open science practices are also an integral part of community research designs as it ensures that the most vulnerable are able to access the data that could inform decisions on the growth of human settlements.

Through this research endeavor, the SACPA was developed and tested via mixed method, comparative case study research design. It uncovered that despite geographic similarities, the vulnerabilities of the coastal communities of the Caribbean SIDS are not inherently the same. Based on the findings of this research mixed method research design is recommended as an integral to context specific research. This type of research design revealed the political and cultural nuisances that influence human encroachment in Caribbean SIDS. It also reiterated studies that highlight spatial change as a function of human behaviour, namely that key political and socio-cultural practices impact spatial growth patterns and therefore foster vulnerabilities in coastal communities.

Chapter 1 : INTRODUCTION

1.1 Research Problem

Designated protected areas in hazardous coastal zones preserve natural ecosystem functions and promote disaster risk reduction by reducing the population's exposure to natural hazards (Paz-Alberto and Sigua, 2012; Kumar et al., 2017). In coastal protected areas, it is accepted in research that "integrating wetlands as natural infrastructure for disaster risk reduction, alone or in conjunction with traditional 'hard' infrastructure, can mitigate hazards and increase the resilience of local communities and those living across entire river basins or coastal zones" (Kumar et al., 2017; Peiling and Blackburn, 2014).

There is a global increased threat to the viability of coastal protected areas in the global landscape (Plumptre et al., 2014). These threats are a result of the encroachment of human settlements and the ever-present illegal extraction of natural resources (Plumptre et al., 2014; Andrade and Rhodes, 2012). Research also highlights that the implications to the loss of protected areas signifies the loss of biodiversity and climate resilience (Geldman et al., 2013; Mora and Sale, 2011; Selig and Bruno, 2010).

Nevertheless, limited resources and knowledge gaps persist in ensuring the integrity of these protected areas. Of particular concern to the research is the resilience of Caribbean SIDS to the impact of natural disasters due to their geographical location and physical size (Chatenoux and Wolf, 2013; Gomes, 2014). Disasters that occur in coastal zones highlight the inherent conflicts between of human activity and natural processes that result in the vulnerabilities of human settlements (Small and Nichols, 2003). In developing countries, the landscape of coastal zones is rapidly changing due to the growth of human settlements. As development in coastal zones increase so does the susceptibility of the coastal communities. In an effort to determine the extent of vulnerability and to guide the creation of adaptation vulnerability indexes and adaptation assessments are widely utilized. However, amid advancements in climate change adaptation research the conditions in the Caribbean SIDS remain the same.

The increasing threat of sea- level rise and severity of storms in the Caribbean SIDS makes resilience a priority, especially with the majority of the population residing in coastal areas (Beckford, 2018). Based on this climate related threats coastal locations throughout the Caribbean were designated as protected areas through the Ramsar Convention. The designation of Ramsar sites represent the importance of the preservation of wetland resources to address the growing changes to the climate and is seen as key sources for climate change adaptation (Nicholls, 2004; Renaud et al., 2016), carbon sequestration (Post and Kwon, 2000; Alongi, 2012); protected areas (Dudley et al., 2015); disaster risk management planning (Renaud et al., 2013).

The designation was also intended to reduce the development in coastal wetlands by emphasizing the eco-system benefits to country by retaining the natural habitat (Ramsar, 2017). Although these protected areas are designated by international agencies to ensure the protection of biodiversity and increased resilience to the impacts of climate change, their everyday management is the responsible of national authorities and local organizations (Vergara-Ansenjo and Potvin, 2014; Hausner et al., 2015). As a result, there is a continual reduction in the size of natural coastal ecosystems in the Caribbean with the primary culprit being a steady rise of human encroachment from bourgeoning populations (Small and Nichols, 2003). The objectives of the designation are often difficult to achieve resulting in the loss of natural coastal habitats and the increased vulnerability of populations in the Caribbean. This continued loss of the natural habitat of coastal protected areas provide further evidence of the challenges in management effectiveness of these protected areas.

The International Union for Conservation of Nature (IUCN), leading agency for the research and protection of protected areas, developed the World Commission on Protected Areas (WCPA) with the task of assisting governments with the strategic planning and management of protected areas (IUCN, 2016). With over 50 years of experience the IUCN defined management effectiveness evaluation as a measurement of how a protected area achieves its goals and objectives. The three main themes in determining effective management are outlined as design issues relating to the sites; adequacy and appropriateness of management systems; and delivery of protected area objectives (IUCN, 2016; Hockings et al 2006). The IUCN-WCPA developed a management effectiveness evaluation framework as an established system to evaluate the challenges protected area designation. The framework is not a methodology but is a guide that relies on six elements to gain a deeper knowledge of the social, cultural, economic and spatial challenges to effective management of the protected areas (Hockings et la. 2006).

As a result, the framework for management effectiveness is based on the elements of context, planning, inputs, processes, outputs and outcomes (IUCN, 2006). As Figure 1-1 reflects under the context, the focus is an assessment of threats, policy environment and importance with criteria of significance, values, threats, vulnerability, stakeholders and national context (IUCN, 2006; Borrini-Feyerabend, 2007). Under the planning, the focus is an assessment of protected areas design and planning with criteria of legislation, system design and management planning (IUCN, 2006). Under the inputs, the focus is an assessment of resources to carry out management with criteria resources available towards the management (IUCN, 2006).

Under the process the focus is an assessment of the way management is conducted with the criteria suitability of the management processes (IUCN, 2006).

	Design		Appropriateness/Adequacy		Delivery	
Elements of management cycle	**Context**	**Planning**	**Inputs**	**Process**	**Outputs**	**Outcomes**
Focus of evaluation	Assessment of importance, threats and policy environment	Assessment of protected area design and planning	Assessment of resources needed to carry out management	Assessment of the way in which management is conducted	Assessment of the implementation of management programmes and actions; delivery of products and services	Assessment of the outcomes and the extent to which they achieved objectives
Criteria that are assessed	Significance/ values Threats Vulnerability Stakeholders National context	Protected area legislation and policy Protected area system design Protected area design Management planning	Resources available to the agency Resources available to the protected area	Suitability of management processes and the extent to which established or accepted processes are being implemented	Results of management actions Services and products	Impacts: effects of management in relation to objectives

Figure 1-1: IUCN-WCPA Framework (IUCN, 2006)

Under the outputs the focus is an assessment of the implementation of management programs with the criteria of the results of management actions (IUCN, 2006). Under the outcomes the focus is an assessment of how the outcomes achieve the objectives with the criteria of the effects of management to the objectives. It is a guide towards the development of assessment systems (IUCN, 2006).

This framework was formulated as a guide to protected area practitioners (PAPs) and provide a general direction monitoring the effectiveness of the protected area. As a guide it provides the opportunities for PAPs to develop site specific evaluations based on the unique conditions of their locations. The framework has been the basis for numbers of management effectiveness tools to determine the effectiveness of protected areas throughout the world. These tools of assessments largely focus on shorter evaluation periods, yields generalized ratings and generalized tasks for improving management effectiveness. The problem of encroachment on protected areas still persist despite the existence of these tools based on a framework developed by the WCPA.

The existing assessments developed based on the IUCN-WCPA framework are reliant on qualitative data collection and analysis to determine the effectiveness of protected areas. Quantitative data collection and analysis, namely spatial analysis is not comprehensively explored in these IUCN management effectiveness frameworks (Leverington et al., 2008; Borrini-Feyerabend, 2007). These limitations in measuring spatial change to determine effectiveness then have a direct impact on the ability of the protected area to achieve its peak natural ecosystem functions and support climate resilience. An approach has yet to merge the theoretical and practical aspects of evaluating spatial change in protected areas. In summation, the research problem is the exclusion of an evaluation on spatial change as a determinant for management effectiveness is a significant gap in the existing assessment tools.

1.2 Research focus

The pervasive obstacle to addressing the aforementioned research problem is the inherent divide between theoretical and practical approaches in spatial planning. The essence of planning land use models is a balance of determining whether science or policy receives priority in decision making (Bell and Ledeman, 2003; Couclelis, 2005). "Quantitative spatial assessments are often incomplete, dominated by environmental aspects whereas land uses are a multidisciplinary matter and environmental and sustainable development policies intertwine" (Burrough, 1989; DeRosa, 2018). Prevailing research into spatial analysis in protected areas focus on one or the other dismissing the importance of the social science considerations or the value of concrete data analysis to support social conditions (Moreaux, et al. 2018; DeFries and Eshleman, 2004).

Addressing these cultural and socio-economic gaps in spatial analysis is relevant in gaining knowledge on why protected areas are under threat from anthropogenic activities. Research reveals that only 22% of tropical protected areas have sound management, whereas only half of all are effective while human pressures are increasing (Gray et al., 2016; Watson et al., 2014). These pressures are summed up into the major impacts on protected areas including the conversion of farmland into other uses, the loss of forestry resources, the water quality or related supply problems, the changes as a result of global warming and rapid development (Hamilton et al., 2009; Marcelja, 2010).

Although, theoretical approaches to spatial planning and climate change adaptation emphasize emerging technologies at the community level (Ligtenberg et al., 2004; Couclelis, 2005) these technological advances have minimal impact in low-income, coastal communities (Ervin, 2003). Low-income coastal communities have limited access to technology and are heavily reliant on external technical support. Therefore, access to information is inconsistent and dependent on funding to support technologically advanced research (Luthar, 2003; Ervin, 2003). Due to the technical training required, theoretical approaches to emerging geospatial tools for land use analysis are not readily utilized in practical applications for protected areas management in the Caribbean SIDS. Strategic planning processes need to adapt to changing contextual conditions to determine what is the most effective way to disseminate the information needed for the intended users (Albrechts, 2015). Limited access to these spatial planning tools restricts informed decision making and increase the vulnerability of communities on the front lines (Couclelis, 2005).

The focus of this research is the development of a theoretically sound methodology delivered through a context specific, practical application to reduce the knowledge gaps in decision making for protected area management effectiveness in Caribbean SIDS. This is based on the limitations of the current effectiveness evaluation framework to evaluate the extent that anthropogenic activities encroach on the natural habitat in protected areas. Therefore, the new contribution to research is the use of theoretical methodologies to develop a spatial assessment that evaluates the physical extent and social conditions that foster encroachment in coastal protected areas. Social considerations are applicable to this research based on the knowledge that spatial organization is a construct of social and cultural conditions. Therefore, this research will move beyond an emphasis on a quantitative, spatial analysis to include qualitative factors that impact spatial change.

1.4 Problem Statement

Existing approaches to evaluate the effectiveness of coastal protected areas Caribbean SIDS are not comprehensive. Without an assessment to evaluate spatial change unmonitored, human encroachment will continue to undermine the effectiveness of coastal ecosystems.

1.3 Aim

To evaluate the extent of spatial fragmentation in coastal protected areas in Caribbean SIDS in using a novel open science, spatial assessment approach.

1.4 Objectives

Specific objectives include:

1. To review of climate change vulnerability and disaster risk reduction principles

This objective is a review of the climate change vulnerability and disaster risk reduction principles to support the case for disaster risk reduction. The terms relevant to this discussion are reviewed to clarify how protected areas contribute to disaster risk reduction.

2. To outline the gaps in existing protected area effectiveness assessments

This objective is a critical review of the current discourse on protected areas management effectiveness assessments as tools that monitor the viability of protected area ecosystems. All the existing management effectiveness frameworks based on the IUCN-WCPA resources were discussed to identify the gaps in the current assessments and whether these assessments effectively support measures towards disaster risk reduction.

3. To review theoretical spatial planning methodologies

Central to the research is use of theoretical sound methodologies towards disaster risk reduction. This objective reviews research on planning theories relevant to the development of the spatial evaluation that address the existing gaps. This objective is meant to provide a comprehensive review of the literature on theoretical planning approaches as the foundation to the development of the Spatial Assessment for Protected Coastal Areas.

4. To develop the Spatial Assessment for Protected Coastal Areas (SACPA) approach

This objective will outline SACPA highlighting a reliance on a sound research theory. It will discuss how the theoretical approach is a new contribution to the literature on protected area management effectiveness and outline how this approach should be conducted.

5. To test of the SACPA Ramsar sites in a comparative case study within Caribbean SIDS

This objective is to test the SECPA on the basis of its application to two selected case studies in Trinidad and Tobago and Belize, two SIDS within the Caribbean. The information for this objective will be obtained through documents, interviews and spatial analysis.

6. To report on the results namely the extent of loss in protected areas of Ramsar sites in Caribbean

This objective is to collate the information obtained in the case study in a report format to revealing whether conditions are the same in both locations and what conditions impact the changes in development. Dissemination of the tool is written in a report format to provide detailed information of the information obtained.

7. To provide recommendations based on findings

Based on the research findings recommendations of the best practices on spatial organization that supports climate resilience in coastal protected areas will be provided

1.5 Structure for this research

This research is imperative since despite the existence of vulnerability studies, the involvement in Ramsar designation, there is still an increase of development in coastal zones within Caribbean SIDS. It does not aim at filling the gaps in Ramsar site management in the Caribbean, instead it analyses the extent of spatial change in Ramsar sites to highlight the pervasive challenges to climate change resilience and disaster risk reduction in coastal zones in the Caribbean.

This research explores a mixed-method approach as each method yields information that is key to obtaining the information that is relevant to the research (Amaratunga et al., 2002). Additionally, a comparative case study is utilized to understand whether conditions are the same throughout the Caribbean SIDS. Accordingly, this research will systematically (1) review of climate change vulnerability and adaptation principles (2) review theoretical spatial methodologies (3) outline the gaps in existing protected area effectiveness assessments (4) develop the SACPA methodology (5) test the SACPA for Ramsar sites in a comparative case study within Caribbean SIDS (6) report on the results namely the extent of loss in protected areas of Ramsar sites in Caribbean (7) provide recommendations for best practices on protected area spatial management to address built environment encroachment.

Figure 1-2 is a visual representation of organization of the structure of the research and the objectives that will be addressed in each chapter.

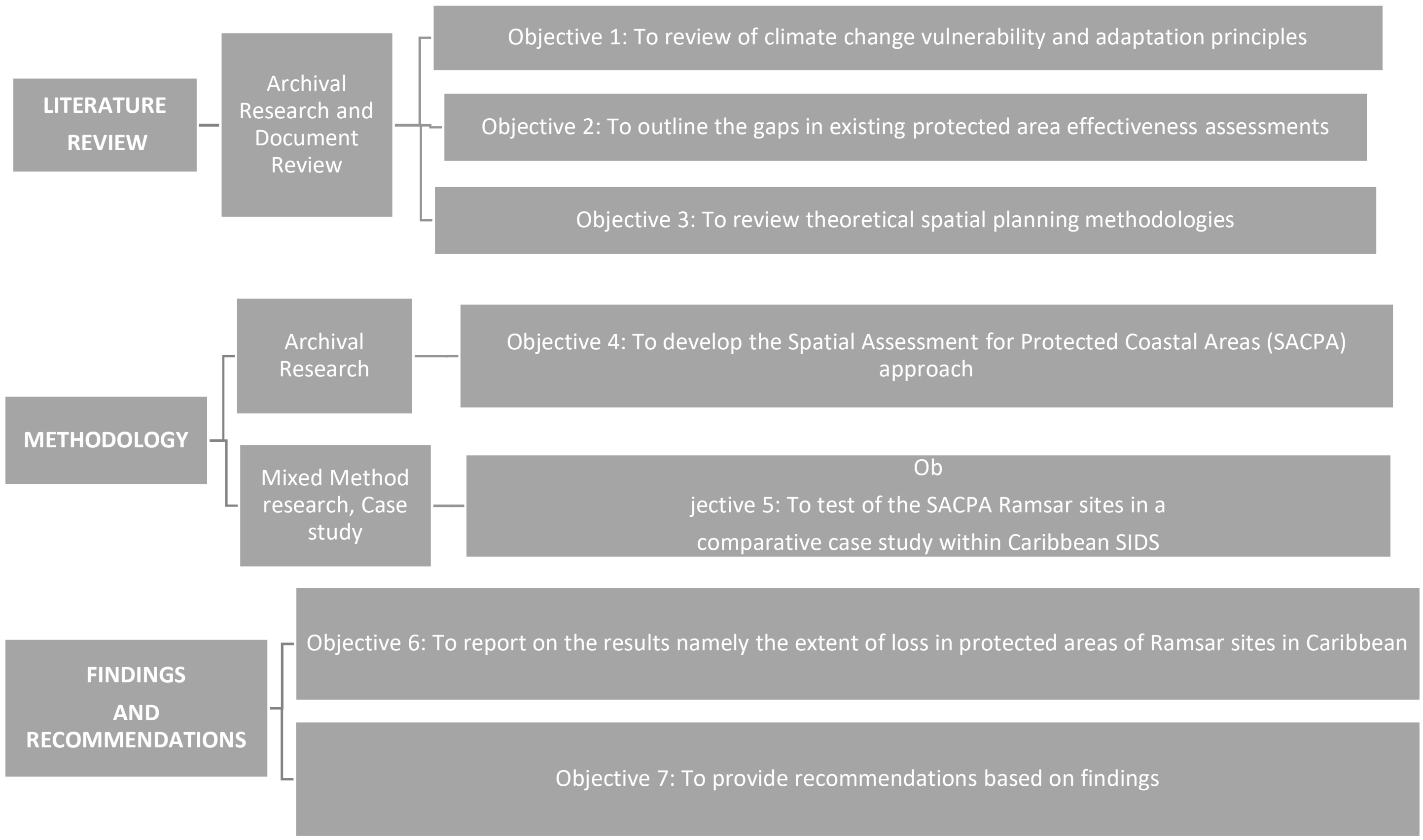


Figure 1-2: Research structure and objectives (created by author)

Based on the objectives, the organization of the chapter's information are as follows:

Chapter 1: As the introductory chapter, it establishes the groundwork for the research problem and focus. It outlines the aim and the objectives of the research. The structure of the research and a brief description of each of the chapters is available in this chapter.

Chapter 2: The literature review chapters address the gaps in the existing assessments and informs the creation of the assessment. The first chapter provides definitions for the key terms of the research. Vulnerability and adaptation are defined in detail. As a measure of disaster risk reduction in coastal communities, monitoring the effectiveness of coastal protected areas is discussed. To outline the new contribution to research the gaps in existing assessments to monitor spatial fragmentation are identified.

Chapter 3: The second literature review chapter provides a review of methodologies utilized to conduct spatial research. The literature review chapter will utilize archival research and document review to address the objectives of reviewing the vulnerability within Caribbean SIDS; the natural infrastructure preservation to address climate change vulnerabilities; and the existing effectiveness methodologies towards preserving the natural infrastructure in protected areas.

Chapter 4: The research methodology chapter outlines the importance of theoretical approach to research; and describes the approach for the spatial assessment. The chapter reviews the standard research methodology while conducting research namely philosophies, approaches, strategies, choices, time horizons, techniques and procedures. The section also reviews data collection and analysis for quantitative and qualitative data. The selection of data collection strategies and the presentation of the data collected outlines the choices of researcher to conduct the spatial assessment utilizes open science.

Chapter 5: The findings chapter is the information obtained from conducting the spatial assessment through a mixed method data collection and analysis. It also contains the comparative analysis of the case studies. This is done to address the objectives of determining the extent of spatial change in the costal protected areas.

Chapter 6: Contains the conclusions on the performance of the spatial assessment and the new contribution to knowledge. This chapter also contains future work and recommendations for this area of research.

Chapter 2 : LITERATURE REVIEW – RESEARCH PROBLEM

2.1 Introduction

The purpose of a literature review in research is to extensively investigate the existing information on the research topic and establish the need for a new contribution to the research (Torraco, 2005; Wee and Banister, 2016). This literature review is an initiation to the themes central to this research and verification that this research can provide new contribution to the discourse on protected areas management in Caribbean SIDS. The systematic approach to the literature review is based on the aim of this research to determine a novel spatial and participatory approach to assessing effectiveness of designated protected areas in Caribbean SIDS. To achieve this, an examination of the main terminology of the research is coupled with a review on theoretical approaches to spatial, planning and planning controls.

The literature review is organized into two chapters illustrated in Figure 2-1. The first chapter provides a document review of the relevant terminology of the research and establishes the case for disaster risk reduction in Caribbean SIDS through the development of protected areas. This research supports the notation that protected area designation in areas prone to natural hazards promote disaster risk reduction. The research on climate change and disaster risk reduction is extensive so it is necessary for this research to review the established definitions.

After a review of terminology and the case for disaster risk reduction is established, a critical review of the existing tools to conduct assessments for protected areas is discussed. The assessments are critically reviewed to provide an example of limited theoretical underpinnings of the existing assessments and to reinforce the need for a spatial assessment approach to monitor the effectiveness of protected areas.

The second chapter is a critical review of the spatial planning theory and planning controls to inform the development of the SACPA approach. This section is imperative to establish a foundation of how a theoretical approach to protected area assessments is needed. Both literature review chapters provide evidence that SACPA must be developed with a sound research design as a new contribution to research in disaster risk reduction through protected areas management.

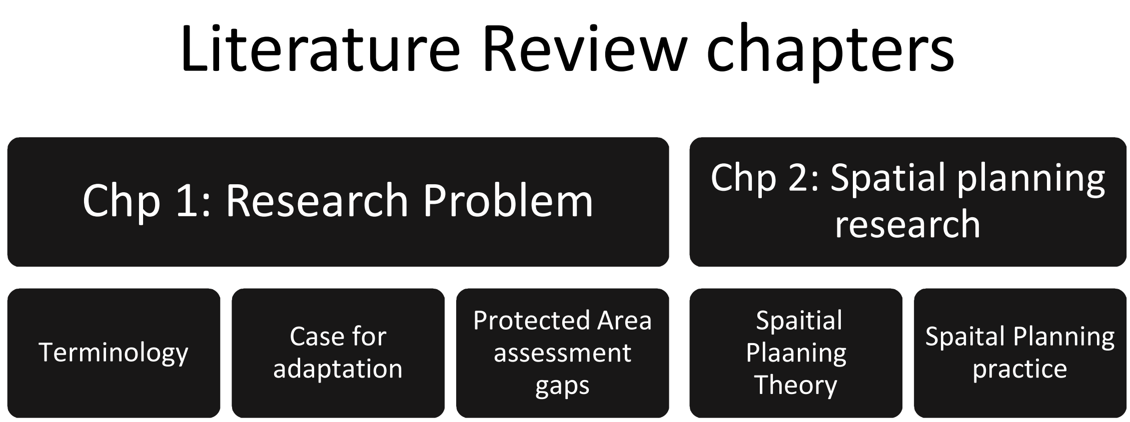


Figure 2-1 Organization of Literature Review (created by author)

2.2 Definitions

This section defines the terms that are relevant to the research. Reviewing the terminology provides the background to the ideas that are relevant to the research. As discussed in the previous chapter the theoretical approach to the research is imperative. With that knowledge defining the key terms is the first section of this literature review.

2.2.1 Climate Change

In 1996 The Intergovernmental Panel on Climate Change (IPCC)'s Working Group to the Second Assessment Report determined that there was a drastic variability in the global climate (IPCC, 1996). Namely an increase in global average temperatures from .3 to .6 Celsius over a 100-year period, an 1% increase in average global precipitation during the 20th century and the sea level rise of 15cm (IPCC, 1996). Although the determining factors for these changes in the climate were not fully examined the balance of evidence suggested a clearly identifiable human influence on climate change (IPCC, 1996).

Anthropogenic activities coupled with natural processes have been the main factors in the transformation of climatic conditions on earth: namely the warming of global climate temperatures as can be seen from the melting of the solar icecaps, worldwide sea level rise, and increased magnitude of storms (U S Environmental Protection Agency, 2016; Marcelja, 2010). As outlined in Figure 2-2 human practices across the globe have impacted ecosystems and reduced the accessibility of ecosystems services (Scheraga and Grambsch, 1998).

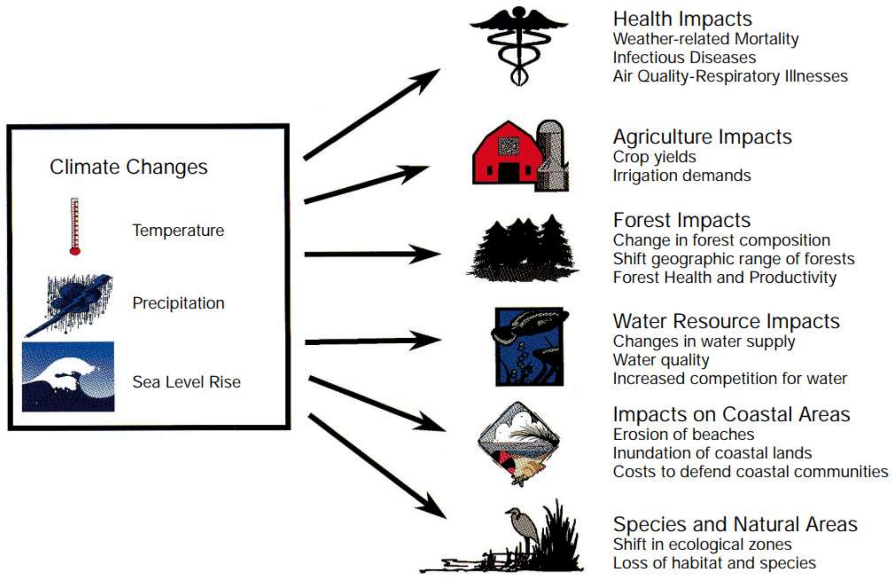


Figure 2-2: Outline of Climate Change Impacts (Scheraga and Grambsch, 1998)

The potential climate change impacts outlined include the health impacts – air/ quality respiratory illnesses, weather-related mortality and infectious diseases; agriculture impacts – irrigation demands and crop yields; forest impacts – shift in the geographic range of forests, forest health and productivity and change in forest composition; water resource impacts – water quality, changes is water supply and increased competition for water; impacts on coastal areas – costs to defend coastal communities, erosion of beaches and inundation of coastal lands; species and natural areas – loss of habitat and species and shift in ecological zones (Scheraga and Grambsch, 1998).

According to scientific research, by the year 2100 the global sea level rise is slated to be between 0.5m to 2.0 m* (Nicholls, et al., 2011). The warming of the earth temperatures is also likely to cause changes in precipitation. "A more active hydrologic cycle" is a result of an increase atmospheric water holding capacity (Easterling, 2002). This increase in the water vapor holding capacity will not only result in increased precipitation during storms, but can also contribute to larger storm surges and surface waves. It is noted that though warming of the climate may not necessarily increase the frequency of these storms, it is likely to result in an increase in storm severity that will have a significant impact on coastal regions (Church, Aarup, Woodworth, Wilson, 2010). These activities, increased frequency of storms or storm severity and their resulting impacts are commonly referred to as natural disasters.

For this research the definition of a natural disaster was adopted by the World Meteorological Organization (WMO) (2016) which outlines that a disaster greatly depends on the impact to human life. In disasters there is the conflict of human activity and natural processes, typically resulting in the damage to human activity and the calculation of time to return a state of natural equilibrium (WMO, 2016). A further description of the point can be illustrated through the detailed explanation of hurricanes. Aside from the know destruction, hurricanes can provide benefits such as the breaking up of bacteria that cause the red tide by providing oxygen to surface waters; helping to regulate global heat balance (The Weather Channel, 2016). More importantly hurricanes help the replenish barrier reef islands by slowly moving the sediments of the islands towards the land mass; and they also replenish inland plant life (The Weather Channel, 2016). Hurricanes are essentially important to the survival of coastal zones.

However coastal zones are also considered hazardous zones as these natural processes, like hurricanes, are likely to adversely impact human activity (WMO, 2016). In the instance where there is population increase in hazardous coastal zones, the risks to human activity is inherently higher and therefore is the impact of the disaster. As a result, prevailing disaster risk reduction research examines whether the disasters are increasing and if the unregulated growth of populations in hazardous coastal zones have increased our risk to natural processes (Sword-Daniels et al., 2015; Thomalla et al., 2006).

2.2.2 Vulnerability

The IPCC defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes." (IPCC, 2007). This definition describes vulnerability as a function of exposure, sensitivity and adaptive capacity where exposure is the extent to which a system is exposed to an extreme event, sensitivity is how affected the system is to this event and adaptive capacity is the ability of the system to adapt to the effects of the extreme event (Engle, 2011). The term exposure is the extent in which a system is exposed to a natural hazard (Metzger, 2006; Garschagen and Romero-Lankao, 2015). The ways in which the system is susceptible to the impact of the hazard. The level of exposure is determined by the extent of vulnerability in the system (Füssel, 2007; Metzger, 2006). The greater the exposure, the most vulnerable the system is. When considering vulnerability reducing the level of exposure is an opportunity to increase the adaptive capacity of the residents. Like vulnerability the exposure of a system is a dynamic function and therefore dependent on demographic factors as social, cultural, geographic and environmental conditions (Cardona et al.,2012; Metzger, 2006)

Vulnerability also highlights the sensitivity of an ecosystem including community to climate change and the extent that the system and people are unable to adapt to the change (Metzger, 2006; Füssel et al., 2006). Climate sensitivity refers to the surface temperature changes in response to the concentration of carbon dioxide in the atmosphere (Cardona et al., 2012; Metzger, 2006). For research purposes it essentially monitors the amount of carbon dioxide that tips the scale into warming the Earth's temperature another degree. There is therefore a limit of carbon dioxide that Earth can recycle and maintain equilibrium to keep surface temperatures. When the amount of Carbon in the atmosphere exceeds that equilibrium the Earth's temperature rises and that relationship is referred to as the climate sensitivity (Hansen et al., 1984; IPCC, 2012)

Considering climate change discussions vulnerability is a function of knowing all the different elements that are involved in making communities vulnerable to the impacts of climate change. These impacts are likely to impact communities based on geographic and demographic conditions (Füssel et al., 2006; Garschagen and Romero-Lankao, 2015).

2.2.3 Vulnerable geographic and demographic conditions

The geographic conditions that are relevant to research are coastal zones. Although in coastal research the term vulnerability is typically used to refer to the geographical vulnerability of coasts (Gornitz, 1991), it has been recognized in other studies that vulnerability must also incorporate a socio-economic component of people living within the coastal zone - within 200 kilometres of the shoreline (Gormitz, 1991; Creel, 2003).

A vulnerable coastal zone might be characterised by geographical factors such as an erodible substrate (sand or other unconsolidated sediments) (Gornitz, 1991; Pendleton et al., 2004), a dune system backing the beach (Abuodha and Woodroffe, 2010), a gentle slope (Pendleton et al., 2004), an open coast and exposure to dominant wave direction (Abuodha and Woodroffe, 2010), a low elevation (Gornitz, 1991), current or historical evidence of subsidence or erosion (Gornitz, 1991), high energy environment from both tides and waves (Pendleton et al., 2004), a high tropical storm probability and the absence of biotic protection from mangroves, coral reefs, sea grasses, or other vegetation (IPCC, 2007). Human and social characteristics that may make a coastal zone more vulnerable to sea level rise (SLR) would include a high population density (Yin, 2012), tourism pressure on the coast and its natural resources (Yin, 2012; Hughes and Brundrit, 1992), developments close to the shoreline causing coastal beach squeeze in which the beach is unable to naturally retreat and re-establish its pre-disturbance profile (Palmer et al., 2011) and a low adaptive capacity (Nicholls and Cazenave, 2010). These conditions are particularly prevalent in Small Island Developing States.

In 1992 the United Nations Conference on Environment and Development delineated a group of nations as Small Island Developing States (SIDS). SIDS are defined as low-lying coastal countries that share similar characteristics that make them more vulnerable to shocks than other countries around the world and have intrinsic geographical and socio-economic characteristics which contribute to their vulnerability (Page, Johnson, and Proosdij, 2014). The geographical characteristics include: relative isolation (Simpson et al., 2010; The Economic Commission for Latin America, 2000), small geographical size (Simpson et al., 2010; IPCC, 2007), high exposure to natural hazards (IPCC, 2007), and fragile ecosystems and the demographic characteristics include a high concentration of population and infrastructure located in coastal areas (Simpson et al., 2010), a low adaptive capacity (ECLAC, 2000), high adaptation costs (IPCC, 2007), and a heavy reliance on these systems for subsistence (IPCC, 2001). Based on demographics of coastal zones in SIDS, the residents of informal settlements tend to be more vulnerable to the impact of hurricanes as the physical structure of their homes are not sturdy enough (Oxfam America, 2004). These structures area typically zinc-coated, tin sheeting, loosely organized wooden structures without foundations, versus a poured concrete house with a strong foundation.

2.2.4 Protected Areas designation

In response to the vulnerabilities of disasters and the increasing concern to climate change, protected areas were designated to reduce the growth of development and preserve the biodiversity of species under the threat of extinction (Dudley et al. 2015; Pouzols, 2014). Protected areas are designated undeveloped tracts of land where anthropogenic activities are restricted or limited to reduce human impact (De Vriend and Van Koningsveld, 2012). Internationally these protected areas contribute to the conservation of flora and fauna by also contribute to the protection of land and humans from climate related impacts (Dudley et al., 2015; Pouzols, 2014). This is particularly relevant in the instance of coastal protected areas which serve as a line of defence against the impact of climate change namely increased intensity of storms and sea level rise (Renaud, 2016; Pouzols, 2014). Coastal protected areas therefore contain mangroves and littoral forests that have key contributions to carbon stores (Donato et al., 2011); erosion control (Gilman et al., 2008); biodiversity (Carugati et al 2018); sea level rise (Gilman et al. 2007) gateway between freshwater and salinated water- protective barrier for seal level rise. Based on their contributions to ecosystem functions these protected areas are also seen as natural or green infrastructure. However, the threat of encroaching development on protected areas cannot be undersold for its importance and the general loss of ecosystem value within specific countries. These threats impact the ecosystem's ability in providing ecological functions that inherently balance out the climate change impacts (Renaud etal. 2016).

The first protected area was established in 1776 (UNESCO, 2018; Pimbert and Pretty, 1997) and later followed by national designations in the late nineteenth century. The initial movement towards international protected areas occurred in the early twentieth century leading to the number of international conventions for protected areas (Klausmeyer and Shaw, 2009; Cliquet et al., 2009). The existing international conventions are The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) established in 1975, The World Heritage Convention established in 1972, the Convention on Migratory Species (Bonn Convention) established in 1979, the Convention on Biological Diversity (CBD) established in 1992 and the focus of this research the Ramsar Convention established in 1971 (International Conventions, 2003).

Habitat change as a result of land use change is one of the top five threats to biodiversity loss along with climate change, invasive species, overexploitation of resources and pollution (Souza et al., 2015; Pecl et al., 2017). Threats in protected areas not only include human activity as a direct impact to biodiversity but also applies to increase in human settlements within protected areas. As coastal zone adaption becomes an increasing interest of SIDS, the preservation of coastal protected areas is central to the discussion (Gopalakrishnan et al., 2017; Sanchez-Arcilla et al., 2016). These coastal protected areas are places uniquely adapted to address climatic changes particularly sea level rise and assist with combating erosion of coastal areas. Coastal protected areas are very applicable to the emerging natural landscapes concept in that they provide ecosystem services and infrastructural benefits to the impacts of climate change adaptation (Sutton et al., 2015; Souza et al., 2015).

However, based on research the establishment of protected area status has not prohibited the increase of traditional farming practices and encouraged an intense shrub encroachment process (Schmitz et al., 2012; Leverington et al., 2010; Hockings, 2006). Additionally, the threats to protected areas are forestry operations, encroachment by human settlements, mining and fossil fuel extraction, bush meat hunting, collection of exotic species for sale, fire, pollution and climate change, invasive species, war and tourism and recreational pressures (IUCN, 1999).   In order for protected areas contribution to climate change adaptation to be understood a few key principles must be evaluated

2.2.5 Adaptation and Adaptive Capacity

Adaptation is the ability of a system to adjust to reduce the impacts of climate change (Osbahr et al., 2010). Prevailing literature identifies adaptation as the way forward for addressing the vulnerabilities is through adaptation.

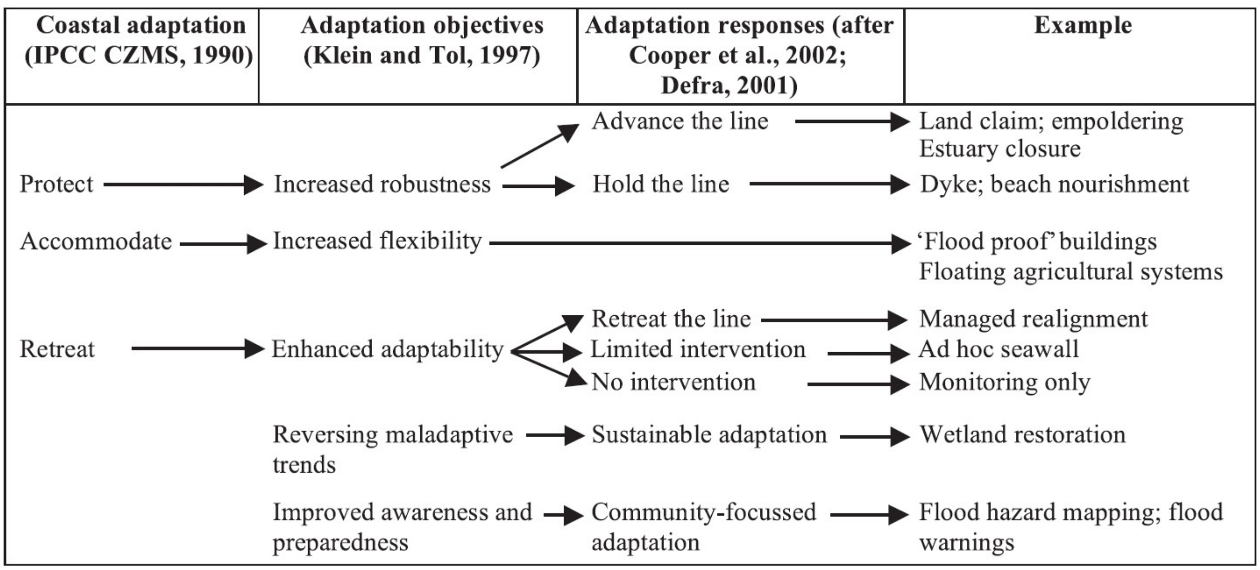


Figure 2-3: Trends of planned coastal adaptation practices (Klien et al., 2001)

A review of adaptation practices is relevant to this research as it marks the systematic steps towards resilience (Klien et al., 2001). According to Figure 2-3 initial adaptation responses were only focused on protection, accommodation and retreat. These were then developed into adaptation objectives namely an expansion from protection to increased robustness, accommodation to increased flexibility and retreat to enhanced adaptability, reversing maladaptive trends, improved awareness and preparedness. They were then expanded from increased robustness to advancing the line and holding the line; from enhanced adaptability to retreating the line, limiting or reducing intervention, sustainable adaptation, and community- focused adaption (Klein et al., 1999; Cheong et al., 2013). Based on Figure 2-3 examples of adaptation can be described as strengthening the understanding of the benefits of 'soft' protection and further use of the accommodate and retreat adaptation measures; building the technologies to manage information and an awareness of the need for coastal adaptation to embrace local socio-economic and natural conditions (Klein et al., 1999; Cheong et al., 2013).

In terms of model creation for climate change adaptation there is high level of uncertainty namely when the factors include highly vulnerable populations and inconsistencies in the downscaling of data models. Under the best scenario 'no-regret' solutions will yield benefits regardless of the changes within the climate (Klein et al., 1999). But more practically 'low-regret' solutions that allow for open opportunities for future changes to the adaptation are preferred.

In achieving adaptation, climate models are valuable in decision-making and where possible a 'bottom-up' approach is effective (Kelly and Adger, 2000; Wilby and Dessai, 2010; Eriksen and Kelly, 2007). The scientific community has tried for decades to develop regional climate downscaling (RCD) methods to address the mismatch between scales. Downscaling of widely available, regional climate data tools have limitations especially when technical data analysis is required (Wilby and Dessai, 2010). In many cases the connections between regional and local climate data are poorly understood without the assistance of individuals with the technical capacity. Another concern in downscaling models is the inaccuracies in downscaling to more detailed scales (Dessai, 2009). In terms of evaluating the benefits and drawbacks of scaling there are two typically methods the 'top-down' and the 'bottom-up' (Wilby and Dessai, 2010; Bhave et al., 2014).

The 'top down' method initially looks at downscaling climate projections under the international greenhouse gas emissions scenarios, these scenarios are then put into models especially crop yields and then adaptation measures are invoked to maximize benefits (Wilby and Dessai, 2010; Bhave et al., 2014). This method is referred to as 'top-down' because the information is 'cascaded' from the first step down to the others with the top stage leading into the stage below it as illustrated in Figure 2-4.

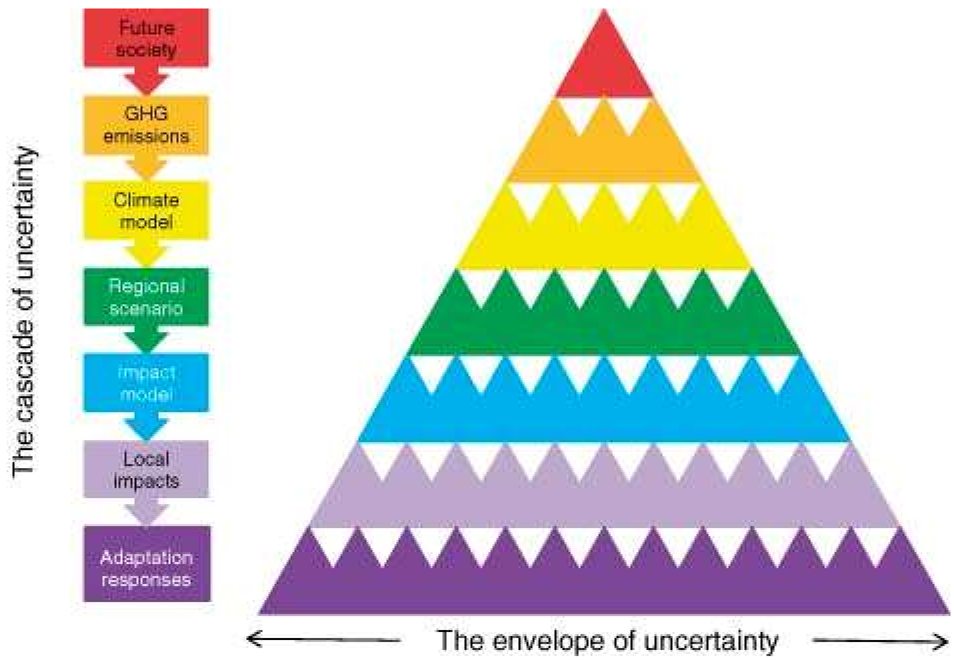


Figure 2-4:'Top-down' approach (Wilby and Dessai, 2010)

The 'bottom-up' method emphasizes reducing vulnerability to climate variability and is typically done in the wake of an extreme natural disaster (Wilby and Dessai, 2010). The method is referred to as 'bottom up' because an analysis begins with an emphasis of the factors and conditions that develop successful coping with climate threats at the individual, household and community level (Bhave et al., 2014; Wilby and Dessai, 2010). Climate vulnerability can be determined by a host of factors namely food availability, wealth, social equality, education and health status, institutional and physical infrastructure, technology and access to natural resources (Brooks et al., 2005; Wilby and Dessai, 2010). The method however requires sufficient observations to understand the frequencies and magnitudes natural disaster and their related environmental and societal consequences (Wilby and Dessai, 2010; Paulutikof et al., 2004). This method can also be considered for the purposes of this research as reactive adaptation.

Adaptive capacity is the number of ways a system can change and benefit for the hazard (Cole, 2008; Metzger, 2006). It is the measure of the system to change understand hazardous conditions and looks that the system's ability to learn and retain knowledge of the hazards then adjust appropriately to not be exposed to those hazards in future scenarios. Adaptive capacity is also very dynamic and dependent on the measure of knowledge the systems can retain at any given moment and the ability of the system to be flexible enough to make the necessary changes in time not to be adversely impacted by the hazard. Adaptive capacity is not achieved once but it is constant measurement and can adjust when the changes in the climate has also occurred (Gunderson, 2001; IPCC, 2012). According to Figure 2-5, the lower the adaptive capacity, the greater the sensitivity and exposure to climate change impacts with a resulting in greater vulnerability. The greater the adaptive capacity, the lower the sensitivity and exposure to climate change impacts resulting in less vulnerability. The very existence of vulnerability implies that vulnerability assessments that are important to be able to understand what factors cause the vulnerability in the system (Black et al., 2008; Clark et al., 2011). The vulnerability relationship illustrated in section Figure 2-5 illustrates that an increase in adaptive capacity subsequently reduces a community's vulnerability to an event such as

SLR. Their ability to adapt begins with the identification of areas that are particularly vulnerable or sensitive to the effects of that event (Page et al., 2014; McLaughlin and Cooper, 2010).

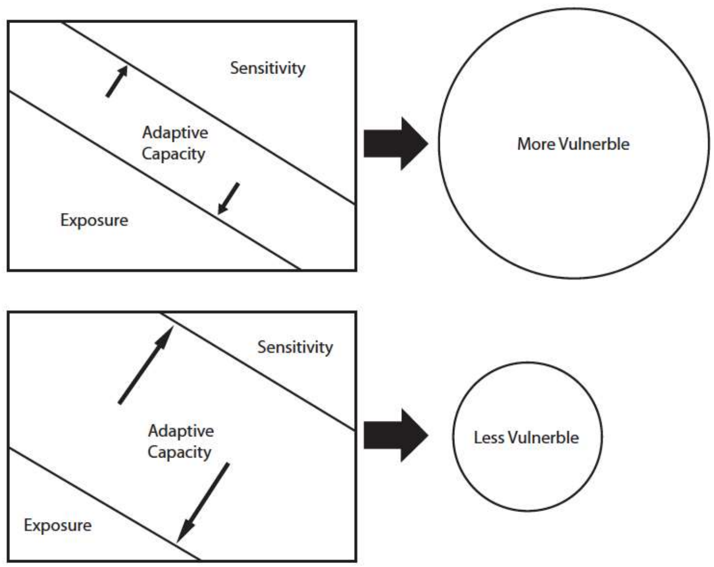


Figure 2-5: Influence of Adaptive Capacity on Exposure, Sensitivity and Vulnerability (Metzger, 2006)

2.2.6 Disaster Risk Reduction

The United Nations Office for Disaster Risk Reduction (UNDRR) outlines that a disaster's impact depends on the how a natural hazards affects human society and the environment (United Nations Disaster Risk Reduction, 2019). Therefore, reducing disasters is based on human action namely through decreasing exposure while reducing the vulnerability of communities. Comprehension of the disaster risk to natural hazards is a function of knowing the hazards, the vulnerabilities, the best measures to adapt and the adaptive capacity of the community (Kelman, 2015).

According the UNDRR (2019) it is imperative to proactively prevent the disaster by addressing the human exposure to the natural hazard, which aligns with the top-down approach. Ecosystem management through the designation of protected areas is seen as a measure to address disaster risk reduction. Protected areas provides support to disaster risk reduction by reducing human exposure to natural hazards particularly in coastal communities where there is an increase exposure to floods, sea level rise and storm surges (Renaud et al., 2013). However, this ecosystems service is only effective in contiguous protected areas, protected areas fragmented by human encroachment foster the human exposure to natural hazards (Bonni-Freyerabend, 2007). In the case of coastal protected areas, burgeoning buffering communities are increasingly exposed to natural hazards and the impacts of climate change. Monitoring the effectiveness of these protected areas are imperative to proactively recognizing the risks for the buffering communities (Muang, 2013) and support disaster risk reduction. As spatial fragmentation also determines the effectiveness of the protected area, assessments to monitor the effectiveness should include an evaluation of spatial conditions. Therefore, it is imperative for this research to critically review whether assessments that monitor the effectiveness protected areas comprehensively include spatial evaluations.

2.3 Protected Area Adaptation Assessments

The following section presents and critically reviews the structure of existing protected area management assessments and whether they provide a comprehensive, spatial evaluation of effectiveness. This list of management assessments was developed by WCPA to chronicle all the existing assessments and provide protected area managers with tools to monitor the effectiveness of their protected areas (Leverington et al., 2008). This document also provides an evaluation of each of the tools and their suggested utility. However, that evaluation is not relevant to the scope of this research. The structure of each assessment is key to this research as it provides information on whether a spatial evaluation was included in the development of the assessment. For the purposes of this research, the structure of each assessment will be presented to highlight the lack of a comprehensive spatial evaluation in the existing tools. This is not to discount the assessments but to emphasize the need for the inclusion of a spatial evaluation to monitor effectiveness of protected areas.

Indicators for the Tracking Tool methodology (2007 version)

Data sheet 1: Details about the protected area and its management objectives, administration, staffing and funding
Data sheet 2: Threat assessment (high, medium, low, not applicable) based on the Conservation Measures Partnership threat hierarchy[i] under the following major headings:
1. Residential and commercial development within a protected area: Threats from human settlements or other non-agricultural land uses with a substantial footprint
2. Agriculture and aquaculture within a protected area: Threats from farming and grazing as a result of agricultural expansion and intensification, including silviculture, mariculture and aquaculture
3. Energy production and mining within a protected area: Threats from production of non-biological resources
4. Transportation and service corridors within a protected area: Threats from long narrow transport corridors and the vehicles that use them including associated wildlife mortality
5. Biological resource use and harm within a protected area: Threats from consumptive use of "wild" biological resources including both deliberate and unintentional harvesting effects; also persecution or control of specific species (note this includes hunting and killing of animals)
6. Human intrusions and disturbance within a protected area: Threats from human activities that alter, destroy or disturb habitats and species associated with non-consumptive uses of biological resources
7. Natural system modifications: Threats from other actions that convert or degrade habitat or change the way the ecosystem functions
8. Invasive and other problematic species and genes: Threats from non-native and native plants, animals, pathogens/microbes or genetic materials that have or are predicted to have harmful effects on biodiversity following introduction, spread and/or increase
9. Pollution entering or generated within protected area: Threats from introduction of exotic and/or excess materials or energy from point and non-point sources
10. Geological events: Geological events may be part of natural disturbance regimes in many ecosystems. But they can be a threat if a species or habitat is damaged and has lost its resilience and is vulnerable to disturbance. Management capacity to respond to some of these changes may be limited.
11. Climate change and severe weather: Threats from long-term climatic changes which may be linked to global warming and other severe climatic/weather events outside of the natural range of variation
12. Specific cultural and social threats
Assessment
1. Legal status: Does the protected area have legal status (or in the case of private reserves is covered by a covenant or similar)?
2. Protected area regulations: Are appropriate regulations in place to control land use and activities (e.g. hunting)?
3. Law enforcement: Can staff enforce protected area rules well enough?
4. Protected area objectives: Is management undertaken according to agreed objectives?
5. Protected area design: Is the protected area the right size and shape to protect species and habitats of key conservation
6. Protected area boundary demarcation: Is the boundary known and demarcated?
7. Management plan: Is there a management plan and is it being implemented?
7a. Planning process: The planning process allows adequate opportunity for key stakeholders to influence the management plan
7b. Planning process: There is an established schedule and process for periodic review and updating of the management plan
7c. Planning process: The results of monitoring, research and evaluation are routinely incorporated into planning
8. Regular work plan: Is there a regular work plan and is it being implemented
9. Resource inventory: Do you have enough information to manage the area? 10. Protection systems: Are systems in place to control access/resource use in the protected area?
11. Research: Is there a programme of management-orientated survey and research work?
12. Resource management: Is active resource management being undertaken?
13. Staff numbers: Are there enough people employed to manage the protected area?
14. Staff training: Are staff adequately trained to fulfil management objectives?
15. Current budget: Is the current budget sufficient?
16. Security of budget :Is the budget secure?
17. Management of budget : Is the budget managed to meet critical management needs?
18. Equipment: Is equipment sufficient for management needs?
19. Maintenance of equipment: Is equipment adequately maintained?
20. Education and awareness: Is there a planned education programme linked to the objectives and needs?
21. Planning for land use : Does land use planning recognise the protected area and aid the achievement of objectives?
22. State and commercial neighbours: Is there co-operation with adjacent land users?
23. Indigenous people: Do indigenous and traditional peoples resident or regularly using the protected area have input to management decisions?
24. Local communities: Do local communities resident or near the protected area have input to management decisions?
24 a. Impact on communities: There is open communication and trust between local and/or indigenous people, stakeholders and protected area managers
24b. Impact on communities: Programmes to enhance community welfare, while conserving protected area resources, are being implemented
24c. Impact on communities: Local and/or indigenous people actively support the protected area
25. Economic benefit :Is the protected area providing economic benefits to local communities, e.g. income, employment, payment for environmental services?
26. Monitoring and evaluation :Are management activities monitored against performance?
27. Visitor facilities: Are visitor facilities adequate?
28. Commercial tourism operators: Do commercial tour operators contribute to protected area management?
29. Fees: If fees (i.e. entry fees or fines) are applied, do they help protected area management?
30. Condition of values: What is the condition of the important values of the protected area?
30a: Condition of values: The assessment of the condition of values is based on research and/or monitoring
30b: Condition of values: Specific management programmes are being implemented to address threats to biodiversity, ecological and cultural values
30c: Condition of values: Activities to maintain key biodiversity, ecological and cultural values are a routine part of park management

Figure 2-6: METT framework (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015)

2.3.1 Management Effectiveness Tracking Tool (METT)

Created by the World Bank/World Wildlife Fund (WWF) Alliance this is a rapid assessment based on a questionnaire with a scorecard (Figure 2-6). The Alliance developed a simplified site-level tracking tool to assist with determining the management effectiveness of WWF/World Bank projects (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015). The scorecard has the six elements of protected areas management discussed in the IUCN-WCPA framework- context, planning, inputs, process, outputs and outcomes. It emphasizes context, planning, input and processes and provides a way to monitor progress towards effective management (Leverington et al., 2008; Gledmann et al., 2015). The objectives of this tool are the provision of integrated reporting systems for protected area assessment; the capability of easy replication; the supply of consistent data to have tracking of progress over time; the ease of completion by protected area staff; does not rely on high level so funding or other resources; easily understood by non-specialist; can be nested into other reporting systems without duplication for effort (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015).

This methodology is implemented in discussion style with protected area staff and local stakeholders, it is also possible to conduct the assessment at a wider scale with PA staff and stakeholders (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015). The process allows for some comments and agreed next steps sections. After introductory questions, 30 additional questions are reviewed.

The 30 questions of this tool served as indicators for the tool. The residential and commercial development within the protected area explores the threats from human settlements or non-agricultural uses that have a great footprint (Stoll-Kleenmann, 2010;

Geldmann et al., 2015). The environmental indicators are geological events, energy production and mining, natural system, climate change and severe weather, transportation and service corridors, biological resources use and harm, and invasive and other problematic species and genes (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015). The social indicators include human intrusions and disturbance, cultural and social threats, impact on communities, indigenous people, education and awareness, state and commercial neighbours, monitoring and evaluation and local communities (Leverington et al., 2008). The policy indicators are determining the legal status of the PA, regulations, law enforcement, boundary demarcation, and the planning process (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015).

The economic indicators are resource inventory, resource management, budgets, staff training, commercial tourism operators, and fees (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015). Spatial indicators are visitor facilities, planning for land use, protected area design, protected area boundary (Leverington et al., 2008). Each indicator comes with a separate question for each and a rating scale for each question. The rating scale gives 0 points for no or progress that is negligible, 1 point is for some progress but have room for improvement, 3 points is for approaching the best situation (Leverington et al., 2008; Stolton et al., 2007).

This tool was adjusted to the Ramsar context, referred to as the Ramsar Management Effectiveness Tracking Tool (RMETT) and contained indicators on 5 different data sheets. Data Sheet 1 collected context and information on the ecological character of the Ramsar site (Leverington et al., 2008; Stoll-Kleenmann, 2010;

Geldmann et al., 2015). Data Sheet 2 collected information the additional national and international designations of the Ramsar site. Data Sheet 3 collected information on the threats to the site including residential and commercial development, agriculture and aquaculture, energy production and mining, transportation and service corridors and biological resource use and harm (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015). Under the residential and commercial development are the indicators of housing and settlement, commercial and industrial areas, tourism and recreation. Under the agriculture and aquaculture are the indicators of annual and perennial non-timber cultivation, drug cultivation, wood and pulp plantations, livestock farming and grazing and marine and freshwaters aquaculture (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015). Under the energy production and mining are the indicators of oil and gas drilling, mining and quarrying and energy generation. Under the transportation and service are the indicators of roads and railroads, utility and service lines, shipping lanes and canals, flight paths and ports with large scale infrastructure (Leverington et al., 2008; Stoll-Kleenmann, 2010; Geldmann et al., 2015). Under resource use and harm are the indicators of unsustainable and illegal hunting, killing and collecting of natural resources.

2.3.2 Rapid Assessment and Prioritization of Protected Area Management (RAPPAM)

The RAPPAM tool developed by WWF provides broad level comparisons among protected areas that includes identifying management strengthen, constraints and weakness, analyses the scope, severity, prevalence and distribution of threats, identifying areas of high ecological and social importance, indicating the urgency and conservation priority for individual protected areas; helping to develop appropriate policy interventions and steps to improve management effectiveness (Ervin, 2003; Stoll-Kleenmann, 2010; Lu et al., 2012; Leverington et al., 2008). Figure 2-7 illustrates that the objectives are to provide a quick and easy method to highlight major trends to be addresses to improve management effectiveness – it allows for the analysis of the major threats facing the protected areas, looking at how the system is functioning on a whole and to develop corrective steps to improve system management effectiveness (Figure 2-7, 2-8 and 2-9).

WCPA Elements	Sections	Questions
	1. Background	includes specific management objectives and critical management activities
Context	2. Pressures and threats	including trend, extent, impact, permanence, and probability of past and future threats
Context	3. Biological importance	Number of rare, threatened or endangered species Relative level of biodiversity Degree of endemism Critical landscape function Extent of full range of plant and animal diversity Contribution to the representativeness of PA system Minimum viable populations of key species Consistency of structural diversity with historic norms Historic range has been greatly diminished ecosystems Extent of full range of natural processes and disturbance regimes
Context	4. Socio-economic importance	Employment for local communities Dependence of communities on PA resources for their subsistence Community development opportunities through sustainable resource use Religious or spiritual significance Unusual aesthetic features Plant species of high social, cultural or economic importance Animal species of high social, cultural or economic importance Recreational value Ecosystem services and benefits to communities Educational and/or scientific value
Context	5. Vulnerability	Low law enforcement Common bribery and corruption Civil unrest and/or instability Conflicting cultural practices, beliefs and traditional uses High market value of PA resources Accessibility for illegal activities Demand for vulnerable resources Pressure to unduly exploit resources Difficult recruitment and retention of employees Difficulty in monitoring illegal activities within the PA
Planning	6. Objectives	PA objectives provide for the protection and maintenance of biodiversity. Specific biodiversity-related objectives are clearly stated in the management plan. The management policies and plans are consistent with the PA objectives. PA employees and administrators understand the PA objectives and policies. Local communities support the overall objectives of the PA
Planning	7. Legal security	The protected area has long-term legally-binding protection. There are no unsettled disputes regarding land tenure or use rights. Boundary demarcation is adequate to meet the PA objectives. Staff and financial resources are adequate to conduct critical law enforcement activities. Conflicts with the local community are resolved fairly and effectively
Planning	8. PA site design and planning	The siting of the PA is consistent with the PA objectives. The layout and configuration of the PA optimises the conservation of biodiversity. The PA zoning system is adequate to achieve the PA objectives. The land use in the surrounding landscape enables effective PA management. The protected area is linked to another area of conserved or protected land
Inputs	9. Staff	The level of staffing is sufficient to effectively manage the area. Staff members have adequate skills to conduct critical management activities. Training and development opportunities are appropriate to the needs of the staff. Staff performance and progress on targets are periodically reviewed. Staff employment conditions are sufficient to retain high-quality staff.
Inputs	10. Communication and information inputs	There are adequate means of communication between field and office staff. Existing ecological and socio-economic data are adequate for management planning. There are adequate means of collecting new data. There are adequate systems for processing and analysing data. There is effective communication with local communities.

Figure 2-7: RAPPAM framework (Leverington et al., 2008; Stoll-Kleenmann, 2010; Ervin, 2003)

The RAPPAM workshops typically take three days to review a five-step process effectiveness (Ervin, 2003; Stoll-Kleenmann, 2010; Lu et al., 2012; Leverington et al., 2008).

With limited introductory questions, this tool has seventeen (19) indicators with questions under each indicator (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008). Under the biological importance indicator, the questions focus on affirming the full extent of species diversity and whether the ecosystems have been reduced (Ervin, 2003; Leverington et al., 2008). Under the socio-economic importance the questions focus on livelihood choices for surrounding communities and the ecosystem service benefit for those communities (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008). Under the vulnerability indicator the questions look at political pressures to exploit resources and civil unrest and/or instability. Under the objectives indicator the questions focus on the management policies and plans are consistent with the PA and whether employees understand these

WCPA Elements	Sections	Questions
Inputs	11. Infrastructure	Transportation infrastructure is adequate to perform critical management activities. Field equipment is adequate to perform critical management activities. Staff facilities are adequate to perform critical management activities. Maintenance and care of equipment is adequate to ensure long-term use. Visitor facilities are appropriate to the level of visitor use.
Inputs	12. Finances	Funding in the past 5 years has been adequate to conduct critical management activities. Funding for the next 5 years is adequate to conduct critical management activities. Financial management practices enable efficient and effective PA management. The allocation of expenditures is appropriate to PA priorities and objectives. The long-term financial outlook for the PA is stable.
Process	13. Management planning	There is a comprehensive, relatively recent written management plan. There is a comprehensive inventory of natural and cultural resources. There is an analysis of, and strategy for addressing, PA threats and pressures. A detailed work plan identifies specific targets for achieving management objectives. The results of research and monitoring are routinely incorporated into planning
Process	14. Management decision-making practices	There is clear internal organisation. Management decision making is transparent. PA staff regularly collaborate with partners, local communities and other organisations. Local communities participate in decisions that affect them. There is effective communication between all levels of PA staff and administration
Process	15. Research, monitoring, and evaluation	The impact of legal and illegal uses of the PA are accurately monitored and recorded. Research on key ecological issues is consistent with the needs of the PA. Research on key social issues is consistent with the needs of the PA. PA staff members have regular access to recent scientific research and advice. Critical research and monitoring needs are identified and prioritised.
Outputs	16. Outputs	Threat prevention, detection and enforcement Site restoration and mitigation efforts Wildlife or habitat management Community outreach and educational efforts Visitor and tourist management Infrastructure development Management planning and inventorying Staff monitoring, supervision and evaluation Staff training and development Research and monitoring outputs

Figure 2-8: RAPPAM framework (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington, 2008)

objectives and policies (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008). Under the legal security indicator, the questions focus on conflicts with the local community are resolved fairly and boundary demarcation is adequate (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008). The PA site design and planning indicator focuses on the layout of the PA being consistent to benefit from conservation and biodiversity and the land use in the surrounding landscape fosters effective management (Ervin, 2003; Lu et al., 2012). The staff indicator focuses on staff members having the best skills to perform needed management activities and staff employment conditions are good enough to retain higher skilled staff (Ervin, 2003;

WCPA Elements	Sections	Questions
System-level questions	17. Protected area system design	The PA system adequately represents the full diversity of ecosystems within the region. The PA system adequately protects against the extinction or extirpation of any species. The PA system consists primarily of exemplary and intact ecosystems. Sites of high conservation value for key species are systematically protected. The PA system maintains natural processes at a landscape level. The PA system includes the protection of transition areas between ecosystems. The PA system includes the full range of successional diversity. Sites of high biodiversity are systematically protected. Sites of high endemism are systematically protected. The layout and configuration of the PA system optimises the conservation of biodiversity
System-level questions	18. Protected area policies	National PA policies clearly articulate a vision, goals and objectives for the PA system. The area of land protected is adequate to maintain natural processes at a landscape level. There is a demonstrated commitment to protecting a viable and representative PA network. There is a comprehensive inventory of the biological diversity throughout the region. There is an assessment of the historical range of variability of ecosystem types in the region. There are restoration targets for underrepresented and/or greatly diminished ecosystems. There is ongoing research on critical PA-related issues. The PA system is periodically reviewed for gaps and weaknesses (e.g. gap analyses). There is an effective training and capacity-building programme for PA staff. PA management, including management effectiveness, is routinely evaluated.
System-level questions	19. Policy environment	PA-related laws complement PA objectives and promote management effectiveness. There is sufficient commitment and funding to effectively administer the PA system Environmental protection goals are incorporated into all aspects of policy development. There is a high degree of communication between natural resource departments. There is effective enforcement of PA-related laws and ordinances at all levels. National policies promote widespread environmental education at all levels. National policies promote sustainable land management. National policies promote an array of land conservation mechanisms. There is adequate environmental training for governmental employees at all levels. National policies foster dialogue and participation with civic and environmental NGOs

Figure 2-9: RAPPAM framework (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington, 2008)

Leverington et al., 2008). Under communication and information inputs indicator the question focus on means of collecting new at and systems for processing and analysing data. The infrastructure indicator focuses on the transport systems being able to perform critical activities and visitor facilities are good for the level of visitor use (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008). Under the finances indicator the questions focus on financial management practices and the long-term financial outlook for the PA (Ervin, 2003; Leverington et al., 2008). The management planning indicator focuses on a comprehensive management plan and detailed work plan that identifies targets for achieving objectives. Under the management decision-making practices (Figure 2-8), the questions focus on local communities participate in decision that impact them and there is effective communication between all levels of PA staff and government administration (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008). The research, monitoring and evaluation indicator focuses on research on key social issues consistent with the needs of the PA and critical research and monitoring needs are identified and made priority (Leverington et al., 2008; Lu et al., 2012). Under the outputs indicator the questions focus on threat prevention, infrastructure development and community outreach and educational efforts (Ervin, 2003; Leverington et al., 2008; Lu et al., 2012). The protected areas system design indicator questions the PA system provides high conservation value for key species and the system maintains natural processes at a landscape level (Erwin, 2003; Leverington et al., 2008). The protected area policies focus on the demonstrated commitment to protecting a viable PA network and the management effectiveness is routinely evaluated. The policy environment indicator questions focus on environmental protection goals involved in all aspects of policy development and national policies promote land conservation mechanisms (Ervin, 2003; Leverington et al., 2008; Lu et al., 2012).

This tool is used mostly by protected area managers and national policy makers to determine the effectiveness of the protected area (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008). It provides a broad overview of the PA and has been implemented in Pas to produce useful reports. The benefits of this toll are also its setbacks in that a broad review of PA will not always reveal the extent of concerns that are related to the improving the effectiveness of the PA (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008). This tool is best used at a larger scale and should include a larger number of protected areas which does not always ensure that issues concerning PA are equally addressed (Ervin, 2003; Stoll-Kleenmann, 2010; Leverington et al., 2008).

2.3.3 Programa Ambiental Regional para Centroamérica (PROARCA)

This is a tool meant to be implemented in a shorter time and over a range of protected areas. It mostly looks at creating a desired scenario for those protected areas (Figure 2-10). There are multiple ways session during the use of this tool namely an initial monitoring session to obtain baseline data towards the development of the best scenario (Hockings, 2003; Leverington et al., 2008; Oestreicher et al., 2009). A session

Ambito/ field	criteria	Indicator
social	communication	Evaluation of communication plan and its execution
	participation	Participation of Interest Groups
	information	Pa tenure demarcation and information? .
	education planning	Plan of environmental education - planning, implementation and evaluation
administration	equipment and infrastructure	Suitable equipment for management
		Maintenance of Equipment - preparation and implementation of a maintenance plan
		Management Infrastructure
		Infrastructure maintenance
		Visitor infrastructure and signage
	personnel	Adequate staff for management
		Personnel trained and capable for management according to capacity plan
		Staff satisfaction with living and working conditions
		Program of volunteers - implementation and evaluation
	planning	Plan of effective management and implementation
		Operation plan being implemented
		Internal management zoning
		Analysis of threats
natural and cultural resources	impact	Impacts of park uses on on the natural resources
	protection	Plan of Control and Protection (Monitoring) of the protected area
		Impact of the Plan of Control and Protection (Monitoring) of the protected area
		Limits of the protected area declared and demarcated
	knowledge	Research plan - existence, implementation and periodic implementation
		Systematization of the information
		Connectivity of the area evaluated and documented
		Indicator species Identified and studied
politico-legal	legal framework	Application of the law
		Decentralization of Administration of the protected area
financial	self-sufficiency	Plan for long term financing of the protected area
		Base funding
	goods and services	Goods and services produced by the protected area are identified and valued
		Stakeholders are aware of goods and services
		Groups of interest receive benefits

Figure 2-10:PROARCA framework (Hockings, 2000; Leverington et al., 2008; Oestreicher et al., 2009)

is done every six months to compare progress against the previous sessions but can be used at a national level to determine success of protected area management. The tool is meant for assessing one protected area at a time, so progress can be effectively monitored (Hockings, 2003; Leverington et al., 2008; Oestreicher et al., 2009). There is a scorecard adapted from the TNC Scorecard (more information with the TNC Scorecard).

The prerequisites for the use of this tool are the creation of a protected area management plan approved by a board with clearly outlined goals, objectives and activities, those areas without a management plan should at least have established goals and objectives (Hockings, 2003; Leverington et al., 2008; Oestreicher et al., 2009). There must also be a baseline information for the protected area and the area has been managed for two years with basic equipment to conduct administrative functions. The indicators are categorized into five (5) fields and thirteen (13) criteria (Hockings, 2003; Leverington et al., 2008; Oestreicher et al., 2009). Under the social field, the criteria are communication, participation, information and education planning. The social indicators are the evaluation of a communication plan and execution, participation in interest groups and a plan for environmental education (Hockings, 2003; Leverington et al., 2008; Oestreicher et al., 2009). Under the administration field the criteria are equipment and infrastructure, personnel and planning (Hockings, 2003; Leverington et al., 2008; Oestreicher et al., 2009). The corresponding indicators are the suitability of equipment for management, the maintenance of equipment, management structure, maintenance structure, infrastructure for visitors and signage, sufficient staff for management, staff are trained and capable for management, working conditions are suitable for staff, there is an effective program for volunteers, implementation of an operation plan, an analysis of management threat and plans of effective management and implementation (Hockings, 2000; Leverington et al., 2008; Oestreicher et al., 2009). Under the natural and cultural resources, the criteria are impact, protection and knowledge. The related indicators are the effect of park uses on the natural resources, the impact of the protection plan for the protected area, the limits of PA demarcated and declared, species is identified and monitored for protection, systemization of information in the protected areas and connectivity of PA is evaluated and documented (Hockings, 2000; Leverington et al., 2008; Oestreicher et al., 2009). Under the political-legal field the criteria are legal framework with the indicators as the application of the law and administration of the protected area. Under the financial field the criteria are self-sufficiency and goods and services (Hockings, 2000; Leverington et al., 2008; Oestreicher et al., 2009). The corresponding indicators are plan for long term financing, the existence of base finding, goods and services produced by the protected area are identified and valued (Leverington et al., 2008). The benefits of this tool are the consistent progress checks every six months to monitor the changes in activity (Hockings, 2000; Leverington et al., 2008; Oestreicher et al., 2009). The gaps in this system are the prerequisites namely the assumption that the protected area is established and has a management program (Hockings, 2000; Leverington et al., 2008; Oestreicher et al., 2009). Areas that do not have management programs in place would not have a number of these questions that are not applicable to their case. The tool then becomes of no use to the users.

2.3.4 Enhancing Our Heritage

Tool	Indicators
1. Management values and objectives	Biodiversity values Other natural values Cultural, social and economic values Principal management objectives
2. Identifying threats - stress, source (potential and current), status of threat (area, intensity, action, urgency of action)	Threats to biodiversity Threats to other natural values Threats to cultural and socioeconomic values
3. Relationships with stakeholders and partners	Identify all the stakeholders and partners Details of the stakeholder and the issue being assessed Nature of the relationship between this stakeholder and the issue Economic dependency Impacts – Negative impacts Impacts – Positive contributions Willingness to engage Political/Social influence Organisation of stakeholders Opportunities stakeholders/partners have to contribute to management the Level of engagement of the stakeholder/partner Overall adequacy of stakeholder engagement
4. Review of national context	How adequate is the legislation? To what extent is the legislation used/useful? Is the legislation effective? How high does conservation rank relative to other government policies? Does other government policy relevant to this site contradict or undermine conservation policy? Is there a conscious attempt to integrate conservation within other areas of government policy? Are policies implemented i.e. has the necessary legislation been enacted? International conservation conventions and treaties Are these conventions and treaties reflected in national law? How willing is government to fund the World Heritage site? Does government have the capacity to match its willingness? What is the relationship between site level and agency level staff– e.g. money, staff, training, equipment? What proportion of the agency's budget goes to field operations?
5. assessment of management planning	Name of plan; Level of approval of the plan (L,G,A, S/A,D); Year of preparation, likely completion or most recent review; Year specified for next review of plan Comments (comments should concentrate on the adequacy, currency, and integration of the plan with other planning instruments) Does the plan establish a clear understanding of the desired future for the site? Does the plan provide sufficient guidance on the desired future for the site? Does the plan provide for a process of monitoring, review and adjustment? Does the plan provide an adequate and appropriate policy environment? Is the plan integrated/linked to other significant national/regional/sectoral plans? Is the plan based on an adequate and relevant information base? Does the plan address the primary issues? Are the objectives and actions specified in the plan represented as adequate and appropriate response to the issues? Does the plan take account of the needs and interests of local and indigenous communities? Does the plan take account of the needs and interests of other stakeholders? Does the plan provide adequate direction on management actions? Does the plan identify the priorities?
6. Design assessment	List objectives for biodiversity and other natural values Key habitats Size External interactions Connectivity List community objectives for cultural, social and economic values Key area legal status and tenure List management issues related to legal status, access and boundary issues with neighbours Legal status and tenure Access points Neighbours
7. Management needs	Assessing management needs Assessing whether the inputs available match the management needs
8. Assessment of management processes	Management planning: Is there a plan and is it being implemented? Planning systems: Are the planning systems appropriate i.e. participation, consultation, review and updating? Regular work plans: Are there annual work plans or other planning tools? Maintenance of equipment: Is equipment adequately maintained? Management staff facilities: Are the available facilities suitable for the management requirements of the site? Staff/management communication: Do staff have the opportunity to feed into management decisions? Staff training: Are staff adequately trained? Personnel management: How well are staff managed? Financial management: Does the financial management system meet the Critical management needs? Managing resources: Are there management mechanisms in place to control inappropriate land uses and activities (e.g. poaching)? Law enforcement: do staff have the capacity to enforce legislation? Monitoring and assessment: Are management activities monitored against performance? Resource inventory: Is there enough information to manage the World Heritage site? Research: Is there a programme of management- orientated survey and research work? Reporting: Are all the reporting requirements of the World Heritage site fulfilled?

Figure 2-11: EOH Framework (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010)

The Enhancing our Heritage (EoH) Developed by UNESCO in conjunction with IUCN and the University of Queensland is a workbook meant to assist mangers and stakeholders to create assessments, putting in gaps and create how problems can be addressed (Figure 2-11). The process includes a training for protected areas managers, desktop literature surveys, data collection and review, workshops with staff, workshops with stakeholders, compilation of existing monitoring results, development of increased monitoring program (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). Under the management values and objectives aspect the indicators are biodiversity values, other natural values, cultural social and economic values, principal management objectives (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). Under the identifying threats aspect, the indicators are the threats to biodiversity, threats to other natural values and threats to cultural and socioeconomic values (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). Under the relationships with stakeholders and partners the indicators are collating information on all the stakeholders and partners, details of the stakeholder and the issue being assessed, nature of the relationship between the stakeholders and the issues of the protected area, economic dependency, negative impacts, positive impacts, stakeholders willingness to engage, political and/or social influence, organization of stakeholders, opportunities partners have to contribute to management (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). Under the review of national context there are 13 indicators including an awareness the legislation, its effectiveness, policies develop and implemented, the willingness of the government to fund a World Heritage site (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). Under the assessment of management planning aspect is another 13 indicators meant to understand the effectiveness of a management plan, the plans for monitoring that have set up to help this plan be effective (Leverington et al., 2008). Under the design assessment aspect, the indicators are the connectivity, external interactions, access points, list community objectives for cultural, social and economic values, key habitats, buffering communities and the protected area size (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). Under the management needs aspect, the indicators are assessing the management needs and whether the factors exist to match those management needs (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). Under the assessment of management processes aspect, the indicators also look at the management team and systems in place to manage the resources of the protected area. Under the assessment of the management plan implementation the indicator is to understand the achievement of the management plan actions (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). Under the output assessment aspect, the indicators are the number of users, the volume of programs and projects and the number of projects completed effectively. Under the outcomes of management aspect, the indicators are the function of the ecosystem, the size of the protected area, the diversity, cultural values, recreation management objectives, economic objectives and the contribution to human well-being (Stolton et al., 2006; Leverington et al., 2008; Stoll-Kleenmann, 2010). The scoring of all the above indicators use a four-point scale and is not a definitive system. A result is a report designed to outline corrective actions and have a heavy emphasis on management systems (Stolton et al., 2006).

2.3.5 AEMAPPS

Developed by the Parques Nacionales Naturales de Columbia is an evaluation of management planning and processes in conjunction with social inclusion. Its delivery is a questionnaire that is focused on individual parks and cannot be used in comparison (Figure 2-12 and 2-13). Its purpose is to improve management, raise awareness and support and prioritize resource allocation (Medina, 2005; Leverington et al., 2008; Getzner et al., 2012). It emphasizes participatory approaches to identify strengths and weaknesses, incorporate monitoring and evaluation processes to institutional culture, define the basic lines of strategic, administrative and operation processes; show management tendencies at the national level (Medina, 2005; Leverington et al., 2008; Getzner et al., 2012). The scores are given but there is also room for comments to support the score given. The methodology is broken into five (5) indexes, twelve (12) indicators and forty-seven (47) variables (Medina, 2006).

Under the index for long term effectiveness (Figure 2-12) the indicator is the status of the conservation targets and the variables look to understand the status of conservation of biodiversity, goods, services and culture and amount of change in the habitat or ecosystem (Medina, 2005; Leverington et al., 2008; Getzner et al., 2012). Under the medium-term effectiveness are the indicators for the acceptability of the management situation, extent of social legitimacy and the clarity of the objectives of conservation (Medina, 2005; Leverington et al., 2008; Getzner et al., 2012). The corresponding indicators are the levels of risk, the possibility of success, the social recognition of public function of conservation, recognition of the public function of conservation and the cultural meaning of the protected area (Medina, 2005;

Index	Indicator	Variable
1. long term effectiveness		
1.1. long term effectiveness: level of achievement of the objectives of conservation of the PA	1.1.1. status of the conservation targets	1.1.1.1. status of conservation of the conservation targets regarding biodiversity, goods and services and culture
		1.1.1.2. level of conversion of the ecosystems, habitats or land cover within the PA
2. medium term effectiveness		
2.1. effectiveness in the medium term: potential of management of the PA	2.1.1. favourability of the management situation	2.1.1.1. level of risk
		2.1.1.2. level of possibility of success
	2.1.2. degree of social legitimacy	2.1.2.1. social recognition of the objectives of conservation
		2.1.2.2. social recognition of the public function of conservation of the responsible authorities
		2.1.2.3. social recognition of the existence of the PA as a figure of public protection
		2.1.2.4. cultural meaning of the PA or of some of its values
	2.1.3. level of coherence between the objectives of conservation and the characteristics of the PA, by itself and in a regional context	2.1.3.1. coherence between the design of the PA and the objectives of conservation
		2.1.3.2. complementarities between the objectives of conservation of the PA and the design of the regional system of PA
		2.1.3.3. complementarities between the objectives of conservation and the other areas of the UAESPNN
2.2. medium term efficiency: quality of the strategic planning	2.2.1. quality of the diagnostic of the current situation	2.2.1.1. advance in the diagnostic of the current situation
		2.2.1.2. coordination with social processes
		2.2.1.3. updating of the diagnostic of the current situation
		2.2.1.4. coverage of the current situation diagnostic
	2.2.2. quality of the management strategies	2.2.2.1. advance of the zoning processes
		2.2.2.2. level of intervention of the PA management in the conservation of the conservation targets
		2.2.2.3. coherence and synergy of the planning structure
		2.2.2.4. coordination with social processes
		2.2.2.5. continuity of the strategies
		2.2.2.6. coverage of the strategies
		2.2.2.7. Plan of financial sustainability
		2.2.2.8. agreements protocol
3. short term effectiveness		
3.1.short term efficacy: level of governance	3.1.1. area in which a effective control takes place	3.1.1.1. percentage of the PA managed by some responsible authority
		3.1.1.2. degree of coordination between responsible authorities for control activities in the PA and the buffer zone
		3.1.1.3. degree of accomplishment of the land uses defined in the management zoning

Figure 2-12: AEMAPPS framework (Medina, 2005; Leverington et al., 2008; Getzner et al., 2012)

Leverington et al., 2008). Under the short-term effectiveness is the area where effective control takes place with indicators that determine the percentage of the PA managed by an authority, degree of coordination between relate protected area authorities and degree of accomplishment of land uses (Medina, 2005; Leverington et al., 2008; Getzner et al., 2012). There is a scoring system where indicators are rated on a scale from 1-5 and the scores tabulated to develop the index. The process is meant to access the short-term to long-term effectiveness performance to prioritize range of action (Medina, 2005; Leverington et al., 2008).

Index	Indicator	Variable
		3.1.1.4. degree of accomplishment of the regulation of the activities of the PA research, ecotourism...
		3.1.1.5. degree in which the PA and its buffer zone is affected by armed conflict
3.2.short term efficiency: quality of the operation management	3.2.1. quality of the operation planning	3.2.1.1. advances in the operation planning
		3.2.1.2. coherence of the operation plan in relation to the management objectives
		3.2.1.3. coherence of the work plans in relation to the operation plan
		3.2.1.4. coordination of the operation plan formulation with social processes
		3.2.1.5. coverage of the operation plan
	3.2.2. quality of the processes of implementation	3.2.2.1. accomplishment of the goals of the operation plan
		3.2.2.2. coordination with social processes during the execution
	3.2.3. quality of the monitoring processes	3.2.3.1. advances in the monitoring processes
		3.2.3.2. coordination of the monitoring with social processes
		3.2.3.3. continuity of the monitoring processes
		3.2.3.4. coverage of the monitoring
		3.2.3.5. feedback of the monitoring to the programming
	3.2.4. quality of the monitoring of management	3.2.4.1. Inputs to the operation plan by the "UAESPNN" and the social and institutional interest groups
		3.2.4.2. periodicity of the monitoring of work plans
		3.2.4.3. coordination of the monitoring with social processes
		3.2.4.4. Inputs of the monitoring to the planning processes
	3.2.5. quality of the administrative processes	3.2.5.1. status of the material and financial resources
		3.2.5.2. resources and projects management
		3.2.5.3. human resources management
		3.2.5.4. status of the human resources

Figure 2-13:AEMAPPS framework (Medina, 2005; Leverington, 2008; Getzner et al., 2012)

2.3.6 The Nature Conservancy Conservation Action Plan

The Nature Conservancy (2007) developed the Conservation Action Planning (Figure 2-14). This approach looks at setting goals and priorities, developing strategies and measuring results (Hockings, 2003; TNC, 2007, Kiesecker et al., 2007). This approach can be used on primarily for the focus on key values, developing a clear framework for evaluating the status of values, adaptability of approach to look at multiple factors, good network of trained professionals to assist in implementing approach (Hockings,2003; TNC, 2007; Leverington et al., 2008). The process for this approach is divided into four main thematic areas with 10 sub-questions. The defining your project thematic section is identifying the team involved in the project, defining the project scope and pinpointing the focal conservation tips and requires that no more than 8 targets are placed (Hockings,2003; TNC, 2007; Leverington et al., 2008). The developing your conservation strategies and measures is assess the viability of conservation targets by selecting attributes and measurable indicators to determine a desired status for each attribute (Hockings,2003; TNC, 2007; Leverington et al., 2008). Identifying critical threats section is the rating of the stresses and the sources of those stresses to determine the critical threats. The developing conservation strategies section is the creation of a situational analysis to identify threats and opportunities to create targeted objectives and strategic actions

A. Defining Your Project
1. **Identify People Involved in Your Project**
   - Selection of core project team members and assignment of roles
   - Identification of other planning team members and advisors as needed
   - Identification of a process leader
2. **Define Project Scope & Focal Conservation Targets** (5S = Systems)
   - A brief text description and basic map of your project area or scope
   - A statement of the overall vision of your project
   - Selection of no more than 8 focal conservation targets and explanation of why they were chosen

B. Developing Your Conservation Strategies and Measures
3. **Assess Viability of Focal Conservation Targets** (5S = Systems)
   - Selection of at least one key ecological attribute and measurable indicator for each focal target
   - Your assumption as to what constitutes an acceptable range of variation for each attribute
   - Determination of current and desired status of each attribute
   - Brief documentation of viability assessments and any potential research needs
4. **Identify Critical Threats** (5S = Stresses & Sources)
   - Identification and rating of stresses affecting each focal target
   - Identification and rating of sources of stress for each focal target
   - Determination of critical threats
5. **Develop Conservation Strategies** (5S = Strategies)
   - A situation analysis that includes indirect threats/opportunities and associated stakeholders behind all critical threats and degraded attributes
   - A "picture" – either in narrative form or a simple diagram – of your hypothesized linkages between indirect threats and opportunities, critical threats, and focal targets
   - At a minimum, good objectives for all critical threats and degraded key ecological attributes that your project is taking action to address and if useful, for other factors related to project success
   - One or more strategic actions for each conservation objective
6. **Establish Measures** (5S = Success)
   - A list of indicators and methods to track the effectiveness of each conservation action
   - A list of indicators and methods to assess status of selected targets and threats you are not currently working on

C. Implementing Your Conservation Strategies and Measures
7. **Develop Work Plans**
   - Lists of major action steps and monitoring tasks
   - Assignments of steps and tasks to specific individual(s) and rough timeline
   - Brief summary of project capacity and a rough project budget
   - If necessary, objectives and strategic actions for obtaining sufficient project resources
8. **Implement**
   - Action
   - Monitoring

D. Using Your Results to Adapt and Improve
9. **Analyze, Reflect & Adapt**
   - Appropriate and scheduled analyses of your data
   - Updated viability and threat assessments
   - Modifications to objectives, strategic actions, and work plans, as warranted
   - Regular updates of project documents
10. **Learn & Share**
   - Identification of key audiences and appropriate communication products for each

Figure 2-14: TNC framework (Hockings,2003; TNC, 2007; Leverington et al., 2008)

(TNC, 2007). The establish measures section creates a list of indicators to track the effectiveness of each action; the list must be items not currently worked on (Hockings,2003; TNC, 2007; Leverington et al., 2008). The develop work plans section lists major action steps, and rough timeline with a summary with project budget The implement section is about action and monitoring. The analyse, reflect and adapt section is finding the appropriate analysis for the data, viability and threat assessments and regular updates of the project documents (Hockings,2003; TNC, 2007; Leverington et al., 2008). The learn and share section identifies the key audiences and communication strategy for each section (TNC, 2007).

The rating system highlights a way of ranking the threats from very high, high medium too low to identify their scope, severity and capability of being reversed (Hockings,2003; TNC, 2007; Leverington et al., 2008). There is also the possibility of rolling up or combing results after the worksheet is completed to combine multiple threats to be addressed by a single targeted objective (TNC, 2007).

2.3.7 How is Your Marine Protected Area doing?

A toolbox made for managers to monitor a marine protected area by developing a tailored system for the particular protected area (Figure 2-15). It was developed by IUCN (WCPA Marine) and WWF jointly giving protected areas an opportunity to invite technical experts to assist with the collection of field data from primary and secondary sources (Gill et al., 2017; Ban et al., 2017; Leverington et al., 2008). The system can be paired with other scorecards to meet the needs of individual managers and indicators must choose to reflect the goals and objectives of the marine Protected Area (Gill et al., 2017; Ban et al., 2017; Leverington et al., 2008). The large book has about 42 indicators divided into biophysical, socioeconomic and governance categories. The biophysical category looks at habitat distribution, focal species abundance and population structure, level and return on fishing effort, water quality, recruitment, composition and structure of ecosystem community, food web integrity, and whether areas are showing signs of recovery (Gill et al., 2017; Ban et al., 2017; Leverington et al., 2008). Under the socioeconomic category there are quality on human health, local resource patterns, percentage of stakeholders group in leadership, stakeholder

biophysical	Area showing signs of recovery
	food web integrity
	Recruitment success within the community
	Composition and structure of the community
	Habitat distribution complexity
	water quality
	Focal species abundance
	Area under no or reduced human impact
	Focal species population structure
	Type, level and return on fishing effort
socioeconomic	Local marine resource use patterns
	quality of human health
	percentage of stakeholder group in leadership
	distribution of formal knowledge to community
	stakeholder knowledge of natural history
	number and nature of markets
	community infrastructure and business
	household income distribution by source
	changes in conditions of ancestral and historical sites, features or monuments
	material style of life
	perception of non-market and non-use value
	perception of local resource harvest
	perception of seafood availability
	Level of understanding of human impacts on resources
	Local values and beliefs regarding marine resources
	occupational structure
governance	availability and allocation of administrative resources
	proportion of stakeholders trained in sustainable use
	degree of interaction between managers and stakeholders
	existence and application of scientific research and input
	existence and adequacy of enabling legislation
	local understanding of MPA rules and regulations
	existence and adoption of a management plan
	existence of an MPA decision-making and management body
	existence and activity level of community organisations
	level of training provided to stakeholders in participation
	level of stakeholder participation and satisfaction in management process and activities
	level of stakeholder involvement in surveillance, monitoring and enforcement
	clearly defined enforcement procedures
	number and variety of patrols per time period per unit area
	degree of information dissemination to encourage stakeholder compliance
	Level of resource conflict

Figure 2-15: How is Your MPA doing framework (Gill et al., 2017; Ban et al., 2017; Leverington et al., 2008)

knowledge of natural history, number and nature of markets, community infrastructure and business, perception of non-market and non-use value, perception of seafood availability, level of recognition of local beliefs on human activity, and human impacts on resources (Gill et al., 2017; Ban et al., 2017; Leverington et al., 2008). Under the governance category are the degree of interaction between managers and stakeholders, availability and allocation of administrative resources, local consciousness of MPA rule and regulations, existence and adequacy of enabling legislation, level of stakeholder engagement in enforcement, enforcement procedures, information shared to support stakeholder involvement and the level resource conflict (Gill et al., 2017; Ban et al., 2017; Leverington et al., 2008).

2.3.8 Mesoamerica Marine Protected Area

In 2004 the Mesoamerican Marine Protected Area (Mesoamerican MPA) was created because of recommendations from workshop on monitoring and evaluation of the marine protected areas in Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama (Figure 2-16 and 2-17). Developed for measuring the effectiveness of the Mesoamerican Barrier Reef System this methodology was designed to be a rapid tool that measures indicators and outcomes with an overall purpose of improving adaptive management (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016). The tool is developed for marine managers trying to determine the level of their administrative management and its goal is to make quick changes to improve their practices (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016). It utilizes IUCN's WCPA

		establish MPA regulations
		Identification of threats
	Planning	Compliance with area objectives
		Area management personnel
		Management Plan
		Operational Plan
		Environmental education program
		Communication program
		Long term funding plan
		Monitoring and evaluation program
		Control and surveillance program
	Inputs	Research program
		Budget
		Infrastructure
		Equipment
		Signs and/or labels
		Necessary personnel
		Trained personnel
		Volunteer program
	Process	Maintenance of infrastructure and equipment
		Mechanisms for registering illegal actions
	Results	Level of personnel satisfaction
		Implementation of the management plan
		Mechanism for obtaining income
	Impact	Level of social participation
Governance - recommended	context	Integration of the MPA within a broader management framework for coastal zones
		Systematization of information
		Local, national and international acknowledgement
	Planning	Mechanisms for stakeholder group participation in the management process
		Promotion of institutional coordination mechanisms
	Process Process	Enforcement of the law
		Level of information dissemination for furthering the compliance of actors involved
	Results	Level of satisfaction of MPA stakeholder groups
	Impacts	Level of conflicts over the use of resources
		Illegal behavior of users
		Recognition of the value of the areas
Biophysical	Impact	Climate
		Temperature
		Salinity
		Turbidity
		Inorganic dissolved nitrogen
		Coverage of hard corals
		Coverage of macroalgae
		Size and mortality of coral
		Abundance of focal fish species
		Density of seagrass shoots
		Density of mangrove stalks and pneumatophores
		Ecological attributes as listed for particular area

Figure 2-16: MesoAmerica MPA framework (Pomeroy, 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016)

framework as the guideline to develop indicators under five (5) headings. Within the socioeconomic field the context indicators are employment, practices and intensity of resource, state of service infrastructure, identification of stakeholders; the process indicators are stakeholder participation and distribution of formal knowledge; the impacts indicator are employment in marine resources, local players in Mesoamerican MPA management, stakeholder group participation (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016). Within the socioeconomic recommended field the context indicators are perception and appraisal of marine resources, identification of conflicts and resolution mechanisms, quality of life; under the process indicators are the users' perception of regulations and standards, maintenance of sustainable use of natural, cultural and archaeological resources; under the impacts indicators are economic income related to products in the Mesoamerican MPA, local perception of state of marine resources, added value of products and services from the MPA and condition of historical-cultural-archaeological sites (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016). Within the governance field the context indicators are legal status, demarcation of

Field	WCPA element	Indicator
Socioeconomic	context	Employment depending on marine resources
		Practices and intensity of local use of marine resources
		State of service infrastructure
		Identification of stakeholders
	process	Distribution of formal knowledge to the community
		Stakeholder participation
	impacts	Practices and intensity of local use of marine resources
		Employment in activities related to marine resources
		Local actors leading MPA management
		Stakeholder group participation
Socioeconomic - recommended	context	Identification of conflicts and resolution mechanisms
		Perception and appraisal of marine resources based on local culture
		Quality of life
	process	Level of users' knowledge about human impacts on natural resources
		Users' understanding of regulations and standards
		Maintenance of sustainable use of natural, cultural and archeological resources based on traditional use
	impacts	Local perception of the state of marine resources
		International, national and local appraisal of non use
		Economic income related to products and services from the MPA
		Quality of life
		Added value of products and services from the MPA
		Condition of historical-cultural-archeological sites
Governance	Context	Legal status
		Demarcation of limits
		Legal and administrative instruments which

Figure 2-17: MesoAmerica MPA framework (Leverington, 2008)

limits, legal and administrative instruments to establish Mesoamerican MPA regulations and identification of threats; the planning field indicators are compliance with area objectives, area management personnel, management plan, operational plan, environmental education program, communication program, long term funding plan, monitoring and evaluation program; the input indicators are the research program, budget, infrastructure, equipment, signs and labels and necessary personnel; under the process field the indicators are maintenance of infrastructure and equipment and mechanisms for registering illegal actions; the results indicators are level of personnel satisfaction, implementation of the management plan and mechanism for obtaining income; the impact indicator is the level of social participation (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016). Within the governance recommended field the context indicators are integration of the Mesoamerican MPA within a broader management framework, systemization of information, acknowledgement at different scales; the planning indicators are mechanisms for stakeholder group participation and promotion of institutional coordination; the process indicators are the enforcement of the law and the level of information dissemination for furthering the compliance of actors involved; the results indicator is level of satisfaction of Mesoamerican MPA stakeholders groups; the impacts indicators are level of conflicts over the use of resources, illegal behaviour of users and recognition of the value of the protected areas (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016). Within the biophysical field the impact indicators are climate, temperature, salinity, turbidity, inorganic dissolved nitrogen, coverage of hard corals, coverage of macro algae, size and mortality of coral, abundance of focal fish species, density of seagrass shoots, density of mangrove stalks and seeds and ecological attributes of the area (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016). Each indictor has scoring responses from no progress, very little progress, poor conditions and ideal condition (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016). This methodology works well for only marine protected areas and but does not look at the spatial effectiveness of the areas (Pomeroy et al., 2005; Corrales, 2004; Leverington et al., 2008; Arrivillaga, 2016).

2.3.9 Padovan

Developed by the Instituti de Pesquisas de Mata Atlantica (Atlantic Rainforest Research Institute) and was used for the assessment of the national monument Guayabo and the Biological Reserve Monteverde in Costa Rica, the National Park in Tilal in Guatemala, Biosphere Reserve Rio Platano in Honduras and the national Forest of Tapajos in Brazil (Figure 2-18 and 2-19). The methodology cross-checks information received from multiple sources including technical documents, field observations and interviews with protected area stakeholders (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). There are three general steps in the methodology data collection, consensus meetings and report

Scope	Principle	Criteria	Indicators
Environmental	1. The management category was designated based on an adequate technical analysis.	1.1. There is coherence between the intrinsic characteristics, the conservation objectives and the management categories.	1.1.1. Correspondence of the management categories with the area characteristics 1.1.2. Compatibility between the management objectives and the area characteristics 1.1.3. Correspondence between the management objectives and the defined management category.
		1.2. The PA uses are compatible with its category.	1.2.1. Compatibility between the PA uses and the management category
	2. The area conserves biological and cultural diversities relevant to the region.	2.1. The area conserves representatives samples of the ecosystems relevant to the region.	2.1.1. The relevant ecosystems are found within the PA. 2.1.2. The ecosystems found within the PA are not representatives.
		2.2. The area conserves natural and cultural attractions that are relevant for the region.	2.2.1. The natural and/or cultural attractive are conserved within the PA.
		2.3. The area contributes to biodiversity conservation.	2.3.1. Indicators species are identified and monitored 2.3.2. Species of special interest for conservation are protected by the PA
	3. The area has appropriate conditions to keep ecological viability.	3.1. The spatial characteristics of the PA favour the ecological viability.	3.1.1. Total optimum PA surface 3.1.2. Adequacy of PA shape to favour ecological viability. 3.1.3. Connectivity between the PA and other areas with the same characteristics. 3.1.4. The PA zoning favour the ecological viability.
		3.2. The ecosystems have their health or vitality improved or maintained.	3.2.1. The vegetal coverage or other fundamental ecosystem structure is maintained. 3.2.2. The degraded ecosystems can recover themselves with time.
		3.3. The uses of the PA don't prejudice the ecological viability.	3.3.1. The practices and the intensity of use don't prejudice the environmental viability.
		3.4. The threats to the ecosystem health and vitality are identified and controlled.	3.4.1. The threats to the ecosystems or habitats are prevented and controlled. 3.4.2. The PA limits are well known and respected.
Social	4. There is integration between the area and the population within and surrounding it.	4.1.There are strategies and these are applied to integrate communities to the PA management.	4.1.1.The Pa has a management board that facilitates the integration of the civil society with the PA management. 4.1.2. Strategies for integration of the population and the PA. 4.1.3. The strategies incorporate different social actors and their particularities. 4.1.4. The target population is kept informed and involved with the strategies' implementation. 4.1.5. The PA and the local communities administrate joint actions. 4.1.6. There are positive manifestations towards the PA management and its surrounding areas.
Economic	5. The PA has positive influence on the economic development of the population that live inside and surrounding it.	5.1. The population that live inside or surrounding the PA receive benefits, either monetary not, direct or indirect, from the PA.	5.1.1. The PA contributes for the improvement of local people's income. 5.1.2. The Infrastructure or services of interest of local people are being provided by the PA. 5.1.3. The community development projects are being promoted by the PA administration.
		5.2. There are effective measures for mitigating or compensating the economic negative impacts that are originated by the PA management activities.	5.2.1. Mechanisms for effective mitigation and compensation of negative impact originated by the PA management activities.
	6. The PA receives enough financial resources for its	6.1. The real costs of the PA management are well known.	6.1.1. Mechanisms for organising the financial information.

Figure 2-18: Padovan framework (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014)

development for each area assessed. The four levels of analysis are scopes, principles, criteria and indicators (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). Under the environmental scope the first principle is designated management of area based on adequate technical analysis with criteria being well planned coherence between conservation objectives and management categories and the PA land uses are compatible (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The indicators of that principle are correspondence of the management categories with the area characteristics, compatibility between the management objectives and correspondence between the management objectives (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014).

Scope	Principle	Criteria	Indicators
	management.	6.2. The PA receives enough financial support to cover the management costs.	6.2.1. The money received by the PA covers the management costs.
		6.3. The sources of funding are adequate and diverse enough to ensure a long term management.	6.3.1. Strategies for obtaining enough financial resources. 6.3.2. Sell of goods and services provided by the PA. 6.3.3. Sell of environmental services.
		6.4. The mechanisms for financial management are adequate and efficient.	6.4.1. Institutional financial management capacity 6.4.2. Transfer of financial resources is adjusted to what requested. 6.4.3. The resources generated are applied on the improvement of the PA management. 6.4.4. Audit and control mechanisms.
Institutional	7. The PA has institutional conditions for its effective management.	7.1. The complementary mechanisms for the PA planning on the different levels are adequate.	7.1.1. The strategic PA planning relates to the policies established for the PA system.. 7.1.2. Coherence between the necessary plans and projects. 7.1.3. Monitoring, assessment and adjustment.
		7.2. The management plan is adequate.	7.2.1. Existence and update of the management plan. 7.2.2. The management plan considers the initiatives for local or regional development. 7.2.3. Execution of the management programmes.
		7.3. The PA staff is qualified enough to pursue the management activities.	7.3.1. Optimum staff quantity 7.3.2. Optimum staff quality
		7.4. The area offers adequate working conditions.	7.4.1. Adequate security and hygiene conditions. 7.4.2. Competitive salary scales and other benefits.
		7.5. The existing structure, infrastructure and equipments satisfies the PA management needs,	7.5.1. The existing structure corresponds to the management objectives. 7.5.2. The structure characteristics and conditions are adequate. 7.5.3.The infrastructure is adequate. 7.5.4. The accesses are adequate to achieve the management objectives. 7.5.5. The equipments and tools are enough and effective.
		7.6. The PA administration receives necessary political support for its management.	7.6.1. Intrainstitutional support 7.6.2. Interinstitutional support
		7.7. The legislation, technical norms and administrative dispositions are being fulfilled.	7.7.1. Legal status of the PA creation. 7.7.2. Rules for natural resources use. 7.7.3. Rules for financial management. 7.7.4. Administrative rules. 7.7.5. Laws related to PA planning and management.
		7.8. The mechanisms for solving conflicts related to domain, land tenure and use of natural resources are effective.	7.8.1. Effective strategy for solving conflicts related to the use of the PA resources.
		7.9. The PA has an organizational structure adequate for its management.	7.9.1. Organizational structure. 7.9.2. Definition of positions and roles. 7.9.3. Clear and functional internal communication system. 7.9.4. Mechanisms for information organization and register.

Figure 2-19: Padovan framework (Padovan, 2002; Leverington, 2008; Azevedo and Faleiro, 2014)

The second principle is the area conserves biological and cultural diversities relevant to the area with the criteria the area conserves representative samples of the ecosystem, the area conserves natural and cultural attractions and the area contributes to biodiversity conservation. The indicators of that principle are the relevant ecosystems are found within the PA and ensuring that the ecosystems found within the PA are not just representative (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The indicator for the area conserves natural and cultural attractions that are relevant for the region criteria is the providing the right conditions for the preservation of natural and cultural heritage in the protected area (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The area contributes to the biodiversity conservation criteria ensure that the indicator species are identified and monitored and species of special interest for conservation protected by the PA (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014).

The third principle is the area has appropriate conditions to keep ecological viability with the first criteria the spatial characteristics of the PA favour the ecological viability and the indicators are total optimum PA surface, adequacy of PA shape to favour ecological viability, connectivity between the PA and other areas with the same characteristics and the PA zoning favour the ecological viability (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). Under the ecosystems have their health or viability improved or maintained are the indicators the vegetal coverage or other fundamental ecosystem, structure is maintained, and the degraded ecosystems can recover themselves with time (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). Under the uses of the PA don't prejudice the ecological viability criteria the indicator is the practices and intensity of use don't prejudice the environmental viability. Under criteria for the threats to the ecosystem health and vitality are identified and controlled the indicators are preventing and controlling the threats to ecosystems and habitats and the limits of the PA are known and respected (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014).

The fourth principle is under the social scope the integration between the area and the population within and surrounding it is the criteria of utilizing strategies that integrate communities to the PA management (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The indicators are ensuring that the board of the PA facilitates in the inclusion of PA management, developing strategies for the integration of the population in the PA; incorporating different social actors; informing the target population effectively; joint administration of local communities and PA managers; ensuring positive manifestations towards PA and surrounding areas (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014).

Under the economic scope are two principles that the PA has a beneficial influence on the economic development of population in the buffering communities and the second, the PA receives sufficient financial resources for the management (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The criteria under the first principle are the population of the buffering communities receive indirect of direct benefits of the PA with the criteria ensuring that the PA contributes to the improvement of the local people's income; the infrastructure or services of interest of local people are being provided by the PA and the community development projects are promoted by PA management (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The second criteria involve the effective measures for mitigating the negative economic impacts of programs developed by the PA management, the indicator is the mechanisms for effective mitigation and compensation of negative impact originated by the activities of the PA management. Under the second principle are three criteria where the real costs of the PA are well known with the criteria of mechanisms organising the financial information (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). Under the PA receives enough financial support to cover the management costs criteria, the indicator is the money received by the PA covers the management costs. Under the sources of funding are adequate to ensure long term management are the criteria for the strategies for obtaining enough financial resources, the sale of goods and services are provided by the PA and the sale of environmental services (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). Under the criteria for the financial management are adequate and efficient the criteria are judging the institutional financial management; transferring of financial resources is appropriately adjusted; the resource generated are applied to improvement of PA management and audit and control mechanisms (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014).

The final scope is the institutional with the single principle is the PA having institutional conditions for effective management – the first criteria is the mechanisms for the PA planning on the different levels are adequate with the indicators for the strategies PA planning relates to the policies established for the PA system, coherence between related plans and projects and the monitoring of assessment and adjustment (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The second criteria involves an adequate management plan with the indicators as the existence and update of the plan; the plan includes initiatives for local and regional development and the execution of management programs (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The third criteria is that PA staff are qualified enough to conduct management activities with the indicators as optimum staff quantity and staff quality. The fourth criteria is the PA offers adequate working conditions with the importance of have adequate security, hygiene conditions and the competitive salary scales and fringe benefits. The fifth criteria is the existing structure, infrastructure and equipment to satisfy the PA management needs with the indicators as a structure that coincides with the management objectives, the condition and infrastructure are adequate and the equipment and tools are enough and effective (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The sixth criteria is the PA administration receive adequate political support for effective management with the indicators as intrainstitutional and interinstituional support. The seventh criteria is the legislation, technical norms and administrative processes are being fulfilled with the indicators as determining the legal status of the organization, the rule for natural resource use and rules for financial management, administrative rules and the laws related to PA planning and management (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014). The eight criteria the effective mechanisms for conflicts regarding domain, land tenure and natural resource use with the indicator being having an effective strategy for solving conflicts related to the PA resource. The ninth criteria is the PA organization has an organizational structure sufficient for management with the indicators as the organizational structure, the definition of positions and roles, a clear and functional internal communication system and the mechanisms for information organization (Padovan, 2002; Leverington et al., 2008; Azevedo and

Faleiro, 2014). The scoring for this tool has a five-level rating where the scores go from 0-4 where the highest value is evidence of optimum management. Based on the structure of this assessment, it is important to note that the optimum scenario has to be achievable. Once scores are calculated the final score will highlight whether the PA does not have minimum resources to ensure basic management (less than 35%); the PA has minimal resources but still vulnerable to internal and external factors (36%-50%); the PA still has key elements missing that would undermine the effective management (52%-75%); the management activities are adequately met and permanence of the protected area is guaranteed (76%-89%); and the area receives all the necessary support for efficient management (90%-100%) (Padovan, 2002; Leverington et al., 2008; Azevedo and Faleiro, 2014).

2.3.10 Monitoring and Evaluation of Protected Areas

The origin of the Monitoring and Evaluation of Protected Areas (MEVAP) was for origins The General Directorate "Nature Protection" of The Ministry of the Environment and Territory charted prof. Davide Marino and continued by University Consortium for Socioeconomic and Environmental Research (C.U.R.S.A), University of Molise and Lands – Expert Network for Sustainable Development with working out a plan to assess the Italian National Parks in order to fulfil obligations under CBD's Programme of Work on Protected Areas (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010). It is a scientifically based tool made up of 87 indices divided by core and supplementary categories. and developed to assess and management effectiveness through a set of indices (Leverington et al., 2008; Marino, 2012;

Gaglioppa et al., 2010). It can be applied throughout different sectors including tourism and agriculture and support procedures in Environmental Balance (Figure 2-20, 2-21). The indices in this tool are broken up in domains, macro-objective, topic and index (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010).

For the purposes of the brevity the complete chart is included in this section but the domains and the indexes will be reviewed in the paragraph (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010). Under the environment domain the context is the richness of fauna, flora,

Economy	Green economy	Certified products	Local products
Economy	Green economy	Certified products	Farms and zootechnical enterprises agreeing to environmentally friendly measures and which practise organic farming
Economy	Green economy	Certified products	Sustainable management from local authorities and local enterprise
Economy	Green economy	Δ+ Sink CO2	absorption capacity forest ecosystems
Economy	Green economy	Δ+ Sink CO2	Absorption capacity agropastoral ecosystems
Economy	Green economy	Hydrological balance	Water Balance
Economy	Conversion of the economic system	Carbon efficiency	Energy independence (Park)
Economy	Conversion of the economic system	Carbon efficiency	Alternative Energy Project Funding (Park)
Economy	Conversion of the economic system	Park laboratory	Enterprises related with the park respect the total of enterprises
Economy	Conversion of the economic system	Park laboratory	Certified products deriving from projects promoted by Park
Economy	Impact of local socio-economic system	Tourism	Tourist flows
Economy	Conversion of the economic system	Certified products	Presence of trademark

Domain	*Macro- objective*	*Topic*	*Index*
Society	Human capital	Socio demographic characteristics	Population density and development
Society	Human capital	Social capital	Level of instruction
Society	Access to resources and benefits	Access to basic services (Quality of life)	Social capital quality
Society	Access to resources and benefits	Access to basic services (Quality of life)	Socio-cultural activities
Society	Access to resources and benefits	Access to basic services (Quality of life)	Quality of life
Society	Access to resources and benefits	Access to basic services (Quality of services)	Stakeholders' perception of benefits
Society	Access to resources and benefits	Access to basic services (Quality of services)	Local residents' perception of benefits
Society	Educational and scientific function	Access to goods and services protected area	Structures managed by the park
Society	Educational and scientific function	Access to goods and services protected area	Visitors' satisfaction
Society	Educational and scientific function	Access to goods and services protected area	Environmental education
Society	Educational and scientific function	Access to goods and services protected area	biking and hiking trails
Society	Educational and scientific function	Access to goods and services protected area	Botanical garden
Society	Educational and scientific function	Access to goods and services protected area	Faunistic Area
Society	Educational and scientific function	Access to goods and services protected area	Scientific research

Domain	*Macro- objective*	*Topic*	*Index*
Governance	Increasing the management capacity territory	Function rate	Administration complexity
Governance	Increasing the management capacity territory	Function rate	Functioning of Park board
Governance	Increasing the management capacity territory	Function rate	Management and planning instruments
Governance	Increasing the management capacity territory	Function rate	Other management plans
Governance	Increasing the management capacity territory	Function rate	Management of AIB service (Antifire wooded plan)
Governance	Increasing the management capacity territory	Function rate	Payment for environmental services (territory)
Governance	Increasing the management capacity territory	Function rate	Indemnification
Governance	Increasing the management capacity territory	Function rate	Administrative sanctions
Governance	Increasing the management capacity territory	Function rate	Intervention plans
Governance	management capacity of the territory (local authority)	Function rate	Other plans obligatory
Governance	management capacity of the territory (local authority)	Function rate	Civil protection structures

Governance	management capacity of the territory (local authority)	Level of planning	Environmental planning capacity (local authority)
Governance	Increase management efficiency	Park as a generator of creative projects	Environmental planning capacity (protected areas)
Governance	Increase management efficiency	Park as a generator of creative projects	Promotion of international co-operation
Governance	Increase management efficiency	Park as a generator of creative projects	Funding through planning activities
Governance	Increase management efficiency	Park as a generator of creative projects	Bioecological architecture
Governance	Increase management efficiency	Park as a generator of creative projects	Payment for environmental services
Governance	Increase management efficiency	Economic efficiency and financial	Staff
Governance	Increase management efficiency	Economic efficiency and financial	Balance indicators about revenue
Governance	Increase management efficiency	Economic efficiency and financial	Indicators on budgetary expenditure

Figure 2-20:MEVAP framework (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010)

vegetation, the nature 2000 network, the threat of vegetable species, the threat to minimal species, the threat of habitats, surface waters quality, groundwater quality, marine and coastal waters

Domain	Macro- objective	Topic	Index
Environment	Natural capital	Biodiversity and genetic resources	Floristic richness
Environment	Natural capital	Biodiversity and genetic resources	Faunistic richness
Environment	Natural capital	Biodiversity and genetic resources	Fichness of vetetation
Environment	Natural capital	Biodiversity and genetic resources	Natura 2000 network
Environment	Natural capital	Biodiversity and genetic resources	Level of threat to vegetable species
Environment	Natural capital	Biodiversity and genetic resources	Level of threat to animal species
Environment	Natural capital	Biodiversity and genetic resources	Level of threat to Habitats
Environment	Natural capital	Biodiversity and genetic resources	Ecosystem services (ES)
Environment	Natural capital	Water Resources	Surface waters quality
Environment	Natural capital	Water Resources	Groundwaters quality
Environment	Natural capital	Water Resources	Marine and costal waters quality
Environment	Natural capital	Forest resources and landscape	Forest fire
Environment	Natural capital	Forest resources and landscape	Forest area condition and quality
Environment	Natural capital	Forest resources and landscape	Level conservation landscape
Environment	Natural capital	Soil and subsoil	Geological fragility
Environment	Level of use (sustainability of resource use)	Biodiversity and genetic resources	Genetic variation in agriculture and in zootechnics
Environment	Level of use (sustainability of resource use)	Water Resources	Intensity of water exploitation
Environment	Level of use (sustainability of resource use)	Forest resources and landscape	Forest resources exploited
Environment	Level of use (sustainability of resource use)	Soil and subsoil	Soil exploitation
Environment	Maintenance and management of resources	Biodiversity and genetic resources	Collection and germplasm bank and/or conservatory
Environment	Maintenance and management of resources	Biodiversity and genetic resources	Management of fauna
Environment	Maintenance and management of resources	Biodiversity and genetic resources	Recovery of agricultural and zootechnic genetic resources
Environment	Maintenance and management of resources	Water Resources	Waste water management
Environment	Maintenance and management of resources	Forest resources and landscape	Reforestation
Environment	Maintenance and management of resources	Forest resources and landscape	Management of forest resources
Environment	Maintenance and management of resources	Forest resources and landscape	Activity of environment recovery
Environment	Maintenance and management of resources	Soil and subsoil	Cost to prevent damages from hydrogeological upheaval
Environment	Maintenance and management of resources	Soil and subsoil	Cost to restore damages from hydrogeological upheaval

Domain	Macro- objective	Topic	Index
Economy	Socio-economic impact	Impact on resources	Agriculture pressure in the environment
Economy	Socio-economic impact	Impact on resources	Sewage purification capacity
Economy	Socio-economic impact	Impact on resources	Tourist intensity
Economy	Socio-economic impact	Impact on resources	Production of urban solid waste
Economy	Socio-economic impact	Impact on resources	Proximity of sites at risk of incident
Economy	Socio-economic impact	Impact on resources	Pressure from road infrastructure
Economy	Socio-economic impact	Income	Economic welfare
Economy	Socio-economic impact	Employed	Employment in economic sectors
Economy	Green economy	Carbon efficiency	Consumption of energy
Economy	Green economy	Carbon efficiency	Sustainable mobility
Economy	Green economy	Carbon efficiency	Energy production through alternative energy resources - Countries
Economy	Green economy	Level of dematerialisation	Energetic intensity
Economy	Green economy	Level of dematerialisation	Production of services and goods with a low intensity of material

Figure 2-21: MEVAP framework (Leverington, 2008; Marino, 2012; Gaglioppa et al., 2010)

quality, wooded fire, forest area conditions, level conservation landscape, genetic variation in agriculture and territory geologic brittleness (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010). The corresponding outputs are botanical garden, the faunistic areas and the collection of germplasm banks (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010).

Under the economy domain the context soil exploitation, agriculture pressure in the environment, the tourist intensity, production of urban solid waste, the proximity of sites at risk, consumption of energy, sustainable mobility, pressure from road infrastructure, intensity of water exploitation, local products, farms and zoo technical enterprises agreeing to environmental friendly measures, energy production through alternative energy resources, production of goods with low intensity materials and the energetic intensity, water balance, economic welfare and absorption capacity (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010). The related output is the tourist intensity, production of urban solid waste, sustainable mobility, local products, farms and zoo technical enterprises, and agreeing to environmentally friendly measures.

Under the society domain is the growth and population density, the social capital quality and the quality of life (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010). The related output is the stakeholder's perception of benefits, the local resident's perception of benefits and the environmental education. Under the governance domain is the biological architecture with the outputs as the management of forest resources, the management of fauna, the activity of environment recovery, reforestation and bio ecological architecture (Leverington et al., 2008; Marino, 2012; Gaglioppa et al., 2010).

The constraints of this tool are obtaining the information can be complex and expensive, the scale to obtain the tool is not necessarily reliable to obtain necessary information and the analysis may not be effective when obtaining historical data is required.

2.3.11 PAN PARKS

This tool was developed by the Pan Parks Foundation to provide an independent audit to focus on the management effectiveness of protected areas, the quality of visitor management, the sustainable tourism activities buffering the protected areas and the local businesses (PAN Parks, 2002; Leverington et al., 2008). The principles of natural values being able to define the scope of protection, international importance and scope of protection; the management effectiveness is conservation management; the visitor management, the sustainable tourism effectiveness and business partners (Figure 2-22

WCPA Elements	PAN Parks criterion [examples]	To meet the Criterion, the following achievements are required
	1.Background	*Include specific management objectives and critical management activities*
Context	2.Pressure and threats **e.g. Criterion 2.3** **The protected area has a long-term conservation strategy that is actively implemented …**	*Indicator 2.3.11: The conservation strategy / management plan is successfully implemented (e.g. via an annual work plan) including research and monitoring activities, threat prevention and mitigation, and restoration.* *Indicator 2.3.12: The annual plan implementation and the overall management effectiveness are regularly monitored and the plan then updated, etc…*
Context	3.Biological importance	*Indicator 1.2.1: The protected area is internationally recognised and/or supports*
Planning	8. PA site design and planning **e.g. Criterion 1.3** **The minimum size of the protected area is 20 000 hectares.[2]**	*Indicator 1.3.1: The protected area is large enough and its composition (one block, fragmented) ensures the conservation of internationally important wildlife and ecosystems.* *Indicator 1.3.2: There is information if the size of protected area has been changed in the past.*
Inputs	9. Staff and finance **e.g. Criterion 2.3** **The protected area has a long-term conservation strategy[3] that is actively implemented…**	*Indicator 2.3.9: The conservation strategy / management plan is addressing needed capacities to effectively manage the protected area, including staff and their range of skills, equipment, organisational structure (functions of board, advisory committee etc.). The protected area management is adequately funded.* *Indicator 2.3.10: The conservation strategy / management plan is addressing existing and future external and internal threats and pressures to the protected area.*
Inputs	10. Communication and information inputs **e.g. Criterion 3.3** **Visitor management creates understanding of and support for the conservation goals of the protected area.**	*Indicator 3.3.1: There are different visitor target groups that need to understand and support the conservation goals of the protected area and that are addressed by specific messages and different techniques.* *Indicator 3.3.2: A code of conduct for visitors is communicated to all visitors, specifying for which visits a qualified guide is needed.* *Indicator 3.3.3: The protected area has a communications and marketing plan that is successfully implemented in communication with the tourism marketing of the surrounding region.*
Process	11. Management planning **e.g. Criterion 2.3** **The protected area has a long-term conservation strategy that is actively implemented...**	*Indicator 2.3.1: There is a conservation strategy that is implemented through nature, visitor, administration and marketing management (sub-) plans.* *Indicator 2.3.4: The conservation strategy/ management plan has long- and short-term goals.* *Indicator 2.3.5: A conservation strategy / management plan goal is that ecological processes and biological diversity will be maintained over the long-term.*
Process	12. Management decision-making practices **e.g. Criterion 2.3** **The protected area has a long-term conservation strategy that is actively implemented…**	*Indicator 2.3.2: The conservation strategy / management plan(s) is developed through a planning process that includes procedures for revision and approval and the participation of different parties in these steps. The plan is communicated to different target groups and achieved via identified funding sources.*

Figure 2-22:PAN PARKS framework (PAN Parks, 2002; Leverington, 2008)

and 2-23). To obtain the tool an applicant must be apply for the application for an evaluation, the Pan Parks Foundation then begins the process to develop the evaluation (PAN Parks, 2002; Leverington et al., 2008). Under the criterion of pressure and threats the indicators are the management plan is successfully implemented and the annual plan is implemented and regularly monitored. Under the biological importance indicator is the protected area as international recognized and supports protection of internationally threatened species and the area contains Natura 2000 site (PAN Parks, 2002; Leverington et al., 2008). Under the socio-economic importance criteria is that goals are aimed at increasing the quality of tourism experience. The vulnerability criteria are a zoning system that ensures effective protection, the zoning is based on a clear method of demarcating boundaries and the zoning allows for human

		Indicator 2.3.3: There are links between the area's (nature conservation) management, the visitor management, and the national/regional sustainable tourism development strategy.
Process	13. Research monitoring and evaluation **e.g. Criterion 2.3** **The protected area has a long-term conservation strategy that is actively implemented …**	*Indicator 2.3.6: The conservation strategy / management plan includes research programmes designed to improve knowledge and contribute to protected area management.* *Indicator 2.3.7: The conservation strategy / management plan includes programmes designed to improve the socio-cultural and economic benefits of the protected area for surrounding communities and tourism development.* *Indicator 2.3.8: The conservation strategy / management plan is based on an adequate site assessment, which includes abiotic and biotic data and an evaluation of past and present human activities and their impacts.*
Outputs	14. Output **e.g. Criterion 2.8** **The protected area management system pays particular attention to threatened and endemic species and habitats, and to ecosystem dynamics.**	*Indicator 2.8.1: The management plan and other sources provide information, in particular in relation to the current management regime, on endemic, red-listed, vulnerable or other rare species occurring in the protected area, as well as on other, native species that have decreased or become extinct* *Indicator 2.8.5: There is a habitat or ecosystem restoration plan, according to which, if necessary, conservation values are being restored on the basis of studies from adequate reference areas. The implementation of the restoration plan and its impacts are regularly monitored, etc…*
System level questions	16. Policy environment **e.g. Criterion 2.1** **Design of the protected area aims to maintain natural ecological values.**	*Indicator 2.1.1: Priority of the management objectives (e.g. as per the act or decree) is the maintenance of natural ecological values.* *Indicator 2.1.2: The design of the protected area allows all key natural values (ecological processes and biodiversity) to exist and be maintained.* *Indicator 2.1.3: There is evidence of bio-geographical connections inside the protected area, with its adjacent areas, and/or with other protected areas.*
System level questions	15.Protected area policies **e.g. Criterion 2.5** **The protected area has an ecologically unfragmented [4] wilderness area of at least 10,000 hectares [5] where no extractive uses [6] are permitted and where the only management interventions are those aimed at maintaining or restoring natural ecological processes and the ecological integrity.**	*Indicator 2.5.1: The protected area has an ecologically non-fragmented wilderness area of at least 10,000 ha, which embraces all important habitat types and ecological processes, and adequately represents the highest value for nature conservation of local natural ecosystems.* *Indicator 2.5.2: The management plan includes a clear management strategy and plan for managing the wilderness area at long term,* *Indicator 2.5.3: Ecological processes within the wilderness area are undisturbed those missing are under restoration…*
System level questions	16. Policy environment **e.g. Criterion 2.1** **Design of the protected area aims to maintain natural ecological values.**	*Indicator 2.1.1: Priority of the management objectives (e.g. as per the act or decree) is the maintenance of natural ecological values.* *Indicator 2.1.2: The design of the protected area allows all key natural values (ecological processes and biodiversity) to exist and be maintained.* *Indicator 2.1.3: There is evidence of bio-geographical connections inside the protected area, with its adjacent areas, and/or with other protected areas.*

Figure 2-23: PAN Parks framework (PAN Parks, 2002; Leverington et al., 2008)

activities compatible with conservation strategy (PAN Parks, 2002; Leverington et al., 2008). Under the objectives criteria is the priority of management objectives, the design of protected areas that allows for key natural values, the evidence of bio-geographical connections inside the protected area. Under the legal security criteria is the area is legally protected by means of an act or decree (PAN Parks, 2002; Leverington et al., 2008). Under the PA site design and planning are the indicators of the PA ensuring conservation of internationally important wildlife and ecosystems; whether there is the change in the size of the protected area. Under the staff and finance criteria are the indicators for a conservation finance strategy including staff and their skills and the management plan is effectively addressing external and internal pressures to the protected area (PAN Parks, 2002; Leverington et al., 2008). Under the communication and information inputs are the different visitor targets groups that support conservation goals, the code of conduct for visitors is communicated to all; and the protected area has a communications and marketing plan that is successful implemented. Under the management planning criteria is a conservation strategy that is implemented through nature, visitor and administration plans, the plans have long term and short-term goals; the conservation plan sets forth that ecological processes and biological diversity is maintained over the long term (PAN Parks, 2002; Leverington et al., 2008). Under the management and decision-making practices, the indicators are that the management plan is developed through a planning process and the plan is communicated and there are links to national strategies and policies (PAN Parks, 2002; Leverington et al., 2008). Under the research and monitoring and evaluation criteria the indicators are including research programs designed to bring overall improvements in knowledge, the socio-cultural and economic benefits for buffering communities and the plan is based on adequate site assessment. Under the output criteria the indicators are the provision of information on management schemes of vulnerable species and there is a habitat and restoration plan. Under the protected areas policies is ensuring the PA has an ecological and non-fragmented area of 10,000*ha* to embrace all important habitat types; a long-term plan for managing wilderness and ecological processes are undisturbed (PAN Parks, 2002; Leverington et al., 2008). Under the policy environment criteria, the indicators are management objectives that maintain ecological values, the design of the protected area allows for key natural values and evidence of bio-geographical connections within the protected area.

2.3.12 West Indian Ocean Marine Protected Area

Developed for the West Indian Ocean Biodiversity Conservation Project the West Indian Ocean Marine Protected Area (WIO MPA) assessment was developed to test and adapt the WCPA methodologies in the Western Indian Ocean (Figure 2-24). The main objective is to simplify the tool for managers to evaluate the management effectiveness (Wells and Mangubhai, 2005; Selig and Bruno, 2010;

Assessment component	**Worksheets**
Context	Management Targets Threats (Sources and Stresses) Review of National Context Assessment of Stakeholder Engagement Stakeholder Engagement Summary
Planning	List of Planning Documents Adequacy of Management Plan (and other plans if relevant) Design Assessment x
Inputs	Assessment of Resources (Inputs) Resources (Inputs) Summary Assessment of Resources (Inputs) Assessment of Capacity
Process	Assessment of Management Processes Assessment of Capacity
Outputs	Assessment of Management Plan Implementation Management Plan Implementation Summary
Outcomes	Assessment of Biodiversity Objectives Assessment of Socio-economic and Cultural Objectives Ranking of Current Threats Current Threat-Target Summary

Figure 2-24: West Indian Ocean MPA framework (Wells and Mangubhai, 2005; Selig et al., 2010; Leverington et al., 2008)

Leverington et al., 2008). It has been applied and used in all the countries along the Western Indian Ocean and the specific indicators can be adjusted based on the national conditions (Wells and Mangubhai, 2005; Selig and Bruno, 2010; Leverington et al., 2008). Under the context assessment component, the worksheets are management targets, threats (sources and stresses), review of national context, assessment of stakeholder engagement and stakeholder engagement summary (Wells and Mangubhai, 2005; Selig and Bruno, 2010; Leverington et al., 2008). Under the planning assessment component, the worksheets are the list of planning documents and the adequacy of management plan and design assessment (Wells and Mangubhai, 2005; Selig and Bruno, 2010; Leverington et al., 2008). Under the input's assessment component, the worksheets are assessment of resources, resources summary, assessment of resources and assessment of capacity (Wells and Mangubhai, 2005; Selig and Bruno, 2010; Leverington et al., 2008). Under the process assessment component, the worksheets are the assessment of management processes and the assessment on capacity. Under the outputs component the worksheets are the assessment of management plan implementation and management plan implementation summary. Under the outcomes component the worksheets are the assessment of biodiversity objectives, the assessment of socio-economic and cultural objectives, the ranking of current threats and the current threat-target summary (Wells and Mangubhai, 2005; Selig and Bruno, 2010; Leverington et al., 2008).

2.3.13 Marine Tracking Tool

Developed in partnership with WWF and World Bank, the Marine Tracking Tool (MTT) as a marine adaption of the MTT tool (Figure 2-25 and 2-26). the scorecard is designed for marine protected areas and considers of a data sheet that gathers all information and 68 questions of an assessment tool (Staub, 2004; Leverington et al., 2008). It is meant to improve management and accountability. It is meant to help the stakeholders determine the progress of protected areas management along the continuum (Staub, 2004; Leverington et al., 2008). The indicators are arranged according to the IUCN-WCPA framework, 34 indicators are organized into six categories (Staub and Hatziolos 2004; Leverington et al., 2008). Under the context category are the legal status of the PA, the marine regulations, law enforcement, sources of control, prosecution of infractions, boundary demarcation, integration of MPA in larger coastal plan the network of PA, resource inventory and stakeholder awareness (Staub and Hatziolos, 2004; Leverington et al., 2008). Under the planning category are the

Context	1	Legal status – Does the marine protected area have legal status?
	2	Marine protected area regulations – Are unsustainable human activities (e.g. poaching) controlled?
	3	Law enforcement – Can staff sufficiently enforce marine protected area rules?
	3a	There are additional sources of control (e.g., volunteers, national services, local communities)
	3b	Infractions are regularly prosecuted and fines levied
	4	Marine protected area boundary demarcation – Are the boundaries known and demarcated?
	5	Integration of the MPA in a larger coastal management plan – Is the MPA part of a larger coastal management plan?
	5a	a. The MPA is part of a network of MPAs which collectively sustain larger marine ecosystem functions
	5b	b. The MPA is part of a network of MPAs which collectively representthe range of bio-geographic variation in a marine eco-region
	6	Resource inventory – Is there enough information to manage the area?
	7	Stakeholder awareness and concern – Are stakeholders aware and concerned about marine resource conditions and threats?
Planning	8	Marine protected area objectives – Have objectives been agreed?
	9	Management plan – Is there a management plan and is it being implemented?
	9a	There is also a long term master plan (at least 5 years)
	9b	The planning process allows adequate opportunity for key stakeholders to influence the management plan
	9c	Stakeholder participation includes representation from the various ethnic, religious and user groups as well as representation from both genders
	9d	The socioeconomic impacts of decisions are considered in the planning process
	9e	The local culture, including traditional practices, social systems, cultural features, historic sites and monuments, is considered in the planning process
	9f	There is an established schedule and process for periodic review and updating of the management plan
	9g	The results of monitoring, research and evaluation are routinely incorporated into planning
	9h	Management plan is tied to the development and enforcement of regulations
Input	10	Research – Is there a program of management-oriented survey and research work?
	10a	a. Carrying capacity studies have been conducted to determine sustainable use levels
	11	Staff numbers – Are there enough people employed to manage the protected area?
	11a	There is additional support from volunteer programs, local communities, etc
	12	Current budget – Is the current budget sufficient?
	12a	There is a secure budget for the marine protected area and its management needs on a multi–year basis.
	12b	The budget is not entirely dependent on government funding; instead, funding also comes from NGO contributions, taxes, fees, etc.
Process	13	Education and awareness program – Is there a planned education program?
	14	Communication between stakeholders and managers – Is there communication between stakeholders and managers?
	14a	There is some communication with other MPA managers (and for example exchanges of good practices
	15	Stakeholder involvement and participation – Do stakeholders have meaningful input to management decisions?
	15a	There are clear financial contributions / agreements between MPA and tourism operators to recover MPA resources rents for local benefits
	16	Indigenous people – Do indigenous and traditional peoples resident or regularly using the MPA have input to management
	17	Staff training – Is there enough training for staff?
	18	Equipment – Is the site adequately equipped?
	19a	Monitoring and evaluation – Are biophysical, socioeconomic and governance indicators monitored and evaluated?
	19a	The MPA participates as a site in national or international environmental monitoring programs such CARICOMP, CPACC, GCRMN, AGGRA or similar. (Provide the name of the program(s))
	19b	There is an Emergency Response Capability in place to mitigate impacts from non threats
Output	20a	Legal status has improved (refers to question 1. Legal status)+2
	20b	Regulations have improved (refers to question 2. MPA Regulations)+2
	20c	Law enforcement has improved (refers to question 3.
	20d	Boundary demarcation has improved (refers to question 4.
	20e	The MPA has been integrated into ICM (refers to question 5. Integration of the MPA)+2
	20f	The resource inventory has improved (refers to question 6.
	20g	Stakeholder awareness and concern has improved(refers to question 7.)+2
	21a	Signs – signs are now available, or new one have been installed
	21b	Moorings – moorings are now available, or new one have been installed
	21c	Education materials – education materials are available, or new one have been developed
	22	Mechanisms for stakeholder participation in decision-making and/or management activities (e.g. advisory council) – are mechanisms available to ensure stakeholder participation?
	23	Environmental education activities for stakeholders (e.g. public outings at the MPA) – have education activities been developed for stakeholders?
	24	Management activities – have the two critical management activities (listed in the data sheet) been improved to address threats
	25	Visitor facilities – does the MPA have sufficient visitor facilities ?
	26	Fees – If fees (entry fees - tourism, fines) are applied, do they help marine protected area management?
	27	Staff Training
Outcome	28	Objectives – Have MPA objectives (listed in the data sheet page) been addressed?
	29	Threats – Have threats (listed in the data sheet page) been reduced?
	30	Resource conditions– Have resource conditions improved?
Outcome - Community welfare – Has community welfare improved?	31	MPA management is compatible with the local culture, including traditional practices, relationships, social systems, cultural features,historic sites and monuments linked to marine resources and uses
	31a	Resource use conflicts have been reduced
	31b	Benefits from the MPA are equitably distributed

Figure 2-25: Marine Tracking Tool framework (Le Staub and Hatziolos 2004; Leverington et al., 2008)

objectives of the marine protected areas, the management plan, the existence of a master plan, key stakeholders have an influence on the management plan, stakeholders participation activities include cultural and religious groups, the socioeconomic impacts of decision are a part of the planning process, the local cultural and social systems are including in the planning process, the results for monitoring and evaluation are incorporated in planning, an established schedule for updating the management plan, the management plan is connected to the enforcement of regulations (Staub and Hatziolos, 2004; Leverington et al., 2008). Under the input category are the existence of a program for surveys and research work, carrying capacity studies have been conducted, the staff numbers are enough to manage the protected area, there is sufficient support from local community, the current budget is well enough and secure, and the budget is not entirely dependent on the government funding (Staub and Hatziolos, 2004; Leverington et al., 2008). Under the process category is the education and awareness programming, communication between stakeholders and PA managers, communication between PA mangers, stakeholder involvement and participation, clear financial contributions between the MPA and tourism operators, whether the buffering communities have an input in management, whether the staff is training, is the PA adequately equipped for the management, all the indicators are monitored and evaluated, the MPA participates in national and international environmental monitoring programs and there is an emergency response capability in place to mitigate impacts (Staub and Hatziolos, 2004; Leverington et al.,

Outcome	31c	The non-monetary benefits of the marine resources to society have been maintained or enhanced
	31d	Environmental awareness – Has community environmental awareness improved?
	32	Compliance – Are users complying with MPA regulations?
	33	Stakeholder satisfaction – Are the stakeholders satisfied with the process and outputs of the MPA?
	34	Stakeholders feel that they are able to effectively participate in management decisions
	34a	Stakeholders feel that they are adequately represented in the MPA decision-making processes
	34b	Community welfare – Has community welfare improved?

Figure 2-26: Marine Tracking Tool framework (Staub and Hatziolos, 2004; Leverington, 2008)

2008). Under the output category the indicators are the improvements of the legal status, the improvements of regulations, the improvement of law enforcement, the MPA is integrated into ICM, the resource inventory is improved, stakeholder awareness and concern has improved, signs are installed, moorings are in place, educational materials are available, mechanisms for stakeholders participation in decision-making, environmental education activities, the existence of critical management activities, sufficient visitor facilities, entry fees for tourism and fines and staff training (Staub and Hatziolos, 2004; Leverington et al., 2008). Under the outcome the indicators are addressing the MPA objectives, threats, the improvement of resource conditions, the management of the PA is compatible with local culture, the resource conflicts have been reduced, benefits from the MPA are equally distributed, the non-monetary benefits of marine source are maintained or enhanced, environmental awareness in the community is improved, are user compliant with MPA regulations, stakeholder satisfied with the process and outputs, stakeholders are actively participate in management decisions, stakeholders feel adequately represented in MPA decision making and there is an improvement in community welfare (Staub and Hatziolos, 2004; Leverington et al., 2008).

2.3.14 World Wildlife Foundation / Agricultural Center of Tropical Investigation and Teaching

Developed by the Central American Office of WWF in conjunction with the Agricultural Center of Tropical Investigation and Teaching (CATIE) it was created to assess protected area management on three levels – individual protected areas, systems of protected areas and performance of administration within the zones of influence of the protected area (Figure 2-27 and 2-28). It was developed before the IUCN-WCPA framework was develop and is measured against the define 'optimum' state. The purpose of this methodology is to improve management and accountability/audit (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016; Leverington, 2018).

Field	Variable	Sub-variable
administrative	Personnel	• Administrator • Technical Personnel • Administrative Personnel • Operative Personnel • Capacity for additional contracting
	finances	Operational budget • Regularity of budget preparation and delivery • Extraordinary and/or special funding • Capacity to manage own resources • Financial-accounting system (parameters in document)
	organisation	• Files • Organizational chart • Internal communication • Structuring of activities
	Infrastructure	• Equipment and tools • Facilities for basic management • Facilities for specific management • Condition of facilities • Security of facilities • Boundary demarcation • Access
policy	Community support and participation	
	Intra-institutional support	Mother institution • PA system administration
	Inter-institutional support	
	External support	
legal	Land tenure	Domain/Possession • Conflicts
	Set of general laws and regulations	• Clarity • Application
	Law creating the PA	
planning	PA management plan	• Plans exist and are up-to-date • Characteristics of the planning team • Plan implementation
	Compatibility of management plan with other plans and organizations	
	Annual Operational Plan	• Plans exist and are up-to-date • Plan implementation
	Level of Planning	
	Zoning	
	Boundaries	
knowledge	Socio-economic information	Subvariables for each variable could be defined depending on the level of available information
	Biophysical information	
	Cartographic information	
	Legal information	
	Research	

Figure 2-27:WWF framework (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016; LEverington, 2008)

The indicators are separated into fields, variable and sub-variables. Under the administrative field, the personnel variable with the sub-variables are administrator, technical personnel, administrative personnel, operative personnel and capacity for additional contracting (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016; Leverington et al., 2008). The finance variable has the sub variables of operational budget, regularity of budget preparation and delivery, extraordinary and/or special funding, capacity to manage own resources, and financial-accounting system (parameters in document).

Field	Variable	Sub-variable
	Monitoring and feedback	
	Traditional knowledge	
management programs	Research	Each program is evaluated according to the following variables: • Design • Implementation • Co-ordination • Follow-up and evaluation
	Environmental education	
	Environmental interpretation	
	Protection	
	Maintenance	
	Outreach to the community	
illegal uses	Timber extraction	
	Extraction of nonrenewable natural resources	
	Extraction of flora and fauna	
	Vandalism of cultural resources	
	Squatting	
	Poaching	
	Agriculture and cattle ranching	
	Fishing	
	Recreation and tourism	
	Building of infrastructure	
legal uses	Timber extraction	
	Extraction of mineral resources	
	Extraction of flora and fauna	
	Hunting	
	Agriculture and cattle ranching	
	Fishing	
	Recreation and tourism	
	Education	
	Building construction	
biogeographical characteristics	Form	
	Size	
	Isolation	
	Vulnerability	
threats	Visitor impact	
	Pollution	
	Fires	
	Advance of human settlements	
	Migration	
	Exotic organisms	
	Natural disasters	
	Development infrastructure	
	Subversive political movements or violent conflicts	
	Drug trafficking and related	

Figure 2-28: WWF framework (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016; Leverington, 2008)

The infrastructure variable has the sub-variable equipment and tools, facilitate for basic management, facilities for specific management, condition of facilities, security of facilities, boundary demarcation and access (Cifuentes, 2000).

Under the field category is the community support and participation variable, intra-institutional support with the sub variable of mother institution and PA system administration; inter-institutional support and external support. Under the legal field is the land tenure variable with the possession and conflicts sub-variables; the set of general laws and regulations variable has the sub variables of clarity and application. The final variable is the law the created the PA (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016). Under the planning field there are six variables. The PA management plan variable has the sub variables of plans exist and are up-to-date; characteristics of the planning team, plan implementation. The compatibility of management plan with other plans and organizations, level and planning and zoning variables have no sub variables. The annual operational plan variable has plans exist and are up-to-date and plan implementation. Under the knowledge field there is seven variables- socio-economic information, biophysical information, cartographic information, legal information, research, monitoring and feedback and traditional knowledge (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016).

Under the management programs field are six variables with each variable getting evaluated according to the design, implementation, co-ordination, follow-up and evaluation. The variables are research, environmental education, environmental interpretation, protection, maintenance and outreach to the community (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016). Under the illegal uses field are the variables of timber extraction, extraction of non-renewable natural resources, extraction of flora and fauna, vandalism of cultural resources, squatting, poaching, agriculture and cattle ranching, fishing, recreation and tourism, building of infrastructure (Cifuentes, 2000).

Under the field of legal uses are the variables of timber extraction, extraction of mineral resources, extraction of flora and fauna, hunting, agriculture and cattle ranching, fishing, recreation and tourism, education and building construction (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016). Under the biogeographical characteristics field are the variables of form, size, isolation and vulnerability. Under the threats field are the variables of visitor impact, pollution, fires, advance of human settlements, migration, exotic organisms, natural disasters, development infrastructure, subversive political movements or violent conflicts and drug trafficking and related. The indicators are rated based on unsatisfactory, minimally satisfactory, moderately satisfactory, satisfactory and very satisfactory (Cifuentes, 2000; Ervin, 2003; Araujo and Bernard, 2016). A point system is related to each rating which can then be displayed for comparative analysis between fields to determine which field needs more attention.

2.3.15 PIP Site Consolidation

Developed by The Nature Conservancy (TNC) and the US Agency for International Development (USAID) as a monitoring tool for Parks in Peril (PiP) to assess the processes required to conserve the individual protected areas and give the managers of these tools to measure progress (TNC, 2004; Leverington et al., 2008). The application of this methodology is the creation of multi-year, life-of-project objectives for PiP sites using standard criteria across a portfolio of protected areas, allowing project managers to track progress of site consolidation at specific protected areas over time, being able to track what areas of the PiP program have been met at particular protected areas, raising awareness of systematic assessment of conservation and to be able to attract future funding and technical resources by demonstrating documented progress in conservation (TNC, 2004; Leverington et al., 2008).

The process is very participatory with managers and stakeholders maintaining open communication and negotiation of management decisions. The first step is to formulate a team of managers and key stakeholders, followed by the compilation of information, defining and documenting baseline scores at the beginning of the assessment (TNC, 2004; Leverington et al., 2008). Setting targets and defining changes necessary to reach those targets of where we want to be and developing strategies on how to get there. The important part of this methodology is to adjust the scores and targets annually creating a feedback loop for adaptive management (TNC, 2004; Leverington et al., 2008). Sixteen (16) indicators are organized in four categories. Under the basic protection activities are the physical infrastructure, on-site personnel, training, land tenure issues, threats analysis and official declaration of protected area status indicators. Under long-term management are the indicators of reserve zoning and buffer zone management, site-based long-term management plan, conservation science needs assessment and monitoring plan development and implementation (TNC, 2004; Leverington et al., 2008). Under the long-term financing are the indicators of NGO self-sufficiency plan and PiP site long-term financial plan. The indicators are then scored by five benchmarks excellent (proper management of the protected area ensured); adequate (protected area is adequately managed for the most critical threats and highest priority conservation targets); progress made (protected area becoming adequately managed, but still has progress to make); work begun (little actual progress towards adequate management of the protected area) and no work has been done (protected area not being managed).

2.3.16 PARKS PROFILES

Developed by Parks Watch in cooperation with local partners to have multi-disciplinary assessments on the state of tropical parks (Leverington et al., 2008). The questionnaire is very detailed with a survey form comprised of 600 questions on the pressures/threats and the managerial aspects (Figure 2-29). It therefore provides a complete assessment of the PA (Leverington et al., 2008). The methodology is based in the WCPA framework and is organized by four categories: intrinsic, sensitivity, consolidation, human pressures and threats (Leverington et al., 2008). A GIS component was added to highlight the geographic distribution of threats and pressures. It is implemented through a literature review, structured interviews, field data collection, photographic and video documentation and collection of spatially explicit data and should be completed by

Category	Indicator
Identification	General administrative information
Characterization	Area and limits Management category Biogeography
Intrinsic Sensitivity	Size Maturity of ecosystems Genetic isolation Landscape diversity Number of threatened species Human footprint Resilience Watershed integrity Natural hazards / Climatic changes
Consolidation Index (similar to WWF:WB Tracking Tool)	Ownership Management agency PA objectives PA design Personnel (numbers and training) Personnel management Management infrastructure Management equipment Maintenance of equipment and facilities Budget Financial plan Financial security Management of Budget Management plan Annual operational plan Enforcement activities Controlling access and use Stakeholder engagement Education and awareness-raising PA boundary Zoning Legal status National policies PA regulations Judicial system response Knowledge on the PA
	Research Monitoring and evaluation Visitor facilities Fees
Human Pressure Index	Research, conservation and development projects Tourism Human settlements and invasions Hunting (legal hunting and poaching) Fishing (legal and illegal) Firewood Collection Non-Timber Products (NTPs) Collection Agriculture Livestock raising Fires Logging Mining Oil exploration/extraction Infrastructure development Industrial activity Pollution Military activity Invasive species
Threat Index	Exposure to human influence Access to PA Transit Inside PA Legal conflicts Negative Political Interests Positive Strategic Importance Threats

Figure 2-29: Parks Profile framework (Leverington et al., 2008)

park managers and stakeholders – including scientists, consultants, NGO workers, tourists, and local residents (Leverington et al., 2008). Under the characterization category of the questionnaire are the indicators of area and limits, management category and biogeography. Under the intrinsic sensitivity category are the indicators of size, maturity of ecosystems, genetic isolation, landscape diversity, number of threatened species, human footprint, resilience, watershed integrity and natural hazards/climatic changes (Leverington et al., 2008). Under the consolidation index category are the indicators of ownership, management agency, PA objectives, PA design, personnel (numbers and training), personnel management, management infrastructure, management equipment, maintenance of equipment and facilities, budget, financial plan, financial security, management of budget, management plan, annual operational plan, enforcement activities, controlling access and use, stakeholder engagement, education and awareness-raising, PA boundary, zoning, legal status, national policies, PA regulations, judicial system response, knowledge on the PA, research, monitoring and evaluation, visitor facilities and fees (Leverington et al., 2008). Under the human pressure index category are the indicators of research, conservation and development projects, tourism, human settlements and invasions, hunting (illegal and legal). Fishing (illegal and legal), firewood collection, non-timber products (NTPs) collection, agriculture, livestock raising, fires, logging, mining, oil exploration/extraction, infrastructure development, industrial activity, pollution, military activity and invasive species (Leverington et al., 2008). Under the threat index category are the indicators of exposure to human influence, access to PA, transit inside PA, legal conflicts, negative political interests, positive strategic importance and threats. Indicators are then rated according to scales utilized by IUCN's system of classifying threatened species in currently not threatened, vulnerable, threatened, critically threatened.

2.3.17 Brazil1999

Developed by WWF Brail in partnership with the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) this methodology seeks to evaluate protected areas in Brazil based on the two major themes of the level of implementation and vulnerability (Lemos, 1999; Leverington et al., 2008), illustrated in Figure 2-30. It was developed based on a questionnaire given to park managers and is meant to assess the status of Federally Protected Areas through 13 indicators (Lemos, 1999; Leverington et al., 2008). Under the theme of implementation are the indicators of the status of land tenure of the PA, existence of management tools, types of use of PA (inside the area), percentage of financial resources required, percentage of total PA area requiring demarcation, hired personnel as proportion of staffing requirements, availability of transportation and communication infrastructure and existing infrastructure available (i.e. Visitor centre, trails). Under the theme of vulnerability are the indicators of the degree of isolation of PA from surrounding natural habitat matrix, percentage of degraded areas within the PA, illegal natural resources exploitation with the PA, predominant land use in PA's buffer zone and

A . Implementation	Status of land tenure of the PA Existence of management tools Types of use of PA (inside the area) Percentage of financial resources required that were available for the PA in 1997 Percentage of total PA area requiring demarcation by survey monument that is not demarcated (excluding rivers and coastlines) Hired personnel as proportion of staffing requirements (from the federal institution or others) Availability of transportation and communication infrastructure (internal and external), including permanent equipment and consumable materials Infrastructure available (Ecological Stations and Biological Reserves: researcher accommodation, laboratory, multipurpose building – National Parks: visitor centre, trails, signposts – In common: administrative building)
B. Vulnerability	Degree of isolation of PA from surrounding natural habitat matrix: percent of natural vegetation cover in buffer zone, in a 10 km radius of the PA Percentage of degraded areas within the PA Illegal natural resources exploitation within the PA Predominant land use in the PA's buffer zone Occurrence of neighbouring development projects conflicting with PA objectives

Figure 2-30: Brazil999 (Lemos, 1999; Leverington et al., 2008)

occurrence of neighbouring development projects conflicting with PA objectives (Lemos, 1999; Leverington et al., 2008). The answers are scored to determine whether the implementation of protected area programming as precarious situation, minimum implementation and reasonable implementation. The vulnerability is determined based on low vulnerability, medium vulnerability and high vulnerability (Lemos, 1999; Leverington et al., 2008). Risk is then calculated based on the average levels of implementation and vulnerability to highlight which areas are under extreme risk, high risk, medium risk and normal risk (Lemos, 1999; Leverington et al., 2008).

2.3.18 Monitoring and Assessment with Relevant Indicators of Protected Areas

Developed by WWF Guianas for the Guianas Forests and Environmental Conservation Project. (Courrau, 2005; Leverington et al., 2008). The Monitoring and Assessment with Relevant Indicators of Protected Areas of the Guianas (MARIPA-G) system, illustrated in

Scope	Indicator
The Political-Legal Scope	Legal status of the protected area
	Compliance of the law associated to the protected area
	Commitment and Support of Authorities
	Customary Law into Account in the Regulations of the Protected Area
	Compliance with the national policy guidelines on protected areas management
The Administrative and Operation Scope	Internal access for the management of the protected area
	equipment for the management of the protected arealdeal
	Equipment maintenance and operation of the protected area
	Physical infrastructures for the management of the protected area
	Maintenance and operation of the installations of the protected area
	Appropriate signs in the protected area
	Indicator: Personnel necessary for the management of the protected area
	Protected area with a training program
	Personnel trained for the management of the protected area - version 1
	Personnel trained for the management of the protected area - version 2
	Level of satisfaction of the personnel of the protected area
	Personnel rotation in the protected area
	Type of contract of core staff
	Local community representation in the staff and the management team
	Volunteers and internship in the protected area
	Management plan for the protected area

Scope	Indicator
	Operational plan for the protected area
	Management Effectiveness Assessments Implemented and Incorporated into the Management of the Protected Area
	Protected area zoned to enable park management
	Threat analysis prepared for the protected area
	Safety and operational guidelines and standards
	Accident and emergency evacuation plan
The Social Scope	Protected area with a communications plan (or program)
	Environmental education plan (or program) of the protected area
	Stakeholder analysis
	Stakeholders satisfaction
	Participation of stakeholders in the in the decision-making concerning the management of the protected area
	Participation of local stakeholders in the Field Management of the Protected Area
	Information on Land tenure within the protected area
	Satisfaction of the visitor to the protected area
Sub-Scope: Local Populations	Impact of the Protected Area on Population Dynamics
	Taking the Use of Natural Resources within the Protected Area into Account in the management plan in order to ensure to local population their traditional way of life
	Impact of the Protected Area on the Transmission of Knowledge
	Impact of the Protected Area on Employment and Income for Local Populations
	Increased well-being accrue to local communities
	Local community empowered to manage resources outside of protected area
	Training and Education Carried Out within the Framework of the Protected Area
	Taking the Gender Division of Labour into Account in the Management of the Protected Area
	Taking Cultural Heritage into Account: Material Culture (Architecture, Archeology) and Oral Memory
	Role of the Protected Area in the Integration of Local Communities in the Surrounding Environment and Role of Civil Society
	Impact of the Protected Area on Commercial Activity and Indirect Income
	Role of Protected Area in supporting Health Programs for AIDS, Malaria, Alcoholism, etc.
	User Compliance with Regulations
	Role of Protected Area in supporting Leisure and Recreational Activities for Visitors and Local Populations
	Impact of the Protected Area on Social Structures
	Impact of the Protected Area on Conflict Management
	How the Protected Area is Perceived by the Local Populations
	Impact of the Protected Area on helping local people to make choices on their future and their Access to Consumer Goods and Services
	Role of the Protected Area in Intercultural Relations between Communities
	Positive activities impacts on communities related to the protected area
	Negative activities impacts on communities related to the protected area
The Natural and Cultural Resources Scope	Types of activities compatibles with the protected area
	Types of activities incompatibles with the protected
	Positive activities impact on the natural resources of the protected area
	Negative impact on the natural resources of the protected area
	Impacts of activities which are external to protected area
	The impact of human activities on the protected area's ecology
	An adequate research program for the protected area
	Research with regulation and follow-up
	Gathering and sharing systematic information on the protected area
	The protected area values (focal management targets) are assessed and monitored
	Physical connections of protected areas are evaluated and documented
	Baseline data of biotic and abiotic components of the protected area systems are available
	Water pollution factors and indicators
	Maintenance of Ecological Integrity
	Buffer zone identified and demarcated
	Student Accommodation and Training Capacity
	Buffer zone management plan

Scope	Indicator
The Political-Legal Scope	Law enforcement plan for the protected area
	Effectiveness of the protected area's law enforcement plan
	Administrative authority of the protected area
	Institutional Framework
	Appropriateness and adequacy of legislation of the protected area
	Co-management agreement of the protected area
	Boundaries of the protected area are declared and demarcated
The Economic-Financial Scope	Long-term financing plan and financial mechanism of the protected area
	Availability of generated funds
	Area with goods and services, amenities, identified and valued
	Stakeholders recognize and appreciate goods and services of the protected area
	Stakeholders receive benefits
	Marketing Plan of the protected area

Figure 2-31: MARIPA-G framework (Corrau, 2005; Leverington, 2008)

Figure 2-31, adapts the PROARCA/CAPAS model to making it more applicable to the Guianas. It's a site level assessment to be produced based on a product of a workshop and focuses on the desired scenario for the protected area, scopes of analysis and indicators for each scope (Courrau, 2005; Leverington et al., 2008). The indicators are organized by five scopes. Under the political-legal scope is the legal status of the protected area, compliance of the law for protected area, commitment and support of authorities, customary law in account in the regulations of the protected area and compliance with the national policy guidelines on protected areas management (Courrau, 2005; Leverington et al., 2008). Under the administrative and operation scope are the indicators of internal access for the management of the protected areas, equipment for the management of the protected area; equipment maintenance and operation, physical infrastructure for the management of the protected area, appropriate signs, personnel necessary for management, training program with protected area, level of satisfaction of personnel of the protected area, type of contract of core staff, local community representation in the staff, volunteers and internship opportunities, management plan, operational plan, management effectiveness assessments implemented and incorporated, zoning of protected area, threat analysis, safety and operational guidelines (Courrau, 2005; Leverington et al., 2008). Under the social scope is the indicator of protected area with a communications plan, environmental education plan, stakeholder analysis, stakeholder satisfaction, participation of stakeholders in decision-making, participation of local stakeholders, information on land tenure within protected area and satisfaction of visitors to protected area (Courrau, 2005; Leverington et al., 2008). Under this scope is a sub-scope of local populations are the indicators of impact of the PA on population dynamics, transmission of knowledge, employment and income of local populations, social structures, conflict management; wellbeing to local communities; empowerment to local community, training and education, gender and cultural considerations; how the protected are is perceived by local populations and intercultural relationships between buffering communities. Under the natural and cultural resources scope are the indicators of types of activities in protected areas; impact on natural resources, adequate research programs, gathering and sharing systematic information, physical connections, water pollution factors and indicators, maintenance of ecological integrity, buffer zone identified and demarcated, student accommodation and training, and a buffer zone management plan. Under the political-legal scope are the indicators of law enforcement plans for PA, effectiveness of protected area, administrative authority, institutional framework, appropriateness and adequacy of legislation, co-management agreement and boundaries of protected area. Under the economic-financial scope are the indicators of long-term financing plan, availability of generated funds, area with goods, services and amenities; stakeholders recognize and appreciate good, stakeholders receive benefits and marketing plan of the protected area.

2.3.19 Catalonia Management Effectiveness Evaluation

Developed by the Catalan Institution of Natural History (ICHN) to assess the condition of the entire system of 148 protected areas in Catalonia, Spain (Mallarach and Varga, 2004; Leverington et al., 2008). The Catalonia Management Effectiveness Evaluation (Catalonia MEE) is therefore meant to improve the entire system of protected areas (Figure 2-32). The methodology has 87 indicators organized under 6 sets is implemented through self-evaluation by evaluators of each protected area and then completed documents are sent to ICHN for compilation and analysis. Consultations are held to discuss the analysis for consensus across the system (Mallarach and Varga, 2004; Leverington et al., 2008). Under the context set of indicators are conservation value of geology; flora and vegetation; vertebrate fauna; invertebrate fauna; domestic traditional breeds; significance of habitat in European context; spiritual, cultural or historical relevance; dimensions; shape; ecological reconstitution stage; fragmentation; ecological connectivity; fire risk; geological risk; urban pressures; infrastructure

Context indicators	Conservation value of geology
	Conservation value of flora and vegetation
	Conservation value of vertebrate fauna
	Conservation value of invertebrate fauna
	Conservation value of domestic traditional breeds
	Presence of habitats of European significance
	Spiritual, cultural or historical relevance
	Dimensions
	Shape
	Ecological reconstitution stage
	Fragmentation
	Ecological connectivity
	Fire risk
	Geological risk
	Urban pressures
	Infrastructure pressures
	Threats significance
	Population
	Area with economic production
	Visitors
Planning and Legislation indicators	IUCN equivalent category
	Adequacy of existing legal protection
	International designations
	Adequacy of design
	Coherence of the protected natural areas system
	Land ownership
	Natural resources management planning level
	Existence and adequacy of the protected area management plan
	Time span between the declaration of the protected area and the approval of the management plan
	Conservation categories included on the management plan
	Public participation during the elaboration of the management plan
	Dissemination of the management plan
	Management of the protected area annual report
Means (inputs)	Staff by type of contract
	Staff by functional responsibility
	Participation of volunteers
	Public participation on the board
	NGOs and corporations making contributions
	Facilities inside the protected natural area
	Facilities outside (around) the protected area
	Fire prevention plan and management
	Use of new technologies
	Environmentally friendly facilities
	Access with motor vehicles
	Budget
	Level of economic autonomy
	Adequacy of the available resources
	Funding sources
Processes	One single indicator to measure how the different processes taking place for the management of the protected areas follow a formal pattern
Activities and services (outputs)	Number of visitors making use of the protected area facilities
	Physical identification of boundaries and accesses
	Informative panels
	Sign posted paths and trails
	Staff devoted to the attendance of visitors
	Litigation and prosecution
	Mandatory consultation reports
	Technical and economic support to local population
	Scientific publications
	Popular publications
	Research related to management
	Educational activities
	Execution of activities included in programs
Results (outcomes)	Changes in key geologic features or elements
	Changes in key species
	Changes in key habitats
	Local extinction of species
	Land use/land cover changes
	Negative impacts due to legal activities
	Changes of rivers ecological conditions
	Eutrophication of marine waters
	Changes on the quality of groundwater
	Impact of wildfires
	Shape and dimension changes
	Changes on the condition of historical and cultural heritage
	Changes on the number of visitors
	Changes on education and sensitivity
	Changes on the perception of quality of the natural environment and the landscape
	Monitoring and research
	Economic activity that has been induced (by the protection of the natural area)
	Number of jobs that have been created
	Changes on the (local population) average family earnings
	Changes on the local population types of jobs
	Changes in the number of farms
	Demographic changes in the local population

Figure 2-32: Catalonia framework (Mallarach and Varga, 2004; Leverington et al., 2008)

pressures; threats significance; population; sectoral work force (Mallarach and Varga, 2004; Leverington et al., 2008). Under the planning and legislation set are economic production, visitors, IUCN equivalent, adequacy of existing legal protection, international designations, adequacy of design, coherence of protected natural areas systems, land ownership, natural resources management, existence and adequacy of protected area management plan, time span between the declaration of the protected area and approval of management plan, conservation categories, public participation, dissemination of management plan, management of protected area (Mallarach and Varga, 2004; Leverington et al., 2008). Under the means of inputs set of indicator are staff by type of contract; staff by functional responsibility; participation of volunteers; public participation on the board; corporations making contributions; facilities inside the protected natural area; facilities outside the PA; fire prevention plan and management; use of new technologies; environmental friendly facilities; access with motor vehicles; budget; level of economic autonomy; adequacy of the available resources and funding sources (Mallarach and Varga, 2004; Leverington et al., 2008). Under the processes activities and service outputs indicators are one single indicators that measure management processes; number of visitors making use of protected areas; physical identification of boundaries and accesses; informative panels; sign posted paths and trails; staff devoted to the attendance of visitors; litigation and prosecution; mandatory consultation reports; technical and economic support to local population; scientific publications; and popular publications (Mallarach and Varga, 2004; Leverington et al., 2008). Under the results set of indicators are the research related to management; educational activities; execution of activities; changes in geologic features or elements; changes in key species; changes in key habitats; local extinction of species; land use/land cover changes; negative impacts due to legal activities; changes of rivers ecological conditions; eutrophication of marine waters; changes on the quality of groundwater; impact of wildfires; shape and dimension changes; changes on the condition of historical and cultural heritage; change on number of visitors; changes on education and sensitivity; changes on the perception of quality of the natural environmental and landscape; monitoring and research; economic activity; number of jobs that have been created; changes on the average family earnings; changes on the types of available jobs; number of farms and demographic changes (Mallarach and Varga, 2004; Leverington et al., 2008).

2.3.20 Belize Management Effectiveness Evaluation

Developed during a consultancy with the redevelopment of the National Protected Areas Policy and Systems Plan (Young etal. 2005; Leverington et al., 2008). It incorporates elements of the PROARCA, the PIP Site Consolidations Scorecard, WWF-CATIE, How is your Marina Park Doing, TNC-CAP, the IUCN-WCPA framework (Wildtracks, 2006; Young etal. 2005; Leverington et al., 2008). The Belize Management Effectiveness Evaluation (Belize MEE) was trialed at over three workshops with the national agency for Forestry and 44 of the 48 protected areas in Belize. There are two sections to the assessment the first section outlines biodiversity importance and outlines threats to the biodiversity (Figure 2-33). The second section is organized like the traditional indicators into seven categories (Young et al. 2005; Leverington et al., 2008). Under the resource information category are the indicators of physical environment; biotic environment; cultural and archaeological resources; social and cultural, economic context; resource use and occupancy; tenures and claims; conservation target scenario; systematic threat assessment; traditional knowledge; information management systems; environmental monitoring activities;

Category	Indicator
1. Resource Information	1.1 Inventory: Physical Environment 1.2 Inventory: Biotic Environment 1.3 Inventory: Cultural and Archaeological Resources 1.4 Inventory: Social, Cultural, and Economic Context 1.5 Inventory: Resource Use and Occupancy 1.6 Inventory: Tenures and Claims 1.7 Site Assessment: Conservation Target 1.8 Site Assessment: Systematic Threat Assessment 1.9 Traditional Knowledge 1.10 Information Management Systems 1.11 Environmental Monitoring Activities 1.12 Functional Research Activities

Category	Indicator
2. Resource Administration, Management and Protection	2.1 Legal: Legal Status 2.2 Legal: Boundary Survey and Demarcation 2.3 Legal: Registration, Permit, and Approval Processes 2.4 Tenure and Claim Conflict Resolution 2.5 Guidelines and Best Management Practices 2.6 Protection: Surveillance Activities 2.7 Protection: Enforcement Activities 2.8 Visitor and Tourism Management Activities 2.9 Visitor and Tourism Monitoring Activities
3. Participation, Education, and Socio-Economic Benefits	3.1 Communication Activities 3.2 Educational Activities 3.3 Dissemination of Knowledge and Information 3.4 Participation: Level of Participation in Management 3.5 Participation: Local Actors Leading Management 3.6 Participation: Volunteer Activities 3.7 Participation: Strength of Social Capital 3.8 Participation: Capacity Building Work 3.9 Benefits: Socio-Economic Benefits Program 3.10 Benefits: Extent of Local Economic Benefits 3.11 Benefits: Recognition of Protected Area Benefits
4. Management Planning	4.1 Management Plan Implementation 4.2 Operational Plan Implementation 4.3 Regulation and Zoning Implementation 4.4 Guidelines and Best Management Practices 4.5 Long Term Management Needs Identification 4.6 Program Monitoring and Evaluation
5. Governance	5.1 Protected Areas Objectives 5.2 Co-Management Arrangements 5.3 Administrative Autonomy 5.4 Operating Procedures: Advisory Committee 5.5 Operating Procedures: Board 5.6 Interorganizational Mechanisms
6. Human Resources	6.1 Site Manager Preparation 6.2 Site Manager Availability 6.3 Admin Staff Availability 6.4 Technical, Scientific, and Professional Staff Availability 6.5 Operations Staff Availability 6.6 Human Resource Surveys 6.7 Training and Development
7. Financial and Capital Management	7.1 Funding Adequacy 7.2 Revenue Generation 7.3 Financial Management 7.4 Infrastructure Adequacy 7.5 Equipment Adequacy 7.6 Internal Access Adequacy 7.7 Signage Adequacy 7.8 Maintenance Adequacy

Figure 2-33: Belize MEE framework (Young etal. 2005; Leverington et al., 2008)

functional research activities (Young etal. 2005; Leverington et al., 2008). Under the resource administration category are the legal status; boundary, survey and demarcation; registration, permit and approval processes; tenure and claim conflict resolution; guidelines and best management practices; surveillance activities; enforcement activities; visitor and tourism management activities and monitoring activities (Young etal. 2005; Leverington et al., 2008). Under the participation, education and socio-economic categories are the indicators of communities' activities; educational activities; dissemination of knowledge and information; level of participation in management; local actors leading management; volunteer activities; strength of social capital; capacity building work; socio-economic benefits program; extent of local economic benefits and recognition of protected area benefits (Young etal. 2005; Leverington et al., 2008). Under the management planning category are the indicators of management plan implementation; operational plan implementation; regulation and zoning implementation; guidelines and best management practices; long term needs; and program monitoring and evaluation (Young etal. 2005; Leverington et al., 2008). Under the governance category of the indicators are the protected areas objectives; co-management arrangements; administrative autonomy; advisory committee; the board operating procedures and interorganizational mechanisms. Under the human resources category are the indicators of site manager preparation; site manager availability; admin staff availability; technical, scientific and professional staff availability; operations staff availability; human resources surveys and training and development. Under the financial and capital management category are the indicators of funding adequacy; revenue generation; financial management; infrastructure adequacy; equipment adequacy; internal access adequacy; signage adequacy and maintenance adequacy (Young etal. 2005; Leverington et al., 2008). The scores are then grouped along the scale of very poor management (<25%), poor management (25%-50%), moderate management (51%-75%) and satisfactory/ good management (76% - 100%) effectiveness.

2.3.21 Ecuador Management Effectiveness Evaluation

Developed by the Instituto Equatoriano Florestal y de Areas Naturales y Vida Silvestre (Ecuador Institute of Forest, Natural Areas and Wildlife) the Ecuador Management Effectiveness Evaluation (Ecuador MEE) evaluates the management of Ecuador's national system of protected areas (SNAP). The aspects of the methodology include several themes to identify the required resources; the products received and the compliance with the protected area objectives (Valarezo et al. 1999; Leverington et al., 2008). Under the them is required resources are the organization, cognition, knowledge, political, economic and technical-administrative. Under the products achieved theme are the protected area protection, participation in the management, ordering of the SNAP system and benefits and self-management (Valarezo et al. 1999; Leverington et al., 2008).

2.3.22 Finland Management Effectiveness Evaluation

Developed by Metsahallitus as a valuation of the Finnish protected area system, the Finland Management Effectiveness Evaluation (Finland MEE) is modified from the RAPPAM methodology (Gilligan et al., 2005; Leverington et al., 2008). The specific questions were developed and organized into six categories (Figure 2-34). Under the context category are questions to understand the national vision and legislative framework for the effective functioning of the PA; personnel and resources well organized; cohesive and national coordinated approach to PA management; transboundary and regional cooperation; values of the PA system documented and assess; threats to PA system well documented and assessed ; are the objectives harmonised with Natura 2000 objectives and are the objectives harmonised with wider cultural objectives (Gilligan et al., 2005; Leverington et al., 2008). Under the planning category are the questions to determine if protected areas identified and organized into a system; are the individual area established through a systematic process; are the established reserves covered by comprehensive management plans; are plans routinely updated; are protected areas located in the places that can protect

Context
1.1 Is there a clearly articulated national vision for the on-going development and management of the Finnish PA system?
1.2 Does the legislative and administrative framework support the effective functioning of the PA system?
1.3 Are personnel and resources well organised and managed with access to adequate resources?
1.4 Is there a cohesive and nationally coordinated approach to PA management?
1.5 Is transboundary and regional cooperation established and maintained in a manner which supports effective management of Finnish protected areas?
1.6 Are the values of the PA system well documented and assessed?
1.7 Are the threats to PA system values well documented and assessed?
1.8 Do Finnish PA management objectives harmonise with Natura 2000 objectives?
1.9 Do Finnish PA management objectives harmonise with wider cultural objectives including those relating to the Sámi?

Planning
2.1 Are protected areas identified and categorised in an organised system?
2.2 Are individual protected areas designed and established through systematic and scientifically based criteria and process with a clearly articulated vision?
2.3 Are established reserves covered by comprehensive management plans?
2.4 Are management plans routinely and systematically updated?
2.5 Are protected areas located in places with the highest/most threatened biodiversity values?
2.6 Are stakeholders given an opportunity to participate in planning?

Resources
3.1 What level of overall resource is provided for PA management?
3.2 How have resource levels varied with increases in protected areas in recent years?
3.3 On what basis are resources allocated to PA for management?
3.4 At the park level, are resources linked to priority actions identified in management plans?
3.5 What level of resources is provided by partners and/or volunteers?
3.6 Do PA managers consider resources to be sufficient?

Process
4.1 Is management performance against relevant
planning objectives and management standards routinely assessed and systematically audited as part of an on-going 'continuous improvement' process?
4.2 Is NHS staff performance management linked to achievement of management objectives?
4.3 Is the NHS internal audit function systematic and credible?
4.4 Is there external and independent involvement in internal audit?
4.5 Is there effective public participation in PA management in Finland?
4.6 Is there a responsive system for handling complaints and comments about PA management?

Output
5.1 Is adequate information on PA management publicly available?
5.2 Are visitor services appropriate for the relevant protected area category?
5.3 Are management related trends systematically evaluated and routinely reported?
5.4 Do audit reports reveal effective management?
5.5 Is there a systematic maintenance schedule in place for built infrastructure/assets?
5.6 Does Finland fulfill its monitoring and reporting obligations under European Directives and international conventions?

Outcomes
6.1 Are threats to reserve heritage values held in check or reduced?
6.2 Are threatened species populations stable or increasing?
6.3 Are parks and reserves losing native species?
6.4 Are selected indicator species within acceptable ranges?
6.5 Are biological communities at a mix of ages and location that will support native biodiversity?
6.6 Are ecological processes (in the PA) functioning in a healthy and sustainable manner?
6.7 Are the expectations of visitors generally met or exceeded?
6.8 Are neighbors and adjacent communities supportive of PA management?
6.9 Are cultural heritage assets protected?

Figure 2-34: Finland MEE (Gilligan et al et al., 2005; Leverington, 20 et al08) highest threatened biodiversity values and are the stakeholders given the opportunity to participate in planning (Gilligan et al., 2005; Leverington et al., 2008). Under the resources category are the questions on the level of resources provided for PA management; whether the resource levels have varied in recent years; the basis on which resources are allocated for PA management; the resources have been linked to priority actions; level of resources is provided by partners and are PA managers consider available resources sufficient to complete the work (Gilligan et al., 2005; Leverington et al., 2008). Under the process category are the questions of management performance against relevant planning objectives; the independent involvement in internal audit; an effective public participation in PA management and a responsive system for handling complaints and comments about PA management (Gilligan et al., 2005; Leverington et al., 2008).

Under the output category are questions to determine whether adequate information is publicly available; whether visitor services are appropriate for protected areas; whether management trends are routinely reported; whether audit reports reveal management effectiveness; whether a systematic maintenance schedule is in place and whether the monitoring and reporting obligations are fulfilling regional and international conventions (Gilligan et al., 2005; Leverington et al., 2008). Under the outcome category are questions to determine threats to reserve heritage values; threatened species populations are stable or increasing; reserves containing native species; indicator species in acceptable ranges; whether biological communities can support native biodiversity; ecological processes function in a healthy and sustainable manner (Srinivasan et al., 2003; expectations of visitors are met and exceeded;

buffering communities supportive of PA management and the cultural heritage assets protected (Gilligan et al., 2005; Leverington et al., 2008).

2.3.23 Galapagos Management Effectiveness Evaluation

Developed by the Servicio Parque Nacional Galapagos – SPNG (Galapagos National Park Service) from the WWFCATIE methodology adapted to include additional variables, sub-variables and indicators of ecological, social and economic integrity (Velasquez and Villegas, 2004; Leverington et al., 2008). The Galapagos Management Effectiveness Evaluation (Galapagos MEE) objectives are to know if the SPNG management objectives are achieved; to identify factors that interfere with the management capacity; the improvement of connectivity to projects; provision of needed inputs to adaptive management and an elaborate too for determining park's accountability (Figure 2-35). An eight-step process is

WCPA Element	**Indicator**	**Level of assessment (Site, State, National)**
Context	Are the values of the site well documented, assessed and monitored?	Site
	Are the threats to site values well documented and assessed?	Site
	Is the site free from human and biotic interference?	Site
	Is there a clearly articulated vision for the development and management of PA network in the State/India?	State/National
	Does the administrative framework adequately support the effective functioning of the PA network?	State
	Is there a cohesive and well coordinated approach to PA management?	State/National
	Is regional cooperation (i.e. inter-state/international) established and maintained in a manner which supports effective management of PA?	State/National
	Does the legislative framework adequately support the effective functioning of the PA network?	National
Planning	Is the site properly identified and categorized (in terms of zoning) to achieve the objectives?	Site
	Does the site have a comprehensive Management Plan?	Site
	Are Management Plan(s) routinely and systematically updated?	Site/State
	Does the site safeguard the threatened biodiversity values?	Site
	Are stakeholders given an opportunity to participate in planning?	Site
	Are habitat restoration programs systematically planned and monitored?	Site
	Are reintroduction programs systematically planned and monitored?	Site
	Does the site has an effective protection strategy?	Site
	Has the site been effective in the mitigation of human-wildlife conflicts?	Site
	Is the site integrated into a wider ecological network following the principles of the ecosystem approach?	Site
	Are protected areas designed and established through a systematic and scientifically based criteria and process with a clearly articulated vision?	State/National
	Are there mechanisms in place for sharing of revenues from PA	State
Inputs	Are personnel well organised and managed with access to adequate resources?	Site
	Are resources (vehicle, equipment, building etc.) well organised and managed with access to adequate resources?	Site
	Are resources (human and financial) linked to priority actions and are funds released timely?	Site
	What level of resources is provided by NGOs?	Site
	Does PA manager consider resources (human and financial) to be sufficient?	Site
	How have resource levels varied with increases in protected areas in recent years?	State/National
Process	Does the site have trained manpower resources for effective PA management?	Site
	Is PA staff performance management linked to achievement of management objectives?	Site/State
	Is there effective public participation in PA management?	Site
	Is there a responsive system for handling complaints and comments about PA management?	Site/State/ National
	Does PA management address the livelihood issues of resource dependent communities, especially women?	Site
	Does the state have trained manpower resources for effective PA management?	State
	Is management performance against relevant planning objectives and management standards routinely assessed and systematically audited as part of an on-going 'continuous improvement' process?	State/National
	Is there an external and independent involvement in internal audit?	State/National
Outputs	Is adequate information on PA management publicly available?	Site/State/ National
	Are visitor services (tourism and interpretation) and facilities appropriate for the relevant protected area category?	Site
	Are management related trends systematically evaluated and routinely reported?	Site/State
	Is there a systematic maintenance schedule and funds in place for management of infrastructure/assets?	Site/State
	Does India fulfill its monitoring and reporting obligations under international conventions?	National
Outcomes	Are threatened/ endangered species populations stable or increasing?	Site/State/ National
	Are biological communities at a mix of ages and locations that will support native biodiversity?	Site
	Have the threats to the site being abated/ minimized?	Site
	Are the expectations of visitors generally met or exceeded?	Site
	Are neighbors and adjacent communities supportive of PA management?	Site
	Are cultural heritage assets protected?	Site

Figure 2-35: Galapagos MEE framework (Velasquez and Villegas, 2004; Leverington et al., 2008)

completed to evaluate the scope of biophysical, legal, governance, social, knowledge, administration, planning, management programs, threats, legal uses and illegal uses (Velasquez and Villegas, 2004; Leverington et al., 2008). Based on the analysis scoring the management is determined as very satisfactory, satisfactory, moderately satisfactory, less satisfactory and unsatisfactory.

2.3.24 Indian Management Effectiveness Evaluation

Developed by the Ministry of Environment and Forests, Government of India and the Wildlife Institute of India. The Indian Management Effectiveness Evaluation (Indian MEE) is based on the IUCN-WCPA framework and done at three levels national state and site (Leverington et al., 2008). All criteria are scored on a four-point scale based on very good (10), good (7.5), fair (5) and poor (2.5). This methodology was meant to provide evaluation of protected areas in India to determine whether India is meeting the conservation objectives as well as social objectiveness for wildlife management (Leverington et al., 2008). Under the context WCPA element the indicators are the values of the site well documented and monitored; the threats to site values are documented and assessed; the site is free from human and biotic interference; the vision is clearly articulated; the administrative framework adequately supports the functioning of the PA; a cohesive and well-coordinated approach to PA management; and legislative framework supports the effective functioning of the PA (Leverington et al., 2008). Under the planning WCPA element the indicators are the site properly identified and zoned; the site have a comprehensive Management Plan; Area Management Plan is routinely and systematically updated; the site safeguard the threatened biodiversity values; stakeholders given an opportunity to participate in planning; habitat restoration programs systematic planned and monitored; the site having an effective protection strategy; the mitigation of human-wildlife conflicts; the site integrated into wider ecological network flowing the principles of ecosystem approach; the mechanisms in place for sharing revenues and the protected areas designed and established through a systematic and scientifically based criteria (Leverington et al., 2008). Under the inputs WCPA element are the indicators of personnel being well organized and managed; organization of resources; resources linked to priority actions and funds released in a timely manner; the level of resources provided by the NGO; the PA manager consider the resources are sufficient; and resource levels have increased in the recent years (Leverington et al., 2008). Under the process WCPA element are the indicators of site have the trained staff to effectively manage PA; the staff performance is linked to achievement of management objectives; there exists effective public participation; a responsive system for handling complaints; management address livelihood issues of resource dependent communities; systematic 'continuous improvement' process (Leverington et al., 2008). Under the outputs WCPA element are the indicators of adequate information on PA management available publicly' visitor services are appropriate for PA category; systematic managements of PA infrastructure assets; whether India fulfils the monitoring and reporting obligations under international conventions (Leverington et al., 2008). Under the outcomes WCPA element are the indicators of threatened and endangered species stabilized or increasing; support to native biodiversity; threats to the site are minimized; expectations of visitors generally met or exceeded; neighbours and adjacent communities supportive of PA management and cultural assets protected (Leverington et al., 2008).

2.3.25 Tasmanian Management Effectiveness Evaluation

Developed by the Tasmanian Parks and Wildlife Service provide feedback on the management effectiveness as well as address public accountability requirements towards key desired outcomes (Parks and Wildlife, 2004; Leverington etal, 2008). The Tasmanian Management Effectiveness Evaluation (Tasmanian MEE) information is derived over a period of time through audits of the management plans, stakeholder surveys and interviews (Figure 2-36). The reporting is organized based on the management plan with reporting areas as opposed to indicators (Parks and Wildlife, 2004; Leverington etal, 2008). Under the general

Aspect of plan	Reporting areas
General Management and Arrangements	• Achievement of desired outcomes of management. • Balance of management effort across responsibilities. • Community acceptance of TWWHA management. • Legislation, law enforcement and compliance. • Accordance of management with legal instruments and conservation agreements. • Management of controversial issues. • Land tenure, boundary and adjacent area management. • Transmission of knowledge and ability to future generations. • Community engagement with the TWWHA. • Management arrangements for Aboriginal heritage. • Integration of TWWHA management with local and regional planning. • Public health and safety in the TWWHA. • Management of property and assets. • Standard and practice of management. • Performance evaluation and adaptive management.
Identification and understanding of the natural and cultural heritage	• Identification and definition of the natural and cultural values. • Knowledge of the natural and cultural values. • Social and cultural values affecting management. • Adequacy of knowledge for sound management.
Protection of the natural and cultural heritage	• What is the natural and cultural heritage of the TWWHA? • What are the main threats to the natural and cultural heritage? • Management of identified threats and adverse impacts, 1992-19999. • Cessation or reduction of damaging activities and practices. • Wildfires. • Plant diseases and dieback. • Weeds and other introduced plants. • Introduced animals. • Tourism and visitor activities and use. • Development of new facilities and other infrastructure. • Coastal erosion of Aboriginal heritage sites. • Lack of maintenance or active conservation of historic heritage. • Regulation of river flows by hydroelectric power generating operations.
Conservation and rehabilitation of the natural and cultural heritage	• Condition of natural diversity and processes. • Wilderness quality. • Environmental quality. • Landscape quality.
	• Condition of Aboriginal and historic heritage. • Monitored condition of significant values (including degraded values).
Presentation of the natural and cultural heritage	• Community awareness and support for the TWWHA. • Popularity and effectiveness of information and education products and services. • Visitor facilities, use and sustainability. • Visitor satisfaction with facilities, services and their experience of the TWWHA.
Stakeholders' assessments of management performance	• How were stakeholders' assessments gathered? • Overall management performance. • General management and arrangements. • Identification and understanding of values. • Protection and conservation of values. • Presentation values.

Figure 2-36: Tasmanian World Heritage framework (Parks and Wildlife, 2004; Leverington et al., 2008)

management and arrangements are the reporting areas of achieving the desired outcomes; balance of management effort across responsibilities; community acceptance of TWWHA management; legislation, law enforcement and compliance; management with legal instruments; handling of controversial issues; land tenure, boundary and adjacent area management; community engagement with the TWWHA; public health and safety; management of property and assets; standard and practice of management and performance evaluation (Parks and Wildlife, 2004; Leverington etal, 2008). Under the identification and understanding of natural and cultural heritage are the reporting areas of identification and definition of natural and cultural values; knowledge of natural and cultural values; social and cultural values affecting management and adequacy of knowledge for sound management (Parks and Wildlife, 2004; Leverington etal, 2008). Under the protection of natural and cultural heritage are the reporting areas of natural and cultural heritage of TWWHA, threats to natural and cultural heritage; management of identified threats and adverse impacts; cessation or reduction of damaging activities and practices; wildfires; plant diseases and dieback; weeds and other introduced plants; introduced animals; tourism and visitor activities and use; development of new facilities and other infrastructure; coastal erosion of Aboriginal heritage sites; lack of maintenance or active conservation of historic heritage and regulation of river flows by hydroelectric generating operations (Parks and Wildlife, 2004; Leverington etal, 2008). Under the conservation and rehabilitation of natural and cultural heritage are the reporting areas of natural diversity and processes; wilderness quality; environmental quality and landscape quality (Parks and Wildlife, 2004; Leverington etal, 2008). Under the presentation of natural and cultural heritage are the reporting areas of community awareness and support; popularity and effectiveness of information and education products; visitor facilities, use and sustainability; and visitor satisfaction with facilities, service and their experience of the TWWHA (Parks and Wildlife, 2004; Leverington etal, 2008). Under the stakeholders' assessments of management performance are the reporting areas of overall management performance; general management and arrangements; identification and understanding of values; protection and conservation of values and presentation values (Parks and Wildlife, 2004; Leverington etal, 2008). Although there is no structured scoring system, information on each topic is presented to highlight the how the key desired outcomes are addressed in management and suggestions for improvement are highlighted (Parks and Wildlife Service, 2004; Leverington et al., 2008).

2.3.26 Metodología medición de la efectividad del manejo

Developed by the Servicio Nacional de Areas Protegidas (Protected Areas National Service) in Bolivia as a double system for monitoring and evaluation of protected areas (Guachalla et al., 2001; Leverington et al., 2008). The Metodología medición de la efectividad del manejo del SNAP (MEMS) and Sistema de Monitoreo Integral para a Conservación en Áreas Protegidas (SMAP). The MEMS methodology looks at an evaluation of certain aspects of protected areas consolidation whereas the SMAP explores conservation targets, human activities, socio-economic dynamics, socio-political conflicts and protected areas management (Figure 2-37). For the purposes of the research only the MEMS aspect will be discussed (Guachalla et al., 2002; Leverington et al., 2008). The indicators under MEMS are divided into five categories. Under the basic protection activities are infrastructure and equipment, institutional capacity, capacity, land tenure, threats analysis and legal status (Guachalla et al., 2002; Leverington et al., 2008). Under long-term management are protection plan, biodiversity inventory and biodiversity monitoring system. Under the long-term financial management is the operational budget, regularity of resources, capacity for financial management and long-term financial planning (Guachalla et al., 2002; Leverington et al., 2008). Under the social participation are the creation of an ongoing management committee, levels of coordination, relationship with municipal governments and relationship with departmental representatives (Guachalla et al., 2002; Leverington et al., 2008).

	Indicator
A. Basic protection activities	Infrastructure and Equipments
	Institutional Capacity
	Capacity
	Land Tenure
	Threats analysis
	Legal Status
B. Long-term management	Protection Plan
	Biodiversity inventory
	Biodiversity monitoring system
C. Long-term financial management	Operational budget
	Regularity of resources
	Capacity for financial management
	Capacity for long-term financial planning
D. Social participation	Established and ongoing management committee
	Levels of coordination among institutions
	Relationship with municipal governments
	Relationship with the "Prefecturas Departamentales"

Figure 2-37: MEMS framework (Guachella et al., 2001; Leverington et al., 2008)

2.3.27 Qld Park Integrity

Developed by the Queensland Parks and Wildlife Service (QPWS), the Queensland Park Integrity (Qld Park Integrity) to assess whether management is protecting the values of each protected area within the system and the creation of an early warning system to detect emerging threats and impacts (Hockings et al., 2007; Leverington et al., 2008). The methodology is based on the identifying values and indicators to help managers assess current conditions and develop future programming (Hockings et al., 2007; Leverington et al., 2008). The reporting is conducted through a 3-staged process involving field consultations and workshops and information is organized by elements and indicators (Figure 2-38). Under the significant landscapes and regional ecosystems are the indicators of scenic values; significant regional ecosystems; significant landscapes and research values (Hockings et al., 2007; Leverington et al., 2008). Under the significant plants and animals' elements are the indicators of rare and threatened plants and animals; species of special significance and research values (Hockings et al., 2007; Leverington et al., 2008). Under the ecosystem services elements are the indicators of catchment

Natural Values	
Significant landscapes and regional ecosystems	Scenic values Significant regional ecosystems Significant landscapes Research values
Significant plants and animals	Rare and threatened plants
	Rare and threatened animals
	Species of special significance
	Research values
Ecosystem services	Catchment protection
	Landscape function
	' benchmark' value
	Air quality
	Other
Reserve in Context	Surrounding land uses
	Impact of these on the park
Threats to natural values	Pollution from adjacent areas Impacts from park management Siltation/erosion Increasing fragmentation of habitat in the region Internal Fragmentation Pest Plants Pest Animals Inappropriate fire regimes Visitor Impacts Hydrological modification Other

Administration	Administrator	Staff body Quantity Staff Quality Staff Motivation Attitudes Presentation
	Financing	Operational Financing Extra Financing Regularity on resource delivery
	Resources Generation / Organisation	Archive Organogram Internal communication Normatisation
	Infrastructure	Basic infrastructure Special Infrastructure Salubrity Security
	Equipment and Materials	
	Limits demarcation	
Planning	Management Plan	Existence and update Planning team Method Plan execution
	Planning level	Annual operational plan
	Area zoning	
	Resource use compatibility (legal and illegal)	Recreation Tourism Education Fishing Logging Agriculture Cattle ranching Others
	Management programmes (Existence and execution)	Public use Research Protection Maintenance

Figure 2-38: Qld Park Intergrity (Hockings et al., 2007; Leverington et al., 2008)

protection, landscape function, benchmark value, air quality and any unaccounted services (Hockings et al., 2007; Leverington et al., 2008). Under the reserve in context are the surrounding land uses; impact of these on the park. Under the threats to natural values are the indicators of pollution from adjacent areas; impacts from park management; siltation/erosion; increasing fragmentation of habitat in the region; internal fragmentation; pest plants and animals; inappropriate fire regimes; visitor impacts and hydrological modification (Hockings et al., 2007; Leverington et al., 2008).

2.3.28 Scenery Matrix

Developed by the Sao Paulo Forestry Institute for the primary focus of assessing systems of protected area this methodology encourages a participatory process with a standardized scoring scale (De Faria, 2004; Leverington et al., 2008). Its overall objective is to compare the optimum protected area scenario with the current situation. The comprehensive list of indicators is meant as a basis for further discussion (De Faria, 2004; Leverington et al., 2008). Under administration are the indicators of staff body, quantity, staff quality, staff motivation, attitudes; presentation, operational financing; extra financing; regularity on resource delivery; archive; organogram; internal communication; normalisation; basic infrastructure; special infrastructure; salurbity and security (Figure 2-39). Under planning are the indicators of existence and update; planning team; method; plan execution; annual operational plan; recreation; tourism; education; fishing; logging; agriculture; cattle ranching; public use; research; protection and maintenance (De Faria, 2004; Leverington et al., 2008). Under politic-legal are the indicators of community support and participation;

instar-institutional support; inter-institutional support; creation diploma; tenure situation; support to staff; capacity building and norms application and fulfilment (De Faria, 2004; Leverington et al., 2008). Under resource quality are the indicators of size; shape; insulation; altered areas; integrity of catchments; PA resource exploitation; compatibility between the use of surrounding areas and PA objectives and threats (De Faria, 2004; Leverington et al., 2008). Under knowledge are indicators of socio-economic information; bio-physical information; cartographic information; legal information; researches and projects and monitoring and feedback (De Faria, 2004; Leverington et al., 2008). Under the forest management are the indicators of continuous management; inventory; improved forests; productivity and phytosanity.

Politic-legal	Community support and participation	
	Intra-institutional support	
	Inter-institutional support	
	Creation diploma	
	Tenure situation	
	Support to staff	
	Capacity-building	
	Norms application and fulfilment	
Resource quality	Size	
	Shape	
	Insulation	
	Altered areas	
	Integrity of catchments	
	PA resource exploitation	
	Compatibility between the use of surrounding areas and PA objectives.	
	Threats	
Knowledge	Socio-economic information	
	Biophysical information	
	Cartographic information	
	Legal information	
	Researches and projects	
	Monitoring and feedback	
Forest Management (State PA)	Continuous management	
	Inventory	Existence, update and use
	Improved forests	
	Productivity	
	Phytosanity	

Figure 2-39: Scenery Matrix framework (De Faria, 2004; Leverington et al., 2008)

2.3.29 Mexico System of Information, Monitoring and Evaluation for Conservation

Developed by the National Commission of Protected Areas of Mexico (CONANP) this methodology is based on a rapid assessment scorecard utilizing the six elements of the WCPA framework (SIMEC Mexico, 20017; Leverington et al., 2008). In the Mexico SIMEC there are 28 indicators where 16 are process based and 12 are project based used to monitor the effectiveness of all protected areas in the CONANP system (Figure 2-40). The process based indicators are investments from alternate sources; economic tool to encourage conservation; national and international cooperation projects; engagement in restoration; number of permits issued for PA; number of conservation programs; number of projects for priority species; sustainable management; number of works days contracted per year; number of government agencies engaged in conservation initiatives; number of bodies participating in projects; staff accomplishing their individual training programs; total area of PA create per year and total number of PA with conservation certificates (SIMEC Mexico, 20017; Leverington et al., 2008).

1. Investment in the PA from alternate sources (millions of Pesos per year)
2. Number of PA with at least one economic tool or mechanism to encourage conservation
3. Number of PA with national and international cooperation projects
4. Percentage of the PA surface in the process of active or passive restoration
5. Number of permissions issued (for commerce, tourism, recreation, film)
6. Number of programs of conservation and management finished
7. Number of projects of conservation of priority species in curse
8. Area of the Conservation Priority Region with sustainable management
9. Number of work days contracted per year (related to conservation building or soil restoration)
10. Percentage of the Conservation Priority Region with sustainable management (what is the difference between this and 4.1?)
11. Total number of appliers for support (related to producer's training)
12. Number of government bodies which participate in conservation initiatives
13. Number of bodies participating in projects of conservation and/or management of ecosystems (related to social participation)
14. Medium or high level staff accomplishing with their individual training program
15. Total area of PA created per year
16. Total area of the PA with conservation certificates (accredited?)
17. PA with strategic communication materials to create a conservation culture
18. Number of events which contribute to create a conservation culture
19. Number of PA with ecotourism initiatives
20. Number of PA with personal, material and financial resources for its basic operation
21. PA with a program of control and vigilance in coordination with the "PROFEPA"
22. PA with effective co-administration of initiatives and resources with the local government and/or the civil society
23. Percentage of the Conservation Priority Region with initiatives to strengthen social and institutional participation
24. Number of communities in the Conservation Priority Region participating in conservation initiatives
25. Fundraise (millions of Pesos per year) – not clear if it is related to the access fees or general)
26. Number of PA which monitors at least one flag species population
27. PA with research initiative taken by other bodies
28. PA where the rhythm of conversion of natural ecosystems is maintained or reduced

Figure 2-40: Mexico SIMEC (SIMEC Mexico, 2007; Leverington et al., 2008)

2.3.30 Valdiviana

Aspects (broad)	Aspects	Indicators
A. Management and implementation	Legal	Land tenure Legal status (legal instrument of creation or support) Limits demarcation
	Administrative	Field staff (involved in activities of control and protection, legal action, socialization, communication, extension and education) Administration: assigned staff and sufficient staff Technical staff (existence or not) Infrastructure Equipment and materials Financing and budget (permanent and external funding)
	Design and Planning	Design of the system and the PA Planning tools PA Zoning
	Political	Context (institutional support) Local participation and attitude regarding the PA objectives
	investigation, knowledge and education	Existence of information Research Management of information about natural and cultural resources Monitoring and evaluation Environmental education, extension and communication programs
	Actual use	Actual use of the PA
B. Threats and vulnerability	Buffer zone situation	Buffer zone (existence or not) Degree of isolation Predominant land use in the buffer zone Conflicting projects (regional development plans)
	PA situation	Percentage of altered area within the PA Water system protection Illegal activities Use of resources
	Importance of the area	Significance (for conservation)

Figure 2-41: Valdiviana framework (Rusch, 2002; Leverington et al., 2008)

Developed by WWF/Fundacion Vida Silvestre Argentina to assess the status of the protected areas in the Valdiviana Ecoregion. The objectives are to offer the community with an independent and objective tool to evaluate any advances in implementation and to offer a mechanism to direct policies, efforts and conservation actions on private organizations to administer the conservation parks (Rusch, 2002; Leverington et al., 2008). The methodology is implemented through understanding the degree of threats with a four-step data collection process (Figure 2-41). Under the legal aspect are the indicators of land tenure, legal status and limits demarcation (Rusch, 2002; Leverington et al., 2008). Under the administrative aspect are filed staff; administration; technical staff; infrastructure; equipment and materials and financing and budget (Rusch, 2002; Leverington et al., 2008). Under the design and planning aspects are the indicators of design of the system and the PA; planning tools and PA zoning (Rusch, 2002; Leverington et al., 2008). Under the political aspect are the indicators of context and local participation. Under the investigation, knowledge and education aspects are the indicators of existence of information, research, management of information, monitoring and evaluation and environmental education. Under the actual use aspect are the indicators of actual use of the PA (Rusch, 2002; Leverington et al., 2008). Under the buffer zone situation aspects are the indicators of buffer zone; degree of isolation; predominant land use in the buffer zone and conflicting projects (Rusch, 2002; Leverington et al., 2008). Under the PA situation aspects are the percentage of altered areas with the PA; water system protection; illegal activities and use of resources (Rusch, 2002; Leverington et al., 2008). Under the importance of the area aspect is the indicator of conservation significance of the protected area. The scoring analysis determines whether the degree of implementation is unsatisfactory, minimally satisfactory, moderately satisfactory, satisfactory and very satisfactory (Rusch, 2002; Leverington et al., 2008).

2.3.31 Venezuela Vision

Developed by Fundacion para la Defensa de la Naturaleza (FUDENA) and Instituto Nacional de Parques (INPARQUES) for Venezuela to analyse the risk situation of the protected areas in Venezuela (FUDENA/INPARQUES, 2001; Leverington et al., 2008). The Venezuela Vision indicators are organized in two categories. Under the sensitivity category are the indicators for PA size; distance from human influence; genetic isolation; landscape diversity; degree of intervention; regeneration capability; control of catchments; land tenure; plan and regulations; staff; technical staff, equipment; facilities; control and vigilance, access, political interest; strategic importance; knowledge of the area and natural risk (Figure 2-42). Under the pressure category are the indicators of recreation intensity, scientific use, therapeutic or cultural use, use of the image of the area; use as water reserve, deforestation, fire, agriculture, hunting, grazing, commercial or sport fishing, traditional populations, neighbouring populations, roads and electrical cables, gas and water systems, port and other uses,

	Criteria
A. Sensitivity	1. PA size (area) 2. Distance from human influence 3. Genetic isolation 4. Landscape diversity 5. Degree of intervention 6. Regeneration capability 7. Control of catchments 8. Land tenure 9. Plan and regulations 10. Staff 11. Technical staff 12. Equipment 13. Facilities 14. Control and vigilance 15. Access 16. Political interest (for development projects and use) 17. Strategic importance 18. Knowledge of the area 19. Natural risk
B. Pressure (use and other factors)	20. Recreation intensity 21. Scientific use 22. Therapeutic or cultural use 23. Use of the image of the area 24. Use as water reserve 25. Deforestation 26. Fire 27. Agriculture 28. Hunting 29. Grazing 30. Commercial or sport fishing 31. Traditional populations
	32. Neighbouring populations 33. Roads and electrical cables 34. Gas and water systems 35. Port and other uses 36. Mining 37. Communication antennas 38. Navigation routes

Figure 2-42:Venezuela framework (FUDENA/INPARQUES, 2001; Leverington et al., 2008)

mining, communication antennas and navigation routes (FUDENA/INPARQUES, 2001; Leverington et al., 2008).

2.3.32 Biodiversity and Protected Areas Management Reference Information systems

The Biodiversity and Protected Areas Management (BIOPAMA) Reference Information systems (RIS) is an online repository to support decision-making for protected areas in Africa, Caribbean and the Pacific (BIOPAMA, 2018). The data provided is geospatial and it is open sourced available through the internet The RIS tool provides information on protected areas and provides land use land cover (LULC) analysis on targeted protected areas. Users can also evaluate the ratio of protected areas versus built in a particular country. At the country level the tool provides information. At the protected area level, the tool provides information on the designation of the protected area according to international conventions, land cover change (where available), landscape habitats, species, climate conditions, pressures and the provision of management categories and plans (where available). An overall assessment based on the Digital Observatory for Protected Areas (DOPA) tool is also available using the indicators are terrestrial habitat complexity, agricultural pressure, population pressure, population change, external road pressure, internal road pressure, mammals, amphibians and birds. The DOPA tool also provides information on the land cover change, however this information is not reliable data. Users are prompted to search for information on protected areas by country or directly by name. Additionally, there is the opportunity to explore protected area solutions through a link to PANORAMA (BIOPAMA, 2018).

The tools have been slightly adapted by different countries leading to the creation of several version of the tool including for wetland and marine tracking tools. The anecdotal style of the delivery of the tool is beneficial when talking to communities as it lends itself to qualitative data analysis. Sole reliance on qualitative analysis is the problem with this tool as it does not include anecdotal information for spatial indicators. Additionally, there are over 30 indicators which can caused for a long discussion process. The rating scale is very subjective and asks for participants' opinion, which requires consensus between participants.

2.3.33 Review of assessments

Based on the IUCN management effectiveness framework, evaluations on the challenges in buffering communities of protected areas still provide a limited picture on the spatial impact of the expanded development on the protected area and focus solely on the cultural, political and socio-economic forces that drive development. As the literature review above suggests the current assessments emphasize qualitative data collection; lack of a review of spatial change as determinant of management effectiveness; limits the review of multiple sites for comparative analysis of effectiveness and; reporting system that emphasize an overall score in performance dismissing definite solutions that can improve effectiveness. Figure 2-43 is a chart that highlights an overview of these gaps through the categories of spatial component; community input, scoring and site level or comparative review. Under the spatial component heading assessments with a yes notation have a spatial component. Under the community input heading assessments with a questionnaire notation are those that allow for comprehensive community input as the questionnaire is distributed then the data analysed; assessments with a workshop notation are those where government officials, management staff and selected community members are brought together to discuss effectiveness without additional input from community members; toolkits notation are assessments that obtain information from management staff and selected community members and evaluations notations are interviews conducted by officials with management staff and selected community members. Under the scoring heading assessments with a no notation encourage descriptive results of the assessment to provide details of the effectiveness gaps. Under the site level/ comparative heading assessments with multiple notation are those that allow for multiple site assessments to be conducted concurrently.

NAME	TYPE OF PA	SPATIAL COMPONENT	COMMUNITY INPUT	SCORING	SITE LEVEL/ COMPARATIVE
METT	Terrestrial	No	Questionnaire	Yes	Single
RMETT	All	No	Questionnaire	Yes	Single
RAPPAM	All	No	Questionnaire	Yes	Single/ Multiple
PROARCA	All	No	Workshop	Yes	Single, comparative over time
EOH	All	No	Workshop	Yes	Single
AEMAPPS	All	No	Questionnaire	Yes	Single
TNC CAP	All	No	Workshop	Yes	Single
How is Your MPA	Marine	Yes	Toolkit	Yes	Single
Mesoamerican MPA	Marine	No	Not specified	Yes	Single
Padovan	Terrestrial	No	Toolkit	Yes	Single
MEVAP	All	No	Toolkit	No	Single
PAN PARKS	All	No	Questionnaire	Yes	Single
WIO MPA	Marine	No	Toolkit	Yes	Single

MTT	Marine	No	Workshop	Yes	Single
WWF/CATIE	All	No	Workshop	Yes	Single/ Multiple
PIP	All	No	Workshop	Yes	Single
Parks Profiles	All	No	Questionnaire	Yes	Single
Brazil 1999	Not specified	No	Questionnaire	Yes	Single/ Multiple
Maripa-G	Not specified	No	Questionnaire	Yes	Single/ Multiple
Catalonia MEE	All	No	Workshop	No	Multiple
Belize MEE	All	No	Workshop	Yes	Single
Ecuador MEE	All	No	Workshop	Yes	Multiple
Finland MEE	All	No	Questionnaire/ Site assessments	No	Multiple
Galapagos MEE	All	No	Workshop	Yes	Single
Indian MEE	Terrestrial	No	Evaluation	Yes	Single/ Multiple
Tasmanian MEE	Terrestrial	No	Evaluation	Yes	Single
MEMS	Terrestrial	No	Evaluation	Yes	Single/ Multiple
Qld Park Integrity	Terrestrial	No	Workshops	Yes	Single
Scenery Matrix	Terrestrial	No	Workshops, Questionnaire	Yes	Multiple
Mexico SIMEC	Not specified	No	Questionnaire/ Workshops	Yes	Multiple
Valdiviana	Terrestrial	No	Evaluation	Yes	Single
Venezuela Vision	All	No	Evaluation	Yes	Single
BIOPAMA	All	Yes	Evaluation	No	Single

Figure 2-43: Comparative chart of protected area management effectiveness tools (created by author)

This chart was developed as a reference to determine the existing gaps in the assessments that monitor protected areas management effectiveness and reiterate the need for a new research. The existing assessments of protected areas all possess mechanisms to obtain social, economic and political conditions that impact the protected area management effectiveness. These tools are widely used to monitor the protected areas of the world. However, these assessments do not include a comprehensive evaluation of the spatial fragmentation in protected areas. It therefore highlights the gap of evaluating spatial fragmentation to monitor the effectiveness of protected areas.

This chart highlights that although there are 32 protected area assessment tools, there is no tool that provides a comparative spatial change over time with comprehensive community input and yields a report-based analysis with recommendations for community-based adaptation. Out of all the existing tools only two provide a spatial assessment to monitor the effectiveness of the protected areas. Notably spatial assessments in protected areas management is not mainstreamed in protected areas management. With the ever growing encroachment of protected areas monitoring spatial fragmentation in protected area management is becoming necessary. An identification of these gaps provides evidence towards the need of an additional assessment approach to determine the spatial effectiveness of protected areas in the Caribbean. The following sections discuss the context of disaster risk reduction in the Caribbean and reiterates the need for a targeted approach for evaluating spatial fragmentation protected areas in Caribbean SIDS.

2.4 Caribbean SIDS

In 2000, 67% of the population in SIDS lived along in coastal zones (McGranahan et al., 2007). Therefore, vulnerability in SIDS is not limited to the geographical characteristics, but also includes the demographic stressors; population settlement patterns, socio-cultural systems and economic structure. This section provides an overview of Caribbean coastal ecosystems and Caribbean coastal settlement patterns to construct the background information for this study. It was written separately from the literature review due the context specific information that was relevant to the research but not applicable to the terminology discussed in that chapter. Knowledge of vulnerabilities within the Caribbean setting involves a review of the vulnerabilities in every sector and any available information on current adaptation practices.

Although multiple theories exist on the causes that fostered movement of the tectonic plates in Atlantic Ocean to move in an easterly direction causing the growth of the Caribbean plateau (Bachmann, 2001) the Caribbean islands are not homogenous and were formed based on the Caribbean plate's interaction with the surrounding North America, South America, Panama, North Andes, Cocos, and Panama plates (Aubouin et al.,1982). The unique arc of the greater and lesser Antilles islands follows the arc of the Caribbean plate's edge and their geological compositions are not all the same but are grouped according to their location along the Caribbean plate as outlined in Figure 2-44 (Live Science, 2012). Towards the northern and southeastern boundaries of the Caribbean plates there are strike-slip faults supporting an easterly movement fostering the creation of the Puerto Rico trench, the deepest point in the Atlantic Ocean (Ten Brink,2008). Along the western edge of the plate there is continual subduction causing multiple trenches and volcanic activity along the western edge of Central America (Malfait and Dinkelman, 1972) and subduction along the eastern edge with heighten volcanic activity in the Lesser Antilles (Mann, 1999). Figure 2-44 reflects the many locations and interaction of between plates throughout the Caribbean region and as a result of these stark differences in geological formation the Caribbean islands vary in geography in that some islands have limited volcanic origin and have relatively flat

Figure 2-44: Convergence of plates to form Caribbean Islands and image of position of Caribbean plate (Live Science, 2012 and Aubouin, 1982)

terrain namely while other islands boast of towering mountain ranges surrounded by littoral forests (Mann, 1999).

Due to the geographical formation of Caribbean SIDS sea level rise (SLR) is one of the greatest impacts affecting the coastal zone in the face of climate change as its effects on the coast are complex, interrelated and can occur in the form of anthropogenic or natural impacts (Page, Johnson, and Proosdij, 2014). According to the 2007 report (IPCC, 2007), the projected SLR for the year 2100 ranges from 18-59cm. Other studies conducted since then point out that these projections are very conservative and, in some cases, could be even triple that amount and the upper ranges of projected SLR for year 2100 are 100cm, 215cm, 180cm and 175cm (Page, Johnson, and Proosdij, 2014). Simpson et al. (2010), states “The question is not if the Caribbean will face SLR of 1m or 2m under either a 2° or 2.5° global warming scenario, but when.” The impacts of climate change, namely SLR, provide a challenge for coastal communities as they seek to sustainably manage their coastlines and the Caribbean is recognized as one of the most vulnerable areas in the world to SLR due to its relative isolation, high population density, limited geographical size and susceptibility to natural hazards (Forbes, 2011).

The geographical effects of SLR can be generally categorized into coastal erosion, flooding, inundation, saltwater intrusion, and rising water tables, but the greatest coastal impacts are delivered by the first three mentioned (Hughes and Brundrit, 1992; Ozyurt, 2007; UNEP, 1998). It is important to understand that all these effects occur and threaten the shore without a rise in sea level, but that SLR exacerbates these effects. Coastal erosion is the physical removal of sediment by current and wave action and depends on coastal slope, sediment transport, landform type, and wave climate (UNEP, 1998; Ozyurt, 2007). Inundation is the permanent submergence of low-lying land and is determined by slope, sediment availability and the potential for systems to migrate inland (UNEP, 1998). Coastal flooding in most cases can be attributed to storm surge, which is a meteorological phenomenon that results in a sustained positive water level, caused by wave forcing, wind stress and changes in atmospheric pressure (Ozyurt, 2007; Davidson-Arnott, 2010). With an increase in sea level, the effects of storm surge can reach much farther inland and if a storm coincides with high tide, extensive damage could occur (Davidson-Arnott, 2010; Gornitz, 1991). The impacts of climate change increased the vulnerability of coastal ecosystems.

Following the 1992 Rio De Janeiro Earth Summit, it was recognised that Small Island Developing States (SIDS) represent a distinct group of developing countries, on which climate change will have even more severe implications due to a variety of factors (Meakin, 1992). In SIDS, more than 70% of the population lives within 100 km of the shoreline (Creel, 2003).

Research shows that as the populations of Caribbean SIDS continue to grow and settle within coastal ecosystems the disaster risks become greater (McGranahan, 2007;

Nicholls and Cazenave, 2010). Accordingly, it can be argued that climate change is not the sole culprit of devastation from natural processes but is more a function of the settlement patterns within coastal zones (McGranaham, 2007). Increased populations in coastal zones then promulgate the increase risks to human life, property and livelihood. In the Caribbean Sea, during the period of 1992 to 2012, the average range of sea level rise was between 2mm/yr to 6mm/yr (Chatenoux and Wolf, 2013). SIDS, (where there is an inherent vulnerability to sea-level rise), can be severely impacted by a rise of 1m (Nicholls, et al., 2011) resulting in the loss of available land for development in the midst of growing populations, damage to coastal infrastructure and the impediments to industries reliant on coastal resources.

2.4.1 Environmental Vulnerabilities of Caribbean SIDS

The impact on coastal ecosystems were noted as directly correlated to anthropogenic activity (Halpern, 2008). According to R.R. Murray (2003) in the Physical and Bio-Physical Indicators of Drought and Desertification in the Caribbean the vulnerability of Caribbean SIDS developed since the colonial period when many of the islands' native vegetation was cleared for agricultural production. This estate-based agriculture system developed rapidly on low-lying lands destabilizing the steep slopes (Murray 2003; DeLoughrey et al., 2005).

Deforestation remains, a key contributor to land degradation in the Caribbean and the genesis of anthropogenically induced soil erosion (Lugo et al. 1981). However, LA Eyre (1987) in "Jamaica: test case for tropical deforestation?" indicates that in Jamaica a gradual reduction in area of forest land up to the mid-1980s of around 3.3 percent per annum and that much of the clearance was in small lots of between 20ha and 25ha. Notably more than 500 lots had been cleared for "peasant agriculture" (Eyre 1987). Years after independence the majority of those lands were not returned to their natural habitat but colonial agricultural practices provided the basis for development of towns and cities which can be indicated through a patchy Caribbean-wide picture, with some islands showing marked deforestation in recent decades, while others showed marked reversal of this trend by on lack of international investment and increased of the tourism industry in the region (Barker and McGregor, 1995). Additionally, there is a consequence of clearing natural landscapes for human needs that results in the degradation of the environment in several ways- the removal of natural land cover, the contamination of water courses with fertilizers (Foley, et al., 2005).

2.4.2 Socio-Cultural Vulnerabilities

Single urban centres with centralized government services are features of SIDS that limit their ability to effectively manage their response to disasters (Bueno, 2015). The risks to emergency response management increase when a single urban centre is impacted by the disaster or where access to the urban centre is impeded (Bueno, 2015; Peilling and Uitto, 2001). With rapid population growth along the fringes of these urban centres the limited social service infrastructure is insufficient to support the growth of the population (Dunno, 2011; Wittemyer et al., 2008). Typically, these areas have limited or are prone to frequent interruptions in infrastructure services including electricity and water (Bueno, 2015). The higher transportation costs to these areas restricts access to external markets and the flow and quality of access to information (Pelling and Uitto, 2001). Isolation from global networks and limited access to services, insulate these rural communities and increases their vulnerability (Dunno, 2011).

2.4.3 Economic Vulnerabilities

Small economies, heavily dependent on access to natural resources are another feature of SIDS. The economic vulnerability increases as a result of natural disasters since it impacts the country's gross domestic product, thereby hindering economic growth (Dunno, 2011). In light of the globalized diversified markets, Caribbean economies have remained specialized in areas of tourism, offshore finance or agriculture (Pelling and Uitto, 2001). Since the populations have historically relied on certain industries the transition towards economic diversity is slow and limited exportation impedes economic growth and decreases the country's ability to access international funding which in turn limits its ability to invest in social development and efficient infrastructure (Broad and Cavanagh, 2011).

In light of globalized economies and connectivity of world markets, economic crisis in one country can quickly impact the GDP of others and economic vulnerability is becoming an increasing concern as countries' economies are more open and vulnerability to international market (Broad and Cavanagh, 2011). For example, high food imports make developing countries less food secure when coastal regions are under threat of the impacts of climate change (Broad and Cavanagh, 2011).

Additionally, in the Caribbean the vulnerabilities are more significant as it was noted by Achim Steiner that 99 percent of Caribbean's tourism is along the coastline

(Caribbean 360). The absence of coastal flooding adaptation could affect 100 million people/yr. by 2080s, these consequences are highlighted in the Figure 2-45 below showing the potential costs of sea level rise in developing versus developed countries (Nicholls et al., 2007). The implication is that costs in developing nations will be higher because they lack the resources to provide investment for improved protection. The charts show that with an increase in sea level rise the loss to 'dry and wet' lands will gradually increase. To note under the consequence column is the disproportionate numbers of population displacement from developing versus developed countries. Under the cost column although the losses to land increase significantly in developing countries, the protection costs gradually rise over time. Based on the research conducted by the team, until the year 2025 the land protection costs will remain most significant than the losses costs. Furthermore, the increase losses are also directly related to the displacement of populations living within the coastal zone.

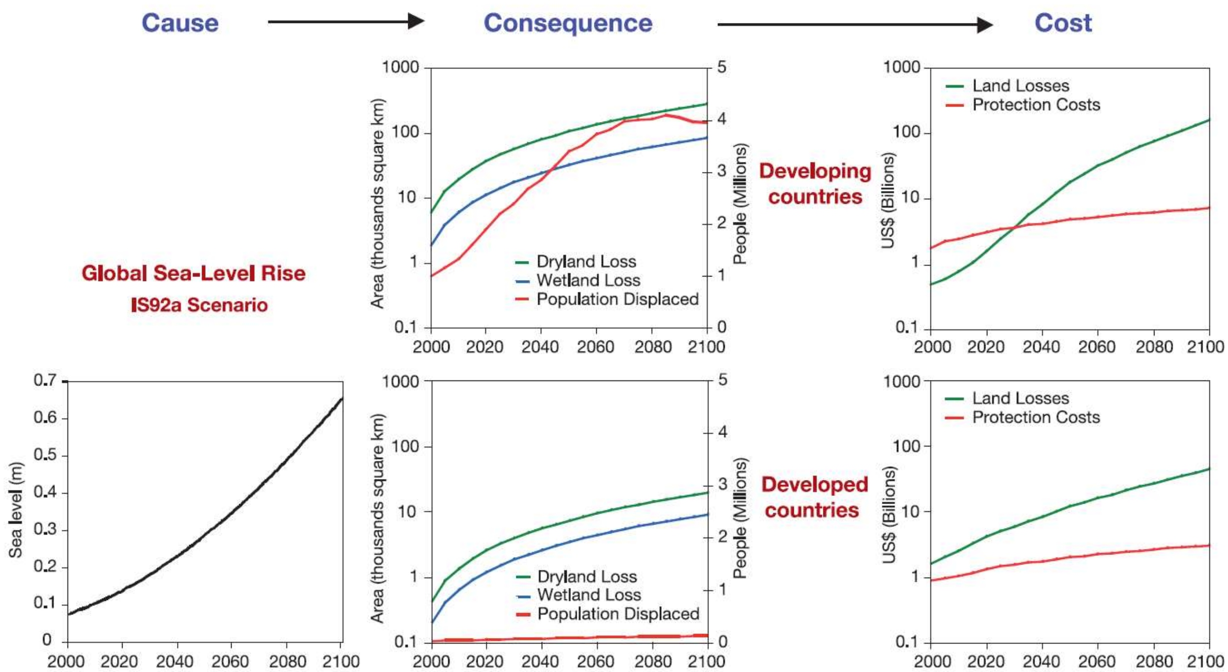


Figure 2-45: Loss and costs associated with limited coastal adaptation (Nicholls et al., 2007)

2.4.4 Infrastructure Vulnerabilities

Increase flooding can severely reduce the service life of the existing housing and infrastructure resulting in early deterioration or complete failure (Mills and Andrey, 2002). Although infrastructure can be built to withstand certain environmental occurrences, the aspect of climate change that promises an increase threat of these environmental hazards makes building for expected conditions an increasingly difficult task (Mills and Andrey, 2002). Mills and Andrey notes that 'gradual changes in sea level may be expected to damage or render inaccessible, low-lying coastal infrastructure including road and railway beds, port and airport facilities, tunnels and underground rail/subway/transit corridors' (2002). Increased precipitation can also directly impact the frequency of slope failures and landslides while flooding can exacerbate issues related to riverine and urban stormwater management.

Another consideration is the connectivity along transportation networks as key to hazard response and adaptation (Dunno, 2011). Connectivity refers to integrated transportation corridors that ensure the movement of goods and services. In SIDS transportation corridors are typically coastal and therefore vulnerable to the impacts of sea level rise, flooding and storm surge. In the event of storm events, these coastal corridors are inundated with water separating rural communities from emergency services. Lack of connectivity also encourages higher transportation costs to these areas and also restrict access to external markets and the flow and quality of access to information (Pelling and Uitto, 2001). In Caribbean SIDS transportation networks, have been used as the foundation for ICT networks as installation costs are cheaper and isolation from global networks and limited access to services, insulate these rural communities and increases their vulnerability (Dunno, 2011).

2.4.5 Coastal Ecosystems Services Vulnerabilities

For the purposes of this research the definition of ecosystem services involves the components of an ecosystem that are integral to the maintenance of human well-being (Fisher et al., 2009). Coastal ecosystems then provide services such as fish production, storm buffering and enhanced water quality (Vilardy et al., 2011) and fresh water resources, agriculture and forestry, fisheries and aquaculture, health, recreation and tourism, biodiversity and settlements and infrastructure (Nicholls et al., 2009; Sutton-Grier et al., 2015).

Research conducted in coastal region of Columbia's Caribbean Sea provide insight on Caribbean Ecosystem services value and loss by providing insight of the ecosystems services of the coastal zone namely the hydrological regime, the mangrove forest and fisheries dynamics (Vilardy, et al., 2011; Sánchez-Arcilla et al., 2016). Hydrological Regime was mostly impacted by the inclusion of colonial commercial activity where the major anthropogenic activity caused a reduction of freshwater into the system due to obstructed water flows. The loss of mangroves forest cover exposed water bodies to wind and sunlight and the exposed areas were susceptible to become salt flats (Sánchez-Arcilla et al., 2016). With a higher saline content, the mangroves then become less likely to produce and distribute propagules and the loss to mangroves also encourage the loss marine animals as the mangroves serve as the nursery for several species of marine habitat (Vilardy, et al., 2011).

Figure 2-46 highlights the relationship in changes between ecosystem services and hydrological dynamics, mangrove coverage and fish communities exposing the dependency of ecosystem services on hydrological dynamics, mangrove coverage and fish communities (Vilardy, et al., 2011). To note the majority of ecosystem services, depend heavily on hydrological dynamics and mangrove coverage namely agriculture, hunting, fuel, wood and timber, medicinal plants, ornamental use, recreational value, climate regulation, air quality, soil formation and fertility, hydrological regulation and habitat conservation (Vilardy et al., 2011). Other services are dependent on all three including fishing, shell fishing, animal-related medicinal use, environmental education, scientific values, local ecological knowledge and the local identity sense of place (Vilardy, et al 2011).

Ecosystem service type	Ecosystem service	Specific ecosystem service	Relationship with changes in		
			Hydrological dynamics	Mangrove coverage	Fish communities
Provisioning	Food	Aquaculture	-	-	×*
		Agriculture	×	×*	-
		Cattle	×	-	-
		Hunting	×*	×	-
		Fishing	×	×	×
		Shellfishing	×	×	×
	Drinkable water		×	-	-
	Forest resources	Fuel	×*	×	-
		Wood and timber	×*	×	-
	Vegetation-related	Medicinal plants	×*	×	-
		Ornamental use	×*	×	-
	Animal-related	Pets	-	×*	-
		Medicinal use	×*	×*	×
		Ornamental use	-	×*	×
Cultural	Educational	Environmental education	×	×	×
		Scientific values	×	×	×
		Local ecological knowledge (LEK)	×	×	×
	Recreational	Aesthetic value	×	×	-
		Nature tourism	×	×	-
		Relaxation	×	×	-
	Local identity	Spiritual values	-	×	×*
		Cultural heritage	-	-	×
		Sense of place	×	×	×
Regulating	Climate regulation		×	×	-
	Air quality		-	×	-
	Soil formation and fertility		×	×	-
	Hydrological regulation		×	×	-
	Nursery	Habitat conservation	×	×	-

Figure 2-46:Ecosystems services relationship (= indirect effect) (Vially et al 2011)*

Figure 2-47 however highlights how the changes in values on certain ecosystem services affected the supply of these services which then in turn impact the hydrological regime (Vially et al. 2011). To note that in an effort to maintain commercial activity along water bodies degraded natural landscapes were propped up by manmade structures which encourage contamination and further degrade the hydrological regime. Particularly during the Environmental crisis period where the investments in infrastructure alter the natural landscape and contribute to the loss of the fisheries services, this period fostered the large-scale degradation of coastal ecosystems where despite the efforts in the following periods to restore the damage. In the current period, Post-restoration, there is evidence of the level of the damage where there is an increase in water salinity, increased in mangrove defoliation and large-scale fish mortality and the continual erosion of the shoreline.

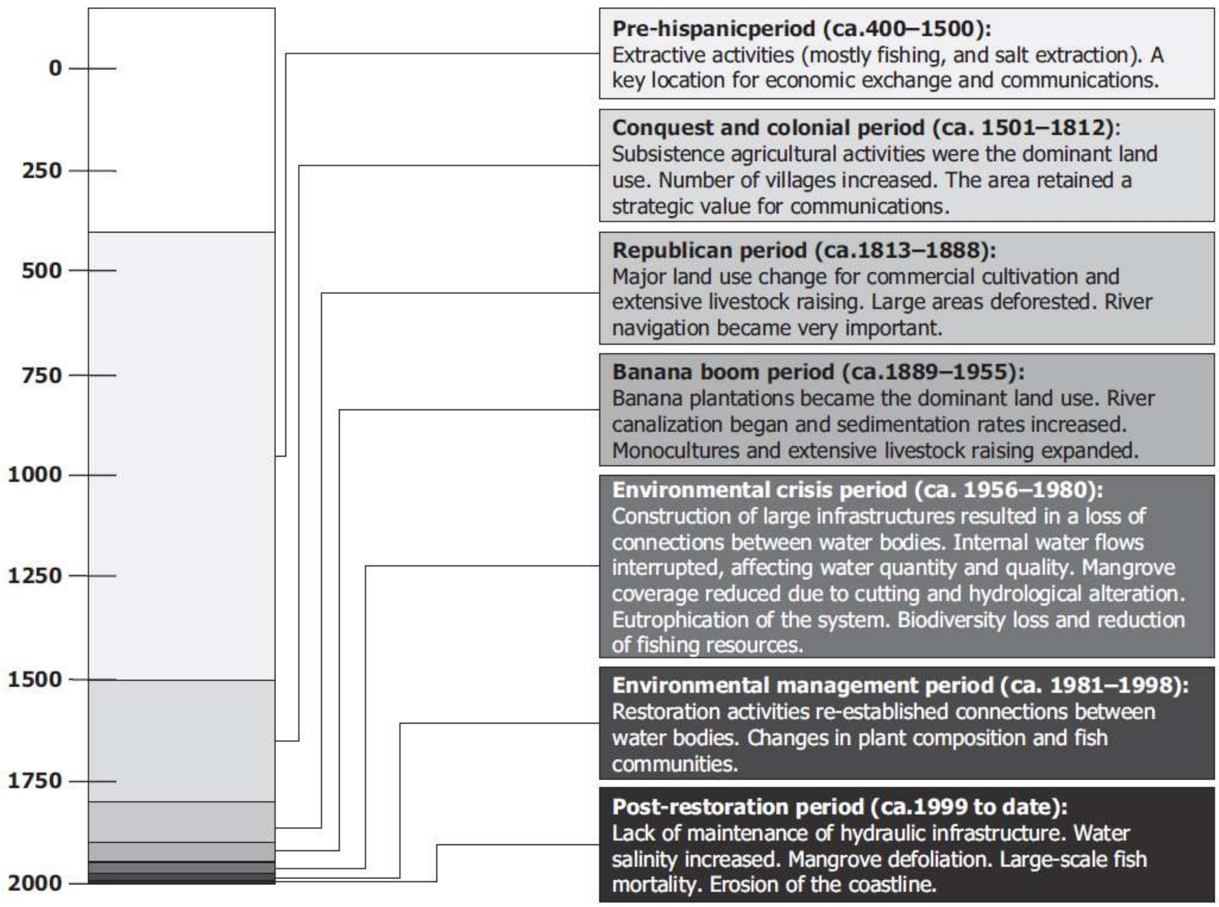


Figure 2-47: Ecosystem Services Supply and Hydrological Regime (Vially et al., 2011)

Human motivation however tends to ensure that only the profitable services are encouraged but this practice typically results in the loss of other cultural, social and ecological benefits (Hicks, et al., 2009). There is therefore a direct connection of social and ecological benefits of ecosystem services and proximity to these services are a determining factor of settlement patterns.

It would be remiss of this research to not highlight the vulnerabilities and impacts of the ecosystem services to climate change. Figure 2-48 provides an overview of the possible areas of vulnerabilities within the myriad of coastal ecosystem related sectors. Elements of climate change such as sea level rise and increased storm events are noted to have a strong impact and directly affect the viability of fresh water resources, agriculture and forestry, fisheries and aquaculture, health, recreation and tourism, biodiversity and settlements and infrastructure. Alternatively, there are certain ecosystem services that are more vulnerable than others due to its ability to be impact the various climate related impacts. To note biodiversity receives the highest rating in terms of larger vulnerability to climate change impacts but more relevant to this research in the chart the strong rating for impact is given to the settlements and infrastructure sector as having the strong vulnerability to temperature rise, extreme events, floods, rising water tables, erosion and salt water intrusion.

Coastal socio-economic sector	Temperature rise (air and seawater)	Extreme events (storms, waves)	Floods (sea level, runoff)	Rising water tables (sea level)	Erosion (sea level, storms, waves)	Salt water intrusion (sea level, runoff)	Biological effects (all climate drivers)
Freshwater resources	X	X	X	X	–	X	x
Agriculture and forestry	X	X	X	X	–	X	x
Fisheries and aquaculture	X	X	x	–	x	X	X
Health	X	X	X	x	–	X	X
Recreation and tourism	X	X	x	–	X	–	X
Biodiversity	X	X	X	X	X	X	X
Settlements/ infrastructure	X	X	X	X	X	X	–

X = strong; x= weak; – = negligible or not established.

Figure 2-48: Climate Change Impacts on coastal ecosystem services (Hicks et al., 2009)

This index conducted a vulnerability assessment on Trinidad shows scores of vulnerability scores in the year 2000 shows scores over 50 over resources, use and environment. The higher scores indicate a higher vulnerability. This index identifies

Trinidad as scoring high in these areas indicating its vulnerability in the three components and the need for work to be done in those three areas.

2.4.6 Settlement vulnerabilities based on historic trends

The built environment refers to the built forms created by humans to define, protect and shelter human activity and applies to infrastructure that supports this activity (Lawerence and Low, 1990). The impact of development patterns in SIDS include informal settlements rapidly occurring in coastal areas (Huq, et al., 2004). However, this seemly haphazard form of development can be traced back to colonial settlement patterns within the Caribbean.

Caribbean cities developed on a mercantile model as the colonial society was based on the merchandise of the 'parent' country and the land was segregated based on the agricultural production. Although Vance developed this model based on his research in east of North America, the trends of development were very similar for the Caribbean and can be used as an aid to discuss the trend of coastal development in the region (Potter, 1995). Figure 2-49 explains the stages of this model: exploration, harvesting of natural resources; emergence of farm-based staple production; establishment of an interior depot centre; and economic maturity and central place infill (Vance, 1970).

<u>Exploration:</u> the initial search phase was an opportunity for colonial powers to the Caribbean to understand the land and people (Vance, 1970). Hulme (1986) depicts on Columbus' early journeys were the colonial exploration of new world yielded the potential of the natural resources. In his personal notes Columbus noted that "I say that it is not right to delay, but to go on our way and to discover much land, until a very profitable land is reached" (Hulme, 1986). This land and its people were different, they were from the Carib and Arawaks tribes of South American heavily dependent on tropical forest agriculture and fishing (Watts, 1987). Their agricultural practices

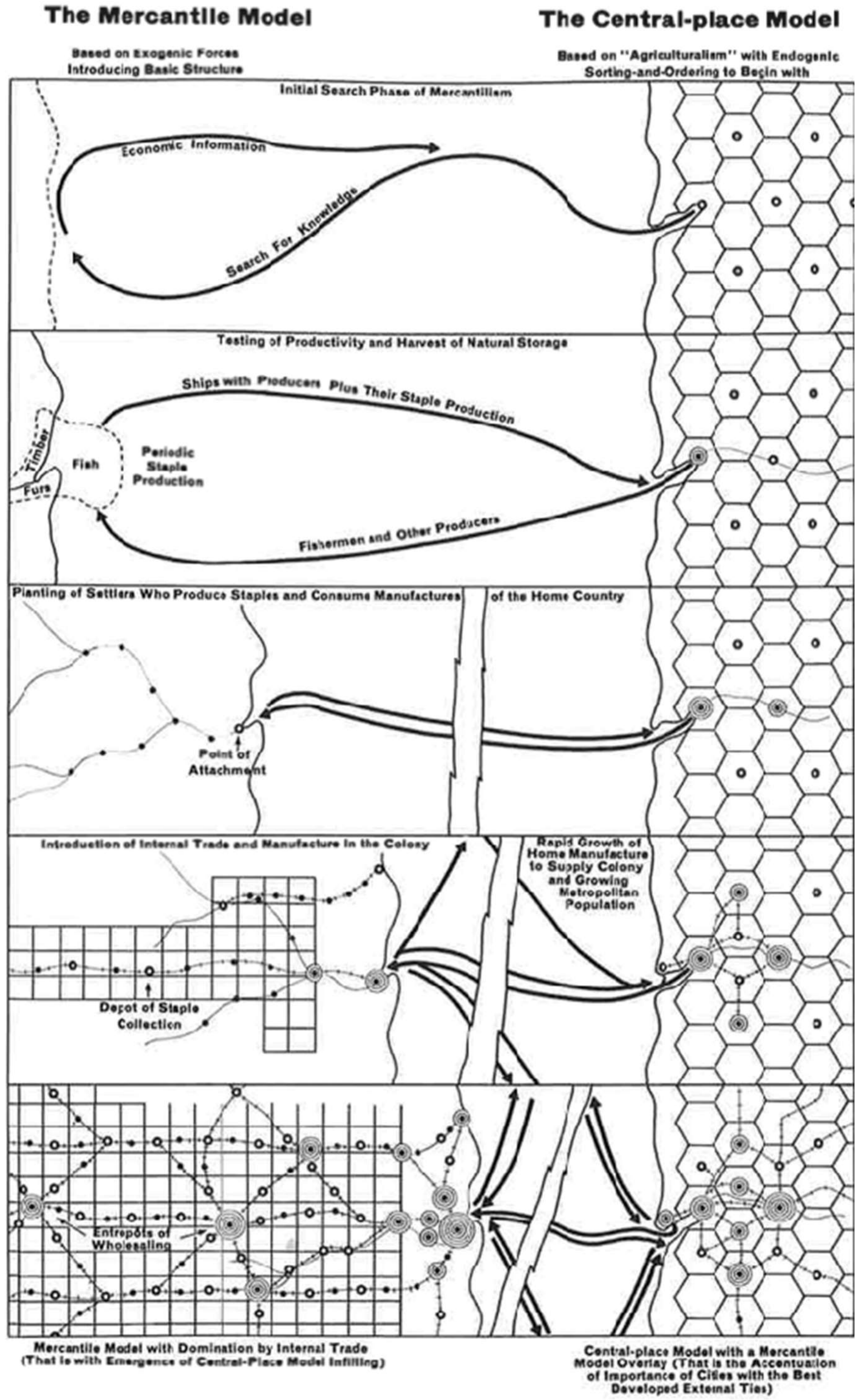


Figure 2-49: Vance Mercantile Model (Vance, 1970)

involved the clearing of forest plots slashing and burning cuttings to develop mounds to use as fertilized soil for the cultivation of root crops, peanuts, corn and beans. Also known as conuco this form of subsistent agriculture occurred on the fringe of the village and mimicked the vertical form of the surrounding natural vegetation (Richardson, 1992).

But burgeoning European exploration represented an opportunity for the expansion of the Spanish mercantilism namely their economic and political control (Wolf, 1982) and ushered in the next stage of the Vance's model.

Harvesting of natural resources: testing of the productivity and harvest birthed the settling of the Caribbean coast with the initial trade of timber and subsistent agriculture (Vance, 1970). Early Caribbean colonization was a mostly modest subsistence and cash-crop cultivation of mostly tobacco, sugar and indigo in an environment in unfriendly agricultural conditions. Within the coastal zone (island littorals) the tropical sun scourged the earth or torrential rains creating flooding conditions (Richardson, 1992) making clearing the natural vegetation for large scale production difficult. The Early European settlers adopted the practices of the native tribes by smaller scale "rink-barking" and burning (Richardson, 1992) until the growth sugar cane industry.

Emergence of farm-based staple production: the planting of settlers who produce staples and consume manufacturing from home country was fostered and as the colonial agricultural production grew the colonizers move inland to obtain larger areas for crop production (Vance, 1970). Sugar cane cultivation become prevalent in the 1640 and grew rapidly based on the demands of the burgeoning European market (Galloway, 1989; Richardson, 1992). This crop production required more acreage and with the recent inclusion of African slaves, large scale forest clearance occurred. Under this system the original coastal settlements become gateways to the interior of the colony (Richardson, 1992).

Establishment of Interior Depot Center: the introduction of internal trade and manufacture in the colony allowed for the creation of towns in the interior that served as depots for collection of the staple crops (Vance, 1970). With an established sugar cane industry, the natural landscape of the Caribbean colonies began to change. The production of subsistent agriculture was greatly reduced during slavery and increased expansion to the interior of the island, typically in the foothills of mountain ranges prevailed. This stage is also referred to as interior colonization.

Economic Maturity and Central Place Infill: the growth of the industry to an extent that it is sustained for a period and creates the development of market centers and towns for the trading of goods between the colony and the European countries (Vance, 1970). At this stage of development in the Caribbean the historical centers take shape namely along the coasts to promote the maritime based trade, but the plantations are typically kept on the best lands marginalizing the less affluent, now emancipated population were relegated to environmentally hazards areas namely the hillsides and swampy lowlands (Richardson, 1983).

This colonial settlement pattern provides historical evidence of the impact of human activity on the natural landscape. Based on the Mercantile model Caribbean early settlements were largely informal with much of the population settling in coastal zones on the fringe of the town centers. After emancipation these settlers did not live from the colonial industry crops and cleared lands to grow crops that requires clean row tillage which promoted further erosion (Richardson, 1992). Post-emancipation settlement had extensive environmental effects where the emancipated settlers were now relying on small subsistent farms for food and these prominent agricultural practices are the foundation of the settlement patterns with in the region and the growth of informal settlements still follows this pattern (Eyre, 1987).

Based on this model of development, larger settlements throughout the Caribbean are in coastal zones and they are growing informally (Durand-Lasserve, 2006). In these low-lying areas, the geological subsidence is susceptible to sea level rise, frequent flooding can lead to groundwater saline intrusion that impacts the tidal range, increased volume of sediment in bays and estuaries, and changes in the details of the shoreline (Doornkamp, 1998). The costs to provide protection to the built environment within coastal zones from the sea level rise can be about 0.02% of the Gross Domestic Product (GDP) (Nicholls, et al., 2011) and higher in nations where the infrastructure has yet to be upgraded.

Based on land tenure issues tenants in these areas are less inclined to invest their resources in an area where their tenure is not necessarily secure (Durand-Lasserve, 2006). The uncertainty of having the government remove these citizens without notice makes these investments very risky and on the other hand the government is less incline to provide increased public services in areas where there is not secure land tenure as citizens do not directly contribute to land taxes (Durand-Lasserve, 2006). In coastal areas, the conditions are more egregious as these informal settlements with limited access to public services increase the vulnerability of these residents including their inability to retreat in the case of emergency or their ability to adapt once the natural hazard has impacted the community (Durand-Lasserve, 2006; Dietz, 2007). Governments are further less inclined to make contributions to increasing public services because then citizens are encouraged by those actions that their land tenure is being regularized (Angel, 1983;

Durand-Lasserve, 2006). Therefore, unregulated and informal settlements along coast lines are an additional element that increases the vulnerability of the population.

2.5 Types of assessments in Caribbean SIDS

Adaptive capacity then becomes the ability of a system to reduce vulnerability. The ability to assess vulnerability then provide steps towards adaptation. A vulnerability assessment involves the identification and prioritization of the vulnerabilities in a system (Turner et al., 2003; O'Brien, 2010; Shimoda, 2003). For the purposes of this research vulnerability and adaptation assessments will be discussed in this section as they both provide tests on the effectiveness of the system to adapt to climate change impacts (Fussel, 2006; O'Brien, 2010; Shimoda, 2003). Although vulnerability assessments and adaptation assessments have the similar goal of addressing climate change adaptation, the approaches are different. Vulnerability Indexes are heavily reliant on robust data collection processes that is beneficial to academic research whereas adaptation assessments are heavily reliant on community processes that are beneficial to planning practitioners.

2.5.1 Vulnerability Indexes

Vulnerability indexes are essentially the quantification of indicators to determine the exposure to a hazard. The following are examples of vulnerability indexes that are relevant to the research as the organization of indexes as opposed to the organization of adaptation assessments is relevant to the creation of spatial assessment.

Climate Vulnerability Index: based on this research the most applicable index to explore would be the one that encompasses the myriad of options to expose the true vulnerability of the population based on climate conditions (Pandey and Jha, 2012). Climate Vulnerability Index tends to focus mainly on water-related issues to a degree of targeting the vulnerability of local populations (Sullivan and Meigh, 2005). Although a broad scale approach the considerations of this vulnerability include resources, access, capacity, use, environment and geospatial. When considering the resources component, the assessment includes the availability of surface water and groundwater; an evaluation of resource reliability and the capacity of water storage and population dependence on imported/ desalinated water and water quality assessment (Pandey and Jha, 2012; Sullivan and Meigh, 2005). The access component explores access to sanitation and clean water, and any irrigation coverage according to climate characteristics. The capacity component reviews the capability of the populations in the areas of expendable income, educational level, mortality rate, existence of early warning systems, and access to emergency shelters, percentage of people living in informal housing (Pandey and Jha, 2012). The use component of index reviews the water consumption for industrial, agricultural and residential uses, all these uses are applicable to our study area as three land uses exist in this area (Sullivan and Meigh, 2005). The environmental component explores the loss of habitats, the frequency of floods, and the density of the population. The geospatial component looks at the land at risk from hazards i.e. sea level rise, tidal waves and/or land slips, the possible accessibility to food and water resources, any possible deforestation, soil erosions, land conversion from natural vegetation and risk of deglaciation (Sullivan and Meigh, 2005). With all these considerations, the climate vulnerability is very relevant to SIDS as the small scale of these islands do not give them the allowance for the information sufficient information on climate trends per island (Sullivan and Meigh, 2005). It is more of a regional review of all the islands.

Social Vulnerability Index: served as an attempt to understand the relation between physical coastal vulnerabilities and demographics (Cutter, et al., 2008). Originally created for a global context it was used by Boruff and Cutter (2007) to measure vulnerability in St. Vincent and Barbados. Boruff and Cutter (2007) originally identified 17 broad indicators to be used to identify the causes of social vulnerability namely “socioeconomic status, gender, race/ethnicity, age, development, employment loss, rural/urban, residential property, infrastructure and lifelines, renters, occupation, family structure, education, population growth, medical services, social dependence, and special needs.” These indicators covered age, gender, family structure, special needs, development, infrastructure and rural versus urban land use. After further evaluation, these variables were reduced to 15 demographics indicators covering the population pyramid, the educational attainment, gender ratios, employment, size of household, proportion of disabled, proportioned of retired, density of housing, percentage of housing units with radios, televisions, cooking technologies, lighting and the percentage of land used for agriculture (Boruff and Cutter, 2007; Füssel, 2010). It was noted in the research however that the places with the highest vulnerability was the communities in the coastal lowlands (Boruff and Cutter, 2007).

However globally scaled climate assessment models used locally have inherent flaws. SVI research examined social indicators in vulnerability utilizing census data; there were difficulties gathering sufficient data to determine the SVI (Vincent and Cull, 2010). Indicators in assessing vulnerability are context specific and the best people to identify these variables are the ones directly impacted by the disaster (Dunno, 2011). People are not victims but agents in their own recovery, with their expertise as a source of strength (Van Aalst et al., 2008); the value of experience and knowledge is an integral part in the discussion regarding vulnerability (Keck and Sakdapolrak, 2013).

Coastal Vulnerability Index: researchers have made attempts to determine the vulnerability of coastal areas through a variety of means, the most significant method in terms of calculating the vulnerable physical characteristics of coastal regions is the Coastal Vulnerability Index (CVI) (Birdwell, 1994). CVI classified vulnerability based on a numerical analysis of the tide range, average wave height, geomorphology, coastal slop, relative sea-level change and shoreline accretion (Dunno, 2011; Cutter, 2006). This index however does not account for the socio-economic impacts on the vulnerability of coastal communities. Concurrently, the Social Vulnerability Index solely explores the demographic factor that may make communities vulnerable to the impacts of climate change (Cutter, 2006). There has even been an attempt to integrate the two vulnerability indexes to attempt to determine the risk to communities (Cutter, 2006).

Coastal Vulnerability Assessments: The purpose of a coastal vulnerability assessment (CVA) is to guide the adaptation process and increase a community's adaptive capacity (McLaughlin and Cooper, 2010; Page et al., 2014). Even though an approach that predicts the precise outcomes of an extreme SLR event doesn't yet exist, the relative vulnerability of a coast to SLR can be assessed using parameters (McLaughlin and Cooper, 2010; Thieler et al., 2000). Literature suggests that CVAs are a key step in the adaptation process. CVAs help to determine how to best manage risk (Dunno, 2011; Palmer et al., 2011); are advantageous to minimize the socio-economic impacts from climate change related events (Koutrakis et al., 2011) and they serve as a rapid assessment of a large area. This helps to identify areas that require a more detailed study and to provide a valuable framework to help managers allocate limited funds to areas in greatest need (Abuodha and Woodroffe, 2010).

These assessments started off as purely technical (Dunno, 2011) examining the science behind climate change related events and impact to the physical attributes of islands such as landform morphology, erosion and accretion, elevation, RSLR, wave height, and tidal range, which form the basis of the ever-popular Coastal Vulnerability Index (CVI) developed by Gornitz, (1991). As the discussion on vulnerability assessment gained popularity, the emphasis on the demographic attributes of places became integral to coastal vulnerability and adaptation.

Participatory approaches are key to obtaining comprehensive assessments of coastal vulnerabilities. These approaches encourage active participation of community residents in the process of developing coastal zone adaptation strategies and provide the means for them to work towards developing their own solutions for addressing their vulnerabilities (Dunno, 2011; Page et al., 2014). It also ensures that outside agencies work closely with the communities to develop these programmes. Participatory approaches include information gathering tools that allow researchers/ facilitators to engage the community regarding hazards that can impact their daily lives and livelihoods and can significantly contribute to building the community's capacity (Keck and Sakdapolrak, 2013; Page et al., 2014).

Participatory vulnerability assessment tools include but are not limited to focus group meetings, key informant interviews, livelihood surveys, risk mapping and asset inventories (Dunno, 2011; Page et al., 2014). These approaches seek to understand the daily life and livelihoods of communities to determine informed adaptation strategies. Within this category vulnerability mapping utilizes the community residents as the central source of identifying the main hazards within their community (Dunno, 2011; Page et al., 2014; Geldmann et al., 2014). The hazards that are identified in this process have a tendency of being different from hazards identified by outside agencies or researchers (van Aalst et al., 2008; Dunno, 2011). Community residents have a keen perspective on their everyday lives and the impact of the natural hazards, particularly interruption of services and transportation limitations (Page et al., 2014; van Aalst et al., 2008).

Asset inventories on the other hand explores the resources in a community with an emphasis on places that should be "preserved and enhanced" (Kerka, 2003; van Aalst et al., 2008). In the case of vulnerability assessment, these assets are typically institutions, community organizations, natural resources and physical structures that can assist in protecting the communities from the identified natural hazards and challenges (Dunno, 2011). Community asset inventories is key because it identifies places of significance assigned by the community residents (Sharpe et al., 2000; Kerka, 2003) and provides the framework for adaptive measures.

2.5.2 Adaptation Assessments

Adaptation assessments evaluate the adaptive capacity of a system. The following examples build insight of the adaptation assessments to assist with an evaluation of spatial conditions.

2.5.2.1 Participatory Approach for Safe Shelter Awareness

Developed by the International Federation of Red Cross and Red Crescent Societies, the Participatory Approach for Safe Shelter Awareness (PASSA) is the participatory tool for disaster risk reduction and shelter safety (IFRC, 2011). The goal of this tool is to increase the local capacity of a community by boosting awareness and building skills to foster decision-making. It was developed as a process through participatory activities to get the participants to gain an awareness of shelter safety issues on their communities; identify vulnerabilities and hazards that foster risks related to shelter; identify causes of shelter vulnerability; prioritize potential strategies to improve shelter safety; develop a plan to put those strategies in place based on local capabilities and evaluate and monitor progress (IFRC, 2011).

The process for PASSA takes about two months in each community based on the location (IFRC, 2011). The success of this tool is the emphasis on participatory methods. These methods focus on the use of different forms of communication as in objects, stories and images to build a creative and collaborative process with participants (IFRC, 2011). The advantages to this method if that everyone in the community can contribute to the planning as equal contributors regardless of age, sex, social class and educational attainment; the tool builds respect for others and the creation of individual and collective responsibility for decision making; and the development of respect between stakeholders in the community (IFRC, 2011). This tool looks at connecting stakeholders in a particular manner – a PASSA group made up of representation of community members, local authorities, Red Cross volunteers and staff (IFRC, 2011).

Although this tool was developed only to address shelter safety it used as a first defence for disaster response namely to address flooding and increased storm activity (IFRC, 2011). As disaster risk management is a component of climate change adaptation the PASSA tool can be integrated into the disaster management cycle through three phases. The first phase is preparedness and mitigation -as it identifies risks related to habitat and the built environment; the second is relief to recovery – develops a framework for long-lasting shelter solutions by inserting site mitigation and disaster-resistant techniques; the third is a recovery phase which looks at addressing issues not completed in the program and increasing local capacities (IFRC, 2011).

PASSA involves activities like community mapping, a community review of the frequency of hazards, identification of safe and unsafe shelters, creation of solutions and planning for change (IFRC, 2011). The community mapping activity is meant for the community to map their community shelter conditions and identify potential hazards and vulnerabilities, create a baseline map for planning and monitoring and evaluation, develop a common vision and perception of shelter safety, build self-esteem and capacity as participants create community map (IFRC, 2011). The community review of the frequency of the hazards involves the development of awareness of hazards faced by the community and identification of the most important hazards for the group (IFRC, 2011). The identification of safe shelters is meant to highlight individual structures and the community settlement that makes the community vulnerable and outlining priority hazards; and what can be done to make the shelters in the community (IFRC, 2011). Developing options for solutions involves an analysis of options for improving shelter safety and identification of the reasons why effective safety has not been introduced on the community previously and the community capability for making changes (IFRC, 2011). The planning for change involves development of a plan to implement improvements in shelter safety, identify resources required from outside the community in order to implement the plan and agree who will take charge (IFRC, 2011).

2.5.2.2 Green Mapping

Green mapping involves the production of a map containing Green Map© icons that brings together local knowledge and opinions of community members about their sustainable living, natural and cultural resources (Page et al., 2014; Green Map, 2016). With the slogan "Think Global, Map Local", green mapping exemplifies the need for community engagement at the local level and the importance of global interconnectedness for sustainable community development (Page et al., 2014; Green

Map, 2016). It was utilized as a public awareness measure to building the communities knowledge in their role in coastal adaptation (Klein et al., 1999).

At the core of green mapping are the GM icons, which are based on "environmental vitality, economic integrity, and social equity" believed to be the three pillars of a sustainable community (Page et al., 2014; Green Map, 2016). The first icon set of 1996 has evolved over time as community needs and foci have changed and grown, and the latest version incorporates icons to represent the "eco-movement" such as ecotourism, eco info, renewable resources, eco development and design as well as ecological challenges such as deforestation, noise pollution and habitat at risk, some of which are illustrated in Figure 2-50.

Figure 2-50: A selection of Green Map Icons from the most recent icon set (Green Map, 2016)

The Green Map© process begins first with the identification of a project theme and a location of interest or need and secondly with the creation of a Green Map Team. This core group of individuals, often from a wide range of backgrounds, form the role of "mapmaker" and are responsible for delivering workshops, engaging community, registering with the GMS, and producing the final map (Page et al., 2014; Green map, 2016). The GMS provides the mapmaker with a plethora of tools from the GM Tool Centre, to use in workshops and map production, which are "globally linked and locally adaptable", such as the GM icons, as well as an online platform where mapmakers can share experiences and ideas with other mapmakers around the globe (Page etal, 2014; Green Map, 2016). The beauty of this system is that each group uses their creativity to adapt these tools for their specific mapping purpose, often resulting in incredibly unique outcomes. (Green Map, 2016)

Once a target theme is identified, the mapmaker chooses a subset of GM icons to suit their particular theme (i.e.: sustainable tourism) and engages local community members in a workshop setting to collect knowledge and ideas using mapping as the medium. Local icons can be created to enhance a particular theme (i.e.: a mangrove icon for tropical locations), and sometimes are even incorporated into the official GM icon set or used by other mapmakers around the world. The only stipulations of creating a GM are that 1) at least half of the icons used should be from the official set and 2) the map theme should centre on the concept of sustainability (Page et al., 2014; Green Map, 2016).

After the workshop, the collected local knowledge and opinions are compiled, and the resulting map is placed on the GM website (www.greenmap.org), along with a description of the project and mapmaker and any new icons or ideas developed throughout the process, thus creating an international network of GM support and idea sharing (Green Map 2016). The use of Green Mapping is also limited based on the costs associated with the creation and management of the map. It has more use as a way finding map versus a built environment assessment tool.

2.5.2.3 Community Climate Change Adaptation Assessment

Formulated by United States Agency for International Development (USAID) the Community Climate Change Adaptation Assessment (C3A2) it was developed to obtain information on climate change mitigation at the community level. It essentially seeks to answer the perception of climate change in communities the exposure of climate change and the which households or livelihoods are perceived as the most vulnerable (USAID, 2017). The framework, as illustrated in Figure 2-51, relies on a comprehension of the hazard, exposure and vulnerability in five sectors (USAID, 2017; Moriniere, 2016). Under the agricultural and food security sector the indicators explore the impacts of climate variability and change (CVC) on food value chains including production, processing, marketing and consumption (USAID, 2017). Under the energy and infrastructure sector the indicators explore impacts of CVC on hydropower generation, transmission distribution and consumption, sustainability and transportation infrastructure (USAID, 2017). Under the health, sanitation and human settlement sector the indicators explore the impacts of water borne and airborne diseases. Under the terrestrial ecosystems and tourism sector the indicators explore the impacts of CVC on critical landscapes, vulnerable areas, wildlife and vegetation (USAID, 2017). Under

IPCC (AR5): Determinants of Climate Risk	A. Hazard (WHAT)	B. Exposure (WHERE)	C. Vulnerability (WHY/HO
• Hotspot communities (HC)	*(potential occurrence of a natural or human-induced physical event, trend or physical impact →natural variability & anthropogenic CC)*	*(presence of people, livelihoods, species or ecosystems, environ. functions, services, and resources, infrastructure, or assets in places / settings that could be adversely*	*(propensity / predisposition to be adversely affected; sensitivity or susceptibility to harm; lack of capacity to cope and adapt)*
GENERAL			
Climate variability and change (CVC) includes: • Temperature • Precipitation • Wind • X-events: extreme events (i.e., hazards)	A0.1 **What are/will be the impacts of CVC in the HCs?** A0.2 How is CVC perceived and defined by HCs? Which events are felt most strongly? A0.3 Which sector (1-5 below) is perceived as most vulnerable by the HC?	B0.1 Within 'Hotspots': **where / who are the communities most exposed** to CVC and its influences?	C0.1 Which **hhlds / livelihoods/ groups / services** etc. are perceived by HCs as most vulnerable to CVC? C0.2 What do HCs perceive as the most **sustainable adaptation strategies** to be encouraged? C0.3 **What (public and private) institutions / structures /policies** are in place or lacking to help cope and/or adapt?
1. Agriculture & Food Security			
• 3 Value chains (VC: C, L, F): crops, livestock, fish • 4 VC Segments (-p,-s,-m,-c): production, processing, marketing, consumption	A1. What are/will be the perceived impacts of CVC on food value chains? For each segment (list left):	B1. What is/will be the geographical distribution of CVC impacts? Within each HC:	C1.1 Which **socio-economic element** (livelihood group, wealth/ gender/age cohort, public / private institution) **is most vulnerable** and
	• What are the current impacts of CVC? How do they compare to non-climate impacts?	• Which livelihood and Value Chain/Segment is/will be most exposed?	C1.2. What **coping or** (sustainable and beneficial) **adaptive strategies** have been/are/will be employed by each of them?
	• What are potential impacts and risk to sustainability?	• Which crops/animals/fish are/will be most exposed?	
2. Energy & Infrastructure			
2 main services: • Hydropower (H: generation, transmission, distribution and consumption, sustainability); • Transportation Infrastructure (T: access, use, sustainability)	**A2. What are/will be the perceived impacts of CVC on energy and infrastructure services** (list left) in HCs?	**B2. What is/will be the geographical distribution of CVC impacts on those services?** What is the level of reliance on the services? Are there major land-use cover changes in the HC? What is / will be the incidence of water-related conflicts?	**C2. Which socio-economic factors** (wealth/settlement type/ market access) **influence the services?** How aware are HCs about hydropower sustainability? Are parallel services with less CVC-vulnerability (clean-energy technologies or rain/sea/air transport, etc.) available?
3. Health (+ sanitation & human settlement)			
Disease: • Vector borne /malaria (V) • Water/air borne (W)	**A3. What are/will be the perceived impacts of CVC on health status/services in HC?** Which diseases (list left) are most prevalent? Do current trends in incidence have any link to CVC? If yes, do HC perceive a link?	**B3. What is/will be the geographical distribution of CVC impacts on** health status in HCs? Which households in the HCs are most exposed? What is the distance to prevention/treatment facilities?	**C3. Which socio-economic factors** (i.e. sanitation, settlement) **affect CVC-influenced disease trends?** What is the level of awareness among HCs? What have health officials and HCs done (medically and otherwise) to reduce
4. Terrestrial Ecosystems (& Tourism)			
• Critical landscapes (drylands, forests, etc) • Vulnerable areas (tourism sites, biodiversity hotspots, IBAs, wildlife habitats etc.) • Wildlife (species composition, pop. size, migration, etc.) • Vegetation	**A4. What are/will be the perceived impacts of CVC on terrestrial ecosystems** in/nearest HC?	**B4. What is/will be the geographical distribution of CVC impacts on** ecosystem elements (list left)? What critical landscape, vulnerable areas and wildlife are most valued by HC? Which HCs rely on tourism-related revenues?	C4. **Which socio-economic factors affect CVC-impacts?** How are livelihood economies affected by CVC impacts on terrestrial ecosystems? Which livelihood and private sector economies rely on tourism revenues and to what extent? What have officials and HCs done to reduce vulnerability of terrestrial ecosystem elements?
5. Water & Aquatic Ecosystems			
• Availability, Access, Quality-Infrastructure • Aquatic ecosystems (lakes, ponds, rivers, springs, streams and wetlands;	**A5. What are/will be the perceived impacts of CVC on water elements** (list left) in HCs?	**B5. What is/will be the geographical distribution of CVC impacts on water elements in HCs?**	**C5. What social-economic and other factors constrain** water elements/ conservation /protection in the HCs? What have HCs and water officials done to cope/adapt?

Figure 2-51: Community Climate Change Adaptation Assessment (USAID, 2017)

the water and aquatic ecosystems sector the indicators explore the impacts of CVC on aquatic ecosystems, the availability and access to quality infrastructure.

The emphasis on community assessment is prevalent in the means of data collection for the indicators (USAID, 2017). It is a mix qualitative data collection methods including community protocol, storytelling, community calendars, resilience ranking, identification of attributes, photographical transects of risks, risk mapping and give back to verify information gathered (USAID, 2017).

2.5.2.4 Land-Use based Integrated Sustainability Assessment

Developed to analyse the impact the European Union Policies with an emphasis on the spatial component, this tool considers the environmental, social and economic factors (EU Science Hub, 2016; Echenique and Grinevich, 2013; Jacobs-Crisioni, 2017). The Land-Use based Integrated Sustainability Assessment (LUISA) model stimulates the future land-use changes based on the socio-economic and biophysical factors. It therefore adapts a new approach towards activity-based modelling (EU Science Hub, 2016; Jacobs, et al., 2017; Echenique and Grinevich, 2013). A highly

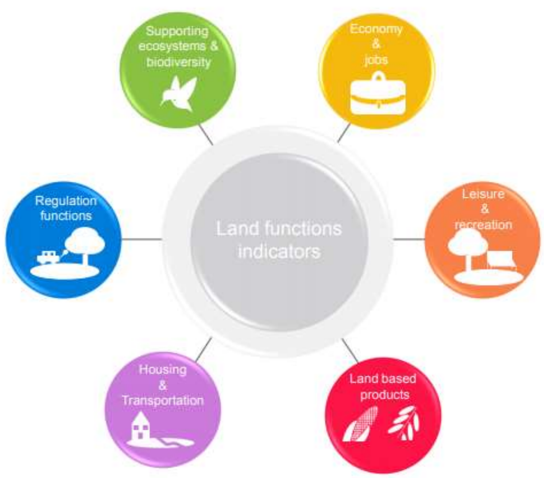


Figure 2-52: LUISA land function indicators (Echenique and Grinevich, 2013)

technical tool its aims at modelling the how land functions are reflection of social conditions and emphasizes the notion of “dynamic land function”. The land function indicators are grouped into six themes as illustrated in Figure 2-52.

Land Function 1 entitled Economy and Jobs is the provision of work and applies to the economic activities namely agriculture, commercial and industrial services (Echenique and Grinevich, 2013; Lavalle et al., 2015). The indicators are the total percentage of population that is employed in the agricultural, industrial, commercial sectors; the national GDP; and the GDP per capita (Echenique and Grinevich, 2013; Lavalle et al., 2015). Land Function 2 entitled Leisure and Recreation is the provision of leisure applies to the available recreational and cultural services and the indicator reflects the recreation potential for leisure activities (Echenique and Grinevich, 2013; Lavalle et al., 2015; De Rosa, 2018). Land Function 3 entitled Land Based Products is the provision of land and water-based products highlighting the capacity to delivery safe drinking water to deliver food products and to deliver energy products (Echenique and Grinevich, 2013; Lavalle et al., 2015). The indicators water consumption, water productivity, food and feed production, energy content of produced food, biomass harvested from energy crops, biomass harvested for material and energy uses, energy content of wood production (Echenique and Grinevich, 2013; Lavalle et al., 2015; De Rosa, 2018). Land Function 4 entitled Housing and Transportation is the provision of housing and transport which applies to the availability of space for residential, social and economic activities. The indicators are share of residential areas, ratio of residential areas per inhabitant, population density, share of commercial and industrial service areas, economic output of commercial and industrial spaces, share of built up areas, productivity of built-up areas, ratio of population to built-up areas, potential accessibility, network efficiency, local accessibility to nearby towns and daily accessibility within town (Echenique and Grinevich, 2013; Lavalle et al., 2015). Land Function 5 entitled Regulation Functions is the provision of regulation by natural and physical structures and processes applies to the capacity of the existing ecosystem to adapt to surrounding anthropogenic activities (Echenique and Grinevich, 2013; Lavalle et al., 2015). The indicators are the NO2 removal by urban vegetation, urban population exposed to PM10 concentrations, urban population exposure to air pollution, capacity of ecosystems to avoid soil erosion, soil retention, ratio between capacity and demand for coastal protection, water retention, relative pollination potential, carbon stock changes and colling effect (Echenique and Grinevich, 2013; Lavalle et al., 2015). Land Function 6 entitled Supporting Ecosystems and Biodiversity applies to the land's capacity for the conservation of biodiversity and maintenance of ecosystems (Echenique and Grinevich, 2013; Lavalle et al., 2015). The indicators are habitat conservation status, habitat quality based on the species distribution of all common birds, habitat quality based on the species distribution of forest birds, habitat quality based on species distribution of farmland birds, proportion of land area covered by green infrastructure; fragmentation of green infrastructure and fragmentation of landscape by artificial areas (Echenique and Grinevich, 2013; Lavalle et al., 2015; European Union Science Hub, 2006).

2.5.2.5 Life Cycle Impact Assessment

Developed by United Nations Environmental Programme, this assessment models the impact pathways on biodiversity and ecosystem services (Koellner, et al. 2013, Wagendrop et al., 2006). It is meant to trace back the causes of local land use changes on global factors. It was further adjusted by the European Commission as the Life Cycle Impact Assessment (LC-IMPACT). LC-IMPACT (Figure 2-53) provides a global life cycle impact assessment on three areas of protection- human health, ecosystem quality and resources (LC-Impact, 2018).

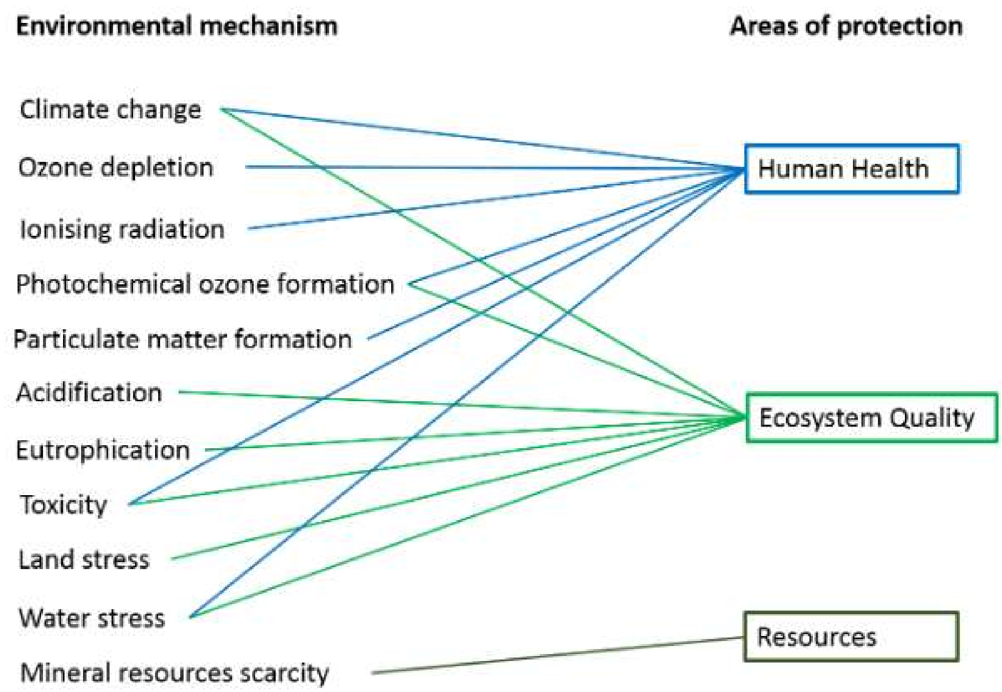


Figure 2-53: LC-IMPACT framework (LC-IMPACT, 2018)

Under the human health area of protection is environmental mechanisms of climate change, ozone depletion, ionising radiation, photochemical ozone formation, particulate matter formation, toxicity and water stress (LC-Impact, 2018; Wagendrop et al., 2006). Under the ecosystem quality area of protection are the environmental mechanisms of climate change, photochemical ozone formation, acidification, eutrophication, toxicity, land stress and water stress. Under the resources area of protection is the environmental mechanisms of mineral resources scarcity (LC-IMPACT, 2018).

In terms of an exploration of assessments for the research, it is the necessary for this research to clarify the difference between the two and provide relevant examples of each. For the purposes of this research vulnerability assessments and adaptation assessments were reviewed to uncover further knowledge on protected areas adaptation and assessments. The next section of this literature review discusses the role of protected areas in adaptation and discuss assessment of the management of protected areas.

2.5.3 Inconsistencies in Adaptation in the Caribbean SIDS and impact on coastal zones

As discussed in the literature review chapter, the reactive adaptation is more frequently adopted in Caribbean settings as the uncertainties regarding climate variability still persist and attempts of adaptation are undermined by maladaptive polices (Smit et al., 2000; Burton, 1997). In other instances, adaptive policies lack implementation mechanisms and do little to thwart maladaptation (Smit et al., 2000). The following are direct examples of the adaptive policies within multiple Caribbean settings.

In an effort to follow the rest of the world towards adaptation, Caribbean countries have developed adaptive policies as the first step towards adaptation (Mercer et al., 2012). These policies are within varying levels of government namely international, regional, national and local. Reviewing the adaptive policies of the Caribbean highlights the willingness of the region to move towards adaptation. Internationally, Caribbean countries have signed unto the Ramsar Convention to designate wetlands as protected areas; at the regional government level, the Caribbean Climate Online Risk and Adaptation Tool was developed to help countries consider adaptation as a tool for decision making; at the national government level, the

Integrated Coastal Zone Management plans were completed to provide national frameworks towards adaptation (Mercer et al., 2012; Ramsar, 2006; Suman, 1998).

2.5.3.1 Ramsar Convention

The Ramsar Convention was developed out of a need to protect the vulnerability of coastal wetlands and formulated as an instrument to conserve resources at the international scale; it was the first of its kind as in a treaty to prevent countries from the exploitation of their natural resources (Matthews, 1993; Agardy, 1994; Edgar et al., 2014). According to the Ramsar Secreteriat (2006) the wise use of wetlands emphasizes "the maintenance of the ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development". The Ramsar convention refers to a wetland as a land area flooded with water on a seasonal or permanent basis; whereas inland wetlands contain aquifers, lakes, streams, marshes, peatlands, ponds, floodplains, swamps and rivers; coastal wetlands include saltmarshes, estuaries, lagoons, seagrass meadows, coral reefs and mangroves (Ramsar, 2015). National Oceanic and Atmospheric Administration (2017) defines mangroves as groups of shrubs and trees that grow in the coastal intertidal zone. The intertidal zone also referred to as the littoral zone is the area along the coast that is exposed during low tide and submerged during high tide. With the considerations of climate change impacts, the peritidal zone is also very relevant to this research as it extends beyond the highest tide level to the lowest tide level namely the spray and backshore zones (Edgar et al., 2014; Dugan et, al. 2013). The correlation of these zones is evident in the formation of sandy beaches - deposits of sand, gravel or shells along the shorelines. These beaches are typically formed by the deposit of particles carried from water currents namely and major part of the sediment transported from the rivers to the sea (Edgar et al., 2014; Dahl, E. 1952).

The convention was in response to the anthropogenic factors such as clearing the wetlands for agriculture that lead to the increased vulnerability of coastal zones namely shoreline destruction, irrigation and the loss of groundwater reserves (Ramsar, 1993). This action was necessary the international scale as many wetlands either lay across international boundaries or play a role in the international habitat protection - consideration of migratory patterns for birds and fish (Ramsar, 1993).

The structure of the treaty allows for the wetland management to occur on three different levels. The first level are the agencies, namely NGOs, responsible for the care of the wetland or group of wetlands in a river basin (Turner et al., 2000). Based on their work this organization will require the most detailed data collection on the instances of flooding, the variability in the shape of water bodies and topographical conditions to assist with the proper management of the site (Ramsar, 1993). The second level of management is the national agencies that are considered a contracting party with the global initiatives to engage in environmental conservation and preservation and they are responsible for developing the legal framework throughout the country and have oversight of the day-to-day responsibilities (Ramsar, 1993; Turner et al., 2000). In the stances of wetlands crossing national boundaries agencies at this level will take responsibility for coordination. The third level is at the convention scale that relies on information from the contracting parties to provide the basis for their global initiatives and monitor the effectiveness of the convention at the international scale (Turner et al., 2000). The convention tenants understand the challenge for national and international conservation of wetlands requires the coordination of bodies at different levels and built their system to coordinate action between parties (Ramsar, 1993; Turner et al., 2000). Although a number of sites throughout the Caribbean SIDS are designated Ramsar sites, monitoring of the sites by the Convention is limited and the information available on the Convention's website is outdated.

2.5.3.2 Regional Government: Caribbean Climate Online Risk Adaptation Tool

The Caribbean Climate Online Risk and Adaptation Tool (CCORAL) developed by the Caribbean Community Climate Change Centre as a web-based tool to assist decision-makers with integrating the principles of climate resilience into their planning. It was developed with input from government ministries, civil society organizations, business services sectors, research institutions and development agency partners. This use of the tool promotes discussion on climate risk management to encourage collaboration between technical experts and community stakeholders (Caribbean Community Climate Change Centre, 2017). The program was developed to review legislation, national planning, strategy and/or policy, programme and/or project and budget preparation.

The tool is mostly used for development of capital projects and involves a five-step process including a quick screening process, a step that seeks to understand the climate influence on the project, a step to apply a climate risk management process, a step to utilize climate-related tools including vulnerability assessment and awareness-raising and climate-related information.

The screening exercise assesses whether your activity is influenced by climate and is relevant when an organization is working on plans to develop and wants to review the activities the organization wishes to develop (Caribbean Community Climate Change Centre, 2017). The second step looks at providing guidance for non-climate experts and provides insight on how climate variability would be relevant to the activity namely being aware of the social, economic, or environmental issues that can affect the project. It also helps how climate impacts can be managed. The third step provides guidance for climate experts through the same lists of categories particularly to understand the climate influence on decisions (Caribbean Community Climate Change Centre, 2017). This stage looks at climate risk management processes which looks at the steps in the risk management process. The steps include analysing the hazard; estimating the risk; evaluating the risk; adaptation, risk control and financing; and implementation and monitoring (Caribbean Community Climate Change Centre, 2017). These activities on the process accounts for all information and the risk communication process with key stakeholders. The next step allows for a search in the database of tools that are great for decisions making, it takes the users through a search of extensive tools for the region. The final stage looks at making robust decisions under the threat of climate uncertainty, this stage speaks of the importance of utilizing climate models and advocates for robust adaptation measures. The CCORAL tool is useful for PAPs but they have not been part of the integral part of the training of the tool. Although trainings have been completed in the region, PAPs are not targeted as part of the training activities. CCORAL is particularly useful for identifying risks developing a response to address those risks. However, for PAPs CCORAL is an underutilized risk management resource.

2.5.3.3 National Government: Integrated Coastal Zone Management

Integrated Coastal Zone Management (ICZM) is the coordinated approach to managing resources as a response to failed management or fisheries, coastal hazards, land use and mining (Cicin-Sain and Knecht, 1998; Cordah Ltd. 2001). Empirical research indicates that the intergradation of resource management and the reduced conflict of resources will be the long-term solution to for adaptation at the national level (UNESCO, 2003). ICZM for the purposes of this research is the multi-sectoral approach to strike a balance between development and protection of coastal environments (UNEP, 2009). ICZM is focused on integration in five ways. Integration among levels of government insists that coastal zone management is more effective when there is a shared common purpose between local, national and regional levels. Integration among sectors is similar to this as looks at coordination between industries within a given country. Integration between terrestrial and marine resources understands the direct links between marine and terrestrial resources within the coastal zone. Integration between nations can be easily understood where wetlands are located across boundaries and their protection requires coordination. Integration between disciplines highlights the many fields of study that are associated with coastal zone studies and the integration of research would benefit the overall field (Cicin-Sain, 1993). Although there are ICZM policies in Caribbean SIDS, putting those policies into action are a great challenge particularly with growing demands of the burgeoning populations and competing economic interests for coastal resources. In the end the private sector as the main driver of economic development supersedes ICZM policies and unregulated development persists in coastal zones.

2.6 Key Findings

Habitat change as a result of land use change is one of the top five threats to biodiversity loss along with climate change, invasive species, overexploitation of resources and pollution. As disaster risk reduction becomes an increasing interest of SIDS, the preservation of coastal protected areas is central to the discussion. However, Ramsar sites in Caribbean settings are sites where increasing human settlements reduce the coastal eco-system value as well as the support to disaster risk reduction. Prevailing research in protected areas only covers arching topics on types of land uses or human activity that impact viability of protected areas. Comprehensive studies on the persistent growth of development in the buffering communities of protected areas have yet to be explored in detail within the Caribbean.

Furthermore, the inconsistencies in data collection sources fosters little awareness across the Caribbean communities about disaster risk reduction and the behaviors that adversely impact the resilience of their communities. Limited assessments of the risks to buffering communities foster the unmitigated growth of development in hazardous zones.

According to the World Commission of Protected Areas, the only assessment tool for protected areas for the Caribbean was developed for Belize (WCPA, 2017). This assessment focuses on resource inventory; administration of the protected area; resource administration, management and protection; management planning; governance; human resources and financial management. Although it is the only one for the region is still lacks in an assessment of the spatial effectiveness of protected areas in the country.

Physical Planning in the Caribbean, is limited to large-scale development. While capital projects are planned and regulated community scale developments are not, causing the unregulated growth of communities without appropriate planning tools. At the community-level the incidence of unregulated development is commonplace (Shah et al., 2013) therefore increasing the exposure of communities. Such a gap in the regulation of the planning and development activities fosters the creation of a built form that encroach upon natural habitats throughout the Caribbean.

In the Caribbean SIDS general guidelines from national governments for building in hazardous coastal ecosystems still lack an appropriate implementation framework and related tools, thus leaving communities with little help and support when making decision about changing the spaces they live in (Cincotta et al., 2000). It has been noted that in Caribbean SIDS development growth occurs along the coastal urban fringe where social factors limit their ability to develop land while increasing their risks to disasters (Sherbinn et al., 2007). This raises even more concerns about these unregulated development practices and their impact on adaptation within coastal ecosystems (Erwin, 2009). The implications of poor land management in fragile coastal zones are not only in terms of environmental issues but have a major negative impact on the local communities' wellbeing and quality of life. Therefore, the need to conduct a spatial assessment of coastal protected areas in the Caribbean is pressing.

Based on the emphasis on the PAPs as the persons responsible for conducting evaluations on protected areas management effectiveness, the development of a more structured methodology is not seen as beneficial and cautioned in the IUCN effectiveness assessment framework document (Hockings et al., 2006). It is not explicitly noted whether practitioners are not able to understand theoretical approaches or whether theoretical approaches are not well suited for the work of protected area management. However, theoretical approaches can contribute to the systematic comprehension of the challenges protected area management effectiveness and provide avenues for sound decision making particularly when addressing disaster risk reduction through coastal protected area management. The next literature review chapter presents evidence of theoretical approaches to spatial research in communities. This highlights the plausibility of community-centric spatial assessments approaches based in theoretical research.

Chapter 3 : LITERATURE REVIEW - SPATIAL RESEARCH METHODOLOGIES

3.1 Theoretical approaches in spatial planning

Watson et al (2014) and Hudson (1979) discusses the challenges between theoretical research and planning practice, especially in theories that are developed in academic journals in developed countries and the juxtaposition with contexts that exist in the developing world. The gap persists when the academics argue that new theoretical approaches are developed but then just ignored by practitioners while practitioners claim that academic theory has no bearing on practice (Alexander, 1997; Allemendinger, 2017). The very nature of planning however seeks to develop theories based on pressing social issues in an attempt to establish change (Allemendinger, 2017; Thompson, 2000). This therefore sets the stage of the continual battle of planning theory where the researcher has to determine the line between an emphasis on creation of knowledge through theory and the translation of theory into practice (Allenmendinger, 2017). The following forms of planning theory are all reflective of an attempt to breach the disconnect between the theoretical discourse and practice.

Blueprint Planning: is an approach that allows the planning agency to operate a program to accomplish its objectives with certainty (Hall, 1983; Weber, 1983; Lane 2005). It therefore requires the agreement on the objectives and those ends are determined largely by the planner (Hall, 1992; Faludi,1973; Lane 2005). The planning process then becomes a means to achieve the objectives. In the early traditions, blueprint planning included no accommodation for the participation and at its core the blueprint approach sees the planner as the all-knowing figure (Faludi, 1973; Lane, 2005).

Synoptic Planning: Synoptic Planning utilizes a systems viewpoint using conceptual or mathematical models and therefore has a heavy reliance on numbers and quantitative analysis. Although it has the capacity for strong methodological elaboration, its real strength is the simplicity. It is roughly categorized into four classical elements (1) goal-setting (2) identification of policy alternatives (3) evaluation of means against ends (4) implementation of policy (Hudson, 1979; Hall, 1983; Lane, 2005). It is the first time that public participation was included into the planning process and consultations were integrated as part of the systematic process that lead by the planner (Hall, 1983; Lane, 2005). This theory upheld the belief that public interest was a unitary ideal and that the goals of planning were universally shared and not related to any particular interests (Hudson, 1979; Lane, 2005).

Incremental Planning: developed as criticism to the synoptic approach incrementalism allows for dissenting opinions in the public participation process. Incremental planning presupposes that decision is better understood through decentralized bargaining processes best suited for democratic settings (Lindblom, 1959; Lane 2005). It is known as the science of muddling through by (1) making margin-dependent choices (2) choosing from a restricted range of policy alternatives and a restricted range of consequences (3) continuously adjusting policy objectives (4) a reconstructive treatment of data (5) serial analysis and evaluation (6) remedial orientation and evaluation (Faludi, 1973; Lane, 2005). Under this theory public participation is limited to consultation with a mechanism of incorporating other actors (Horvat, 1972, Hudson, 1979; Lane, 2005).

Mixed Scanning: proposed that decision making should occur at the operational and strategic level. It allowed for organizations to examine the challenge from a tactical view but also to address broader strategic challenges (Alexander, 1986; Etzoni, 1968; Lane 2005). Due to this, the focus of this theory was not entirely to achieve consensus in the planning community but about achieving the goals, the control remained in the hands of planner (Hall, 1983; Lane, 2005).

Transactive planning: is based on planning that is a process of collecting and analysing information and a dialogue that fosters mutual learning (Friedmann, 1973; Hudson, 1979; Lane, 2005). It allowed for the decentralization of planning processes providing opportunities for institutions to take a more control over their welfare. Planning was then seen as a part of social action and plans were then understood as the having an impact on the values and behaviour of people (Friedmann, 1973; Hudson 1979). The planner under this school of thought became the facilitator of the public participation process and allows for the active engagement of the community in the policy and planning processes (Lane, 2005).

Advocacy planning: sought to challenge conventional views on the unified public interest and calls for plural plans over a single plan (Faludi, 1973; Mazziotti, 1982; Lane, 2005). Its overall goal was to shift the formulation of social policy into an open forum. The foundation of advocacy planning is the (1) inequalities in bargaining powers between groups (2) the access to political power based on inequalities (3) the high numbers of a society that were unrepresented due to a lack of organization

(Davidoff, 1965; Mazziotti, 1982; Hudson, 1979; Lane, 2005). As a result of addressing these inequalities advocacy planning was seen to aspire to the equality and accommodation of all people in the planning process (Hudson, 1979; Lane, 2005). It seeks to ensure that all interests were a part of the decision-making process and the role of the planner was to then actively seek the participation of unlikely actors or directly represent their interests (Faludi, 1973; Davidoff, 1965; Lane 2005).

Bargaining model – is defined as a "transaction" between parties were each party outline their role (Dorcey, 1986; Lane, 2005). Under this approach planning is seen as an important element in policy making rather that a separate field (Faludi, 1987; McDonald, 1989; Lane, 2005). Bargaining with the political institutions was seen as an important aspect of decision making and it challenges previous models that do not rely on political processes (McDonald, 1989). However, it upholds the public participation ideal that participants at all levels of society have a place in decision making even if it is a part of the political process through voting (Lane, 2005). The planner in this approach becomes a part of the political process and utilizes public participation as a secondary actor in the decision -making (Lane, 2005).

Communicative approach – rationality is at the core of this approach with the recognition that different actors in the planning process use knowledge to understand their world in different ways. It allows for a recognition of the actors' expression of societal and personal communication as a means to help understand (Healey, 1992; Hilier, 1993). This approach supports the existence of differing viewpoints and rely on inter-subjective communication demanding participation for a form of dialogue (Healey, 1996; Hilier, 1993). Planning is therefore based on the inclusion of perspectives in an effort to organize attention to the possibilities for action (Lane, 2005; Healey, 1996). The planner in this approach cannot proceed without the involvement of all concerned actors (Lane, 2005).

Radical approach – relies on two streams of thought. The first is activism that is guided by a practical but idealistic vision of mutuality (Hudson, 1983; Gordon, 1971). Actors in this approach are free from manipulation and encouraged to build a cooperative spirit (Hudson, 1983). The second stream is a more critical look at social processes and the impact on class structures and historical dynamics of social movement. The approach then looks at the state as an entity that permeates into the structure of social and economic life and determines the growth of social problems. The planner in this approach upholds the importance of public participation rather than the importance of the state in planning processes.

As the field of planning progression further away from theoretical approaches to practice the aforementioned planning theories were replaced with planning practice approaches to align more with society. The following information on more current practices and provides perspective on why more current planning practice is divergent from theoretical approaches.

3.2 Coproduction – an extension of radical planning theory

Typically planning theory failed to completely explore the dynamics and tensions of interpersonal relationships that exist in particular spaces (Dyrberg, 1997; Albrechts, 2015). A more radical approach to planning is to unravel and resist the influence of the international neoliberal ideologies on planning theory and planning practices in cities and regions (Albrechts and Balducci, 2013). The aim is then to raise awareness, meet direct challenges, provide direction without predetermining the destination. And at every level it implies taking on board the wishes and aspirations of the disadvantaged and the poor. It is supposed to provide the space for all people to be a part of the open dialogue. There is an implicit responsibility of strategic planners to no longer simply seek to be efficient or function in a targeted neutral manner as a means for obtaining prescribed and well-defined ends but to play a dominant role in the process (Albrechts, 2015; Young, 1990). To be more than navigators trying to keep the ship on course but formulating the course in their contexts.

For planners in community contexts only this radical type of planning approach where the disadvantaged becomes an equal part of the action fosters transformative change. The crucial element is the way in which certain groups of people are excluded from direct engagement in the planning process (Healey, 1997; Young, 1990; Albrechts, 2015). The wide range of these relationships fit into this 'one size fits all' concept of community participation (Albrechts, 2015; Healey, 2007; Young, 1990). With the increasing spatial challenges there is an increasing plea for planning practices that treat spaces not just a container where designated things should happen based on planning controls (Albrechts, 2015; Young, 1990). But spaces with complex mixture of nodes, networks, traditional values combine to generate energy. A strategic spatial planning process based on coproduction acknowledged that particular forms of strategic spatial planning tend to reinforce the status quo (Albrechts, 2015, Young, 1990). There should be opportunity to go beyond established discourses and practices to achieve the goals of reaching the disadvantage. Coproduction forces planning experts to engage with the realities of the urban poor and to include their experiences in planning theory and practice. (Healey, 2007; Young, 1990, Albrechts, 2015). This implies that coproduction there are no technical rules and norms according to which coproduction processes are to be conducted (Albrechts, 2015; Young, 1990). It seeks to prepare citizens and more grassroots organizations for a more substantive engagement with the political. It is a way to ensure the creation of more resilient communities are developed to assure its members that their needs are met (Young, 1990; Healey, 2007; Albrechts, 2015).

3.2 Place branding – an extension of Transactive planning

Traditionally planning instruments becoming less effective in coping with dynamic and complex environments and not being able to address the social, spatial and economic needs of a place (Deffner and Metaxas, 2006; Healey, 1997). Place branding has been used a political tool to direct economic restructuring, community participation, environmental conservation, increases in tourism revenues of international interests. Place branding has been used as the pancea of economic or social ailments, but it lacks intellectual grounding or even stable positioning in spatial planning (Deffner and Liouris, 2005; Cutter et al 2008). Place branding focused on a long-term vision and strategic approaches to foster quality of life and place development (Healey, 1997). In order for spatial planning to be more effective there has to be a combination of long-term strategies with short-term actions to impact places more effectively. Promoting places as a tool for profit and involving marketing techniques alongside place management planning (Deffner and Liouris, 2005; Oliveira, 2015). Place branding in theory and in practice has been used as an instrument for spatial planners and spatial strategies because spatial planning alone is not capable of addressing spatial challenges such as attracting businesses, investors, tourists or foster a sense of civic pride in its residents. strategic spatial planning as a tool to support strategic change and improve places using different instruments. Instruments like regulatory zoning instruments, building control instruments and implementation instruments. Place branding can be a tool to achieve means for achieving competitive advantage; means for achieving community development and supporting citizen's identification with their place (Cutter et al., 2008; Kavaratzis and Ashworth, 2010; Oliveira, 2015).

Place branding is an instrument in strategic spatial planning to address social and structural challenges; improve spatial qualities, protect the landscape and highlight the assets. The spatial dimension for place branding initiatives may address the critics that see it as a tool where political pandering to international interests and profit making as opposed to the application of tailored and context sensitive approaches are closer to local needs (Zenker and Rutter, 2014; Kalandides and Kavaratzis, 2012; Oliveira; 2015). place branding determines whether u have the space already has a brand namely what it is known as to the residents and whether its 'newer' brand is counterproductive to the way the residents use it. As a place is the space capable of meeting the strategic economic and social improvement goals of the political machine that is pushing for the place to receive a rebranding (Oliveira, 2015).

3.3 Collective Action- an extension of communicative planning

The work of involving communities requires a collective action of all involved stakeholders (Tompkins et al., 2002). Although challenging it is important for all engages community representatives at the various levels of the community making collective action a strategic approach to community engagement in natural resources particularly in coastal management (Angel, 1983). In order for the success in collective action a very distinct approach must be utilized - it requires that the size of the group is managed and reduced to ensure manageability, as smaller groups tend be able to manage to achieve the goal; being mindful of the different contributions to the stakeholders and as result their commitment to the activity will be a reflection of their contribution whether financial or social; third consideration is insisting that the stakeholders receive a distribution of benefits ensuring that all their needs are met (Angel, 1983).

In the case of informal settlements Sholmo Angel (Angel, 1983; Huchzermeyer and Karam, 2006) outlined the social players in the community development and how the interests of each group influence the the ability to address the vulnerability of a community and how effective adapation happens. He identified these groups in the following categories: the housers; the municipal engineers; the community building stakeholders; the politicians; the international funders and the slum dwellers referred to as informal settlers in this research (Angel, 1983). This information is relevant to the research to determine which stakeholder group is appropriate for determining how to build the community assessment approach.

The Houser are those housing organizations that try to give settlers the resources they need to improve their housing conditions as a result of the lack of government intervention in informal and improvised areas (Angel, 1983). They seek only to improve the lifestyles of the dwellers by putting more resources at their disposal. Social investment programs are usually managed by this group namely through a non-profit or quasi-governmental agency and places a large emphasis on improving the physical conditions the settlers live in. This group pushes for the provision of permanent housing for settlers with the concept that stable houses can give the residents a sense of ownership and community pride. Although sturdier structures are a step to reduce their vulnerability to storms and other types of flooding the assistance is not always available to all residents (Angel, 1983). In some Caribbean countries, informal settlers may need to become part of government registries to receive assistance and in others they residents must be able to provide land tenure documents for these existing structures before assistance is provided (Angel, 1983). In both scenarios obtaining documentation is a lengthy process and impede the ability of the resident to receive long term assistance (Angel, 1983).

The municipal engineers look at infrastructure upgrades as a long-term solution to improving the health of the municipality as a result of flooding on poor drainage, their solutions for improving infrastructure in slums are more cantered on increasing the conditions in the community holistically and not necessarily looking that individual households (Angel, 1983; Gordon-Larsen et al., 2006). They solely focus on whether the community has access to public services versus allowing themselves to get too concerned on the quality of housing. But with the hap-hazard organization of housing in the settlements placing infrastructure to alleviate flooding becomes a difficult task (Angel, 1983).

The community organizations are there to ensure that services are placed in the hands of the community members in order to aid and grow their capacity to impact their lives (Angel, 1983). It is more the focus of this group of organizations to ensure that community is strengthen through organization rather than meeting the individual concerns. It is their assumption that collective action is best for the goals of the community to be met and therefore requires large groups of people and organizations the chance mobilize under one banner to achieve their goal (Angel, 1983). In this scenario, this group utilizes the goal of improved infrastructure to mobilize the community into action but are unable to provide additional support on individual levels. They are however the source of capacity building programming for communities.

The politicians and also the most far removed as they are more concerned about is the election cycle and improving conditions to ensure that votes are retained in the district (Angel, 1983). Usually this investment is broad brush approach and typically occurs along with an election cycle. This form of politics causes a dependency of the community on improvements that coincide with election cycles and is a very normal occurrence in the Caribbean (Angel, 1983; Huchzermeyer and Karam, 2006). Where infrastructural improvements promised in the beginning of an election cycle are not begun until elections are looming and hopefully extended into another cycle when the politician seeks reflection any improvements are temporary improvements.

Lastly are the settlers as people who are most impacted and who are more reliant with the small-scale infrastructure improvements versus proper planning (Angel, 1983). The people's primary objectives are to receive legitimacy in the informal settlements, but any quality improvement typically requires temporary displacement of communities to ensure that infrastructure is placed correctly (Huchzerneyer and Karam, 2006). When this does not occur then roads are installed after the buildings are placed without correct analysis of the capacity of the infrastructure to handle the existing and expanding population (Angel, 1983; Cirolia et al., 2017). Because it is hard to tract the development patterns in informal settlements it is therefore hard to anticipate development and therefore create infrastructure (Angel, 1983). In order to receive legitimacy, the communities only request infrastructure improvements to aid in regularization instead of requesting comprehensive planning and design assistance. Lack of proper physical planning and design assistance exposes the informal settlements in hazardous zones to continual risks and increasing their vulnerabilities (Angel, 1983; Dovey, 2016).

As discussed by Angel (1983), of primer concern are the informal settlers as they are the ones who will live in the areas after the improvements are made. In most scenarios, they are just more pleased with government invention at any scale and not necessarily concerned about this invention falling short of what they actually want to receive (Angel, 1983; Dietz, 2007). However, even in the midst of the support from the other community stakeholders, gaps still exist in the adaptive capacity of the settlers to create long term communities for themselves (Dovey et al. 2016; Angel, 1983). Considering those social conditions, these settlers are limited in the knowledge of their environmental and lack the resources to reduce their vulnerability on the environmental impact of the informal settlements is typically identified at the national level (Dietz, 2007; Maharaj, 2010; Angel, 1983) but there are inherent limitations in provide local opportunities to develop environmental responsible development. Environmental programming is seen as a luxury and not a way of life for informal settlers (Angel, 1983). It is significant to understand which stakeholder an appropriate match for any given adaptation scale as successful adaptation is relies on the successful buy-in of stakeholders at all levels (Adger, 2009).

3.4 Planning Support Systems

The ability to clearly communicate the vision of a plan drives the momentum accomplish the plan. A clearly communicated vision can determine whether a plan remains a conceptual vision of the planners' imagination or if it develops into the physical, tangible reality (Batty, 1996; Brail and Klosterman, 2001). From the onset of the profession, city planners understood the need to effectively convey their visions to stakeholders (Al-Kodmany, 1999; Foster, 2015). Visualization methods have been a key component of conveying planning visions to a broader audience. Visual tools have provided tremendous assistance to strengthening wide-scale knowledge of plans (Batty, 1996; Al-Kodmany, 1999). These visual tools facilitated the discourse between the knowledgeable planners and their stakeholders. A visual representation of a vision provides clarity to strategies used to implement this vision (Billger, 2017; Batty, 1996). Planning support systems for the purposes of this research apply to software programs that allow for the representation of data.

The resulting discourse encouraged a more effective decision-making process. With a clear insight of the tangible results of the vision, stakeholders have the opportunity to make changes in the conception stages of the project (Al-Kodmany, 1999). Without this knowledge, plans are subject to revisions that may cause extra effort and funds (Al-Kodmany, 1999). Also, by providing stakeholders with a more significant voice in the assessment process, a more comprehensive analysis of existing conditions can occur which leads to the development of very detailed strategies to address these conditions (Al-Kodmany, 1999; Billger, 2017).

As visualization tools, have transitioned into more technologically advance methods, the principles of utilizing these tools to convey a vision is increasingly imperative to the Urban Planning process (Billger, 2017). It is now understood that the planning process is imperative to the structure and vitality of cities, so getting the vision of the plan right the first time yields high rewards (Batty, 1996).

In terms of the objective approach to physical planning, which is an attempt to effectively understand the social activities surrounding the physical planning process; visual tools are at the forefront of the planning process (Brail and Klosterman, 2001; Billger, 2017; Batty, 1996). These tools can provide spatial representation of policy implications as well as convey multi-dimensional representation of future plans. These tools also provide support in the planning process by making planners and communities more informed about the impacts of their choices (Billger, 2017). As a result, the process to create the plan could involve greater dependency on the ability of these visual tools. Effective forecasting strategies must be based on Spatial Representation tools to provide detailed measurements of existing conditions, and multi-dimensional modelling provides a vision of what spaces the community may take on in the future (Batty, 1996; Chau et al., 2003). It is therefore useful in community-based adaptation to include spatial representation of the information to assist in building the community's knowledge of their conditions.

While the structure of the research is important to the research design, the tools used to analyse and disseminate the data are also important to the design (Polhill, 2010). Current tools used by researchers to analyse research data and allow for the information to be presented visually to the general public. A review of these tools is also relevant to the formulation of the spatial assessment.

These data analysis tools are tools used to analyze qualitative and quantitative data applicable to planning practice and to this research are Statistical Package for Social Science (SPSS) and Microsoft Excel. A review of the applicability of the current tools used in analyzing qualitative and quantitative data is appropriate for the research. The data collected will be analyzed in the best appropriate manner, and this review allows for the selection of the most appropriate. SPSS is used for the statistical analysis of data in social science (Green and Salkind, 2016; Polhill, 2010). It is the software program utilized by researchers in analysing data through bivariate and descriptive statistics, regression, and geo-spatial analysis. It allows for the analysis of large amounts of data collected by the research and requires training the research practices for use. The software package is purchased on its own and high costs typically makes it available at research institutions that require the analysis of statistical data. SPSS has the ability to create charts for visual representation (Green and Salkind, 2016). Microsoft Excel is a software program developed within the Microsoft Office package (Brown, 2011; Burns et al., 2008). It is the spreadsheet platform that can be used for a wide range of data uses. Statistical analysis can also be conducted in Excel as in SPSS (Brown, 2011; Burns et al., 2008). This software package is widely available and can be purchased on its own and with the package. Microsoft Excel can develop a wider use of line graphs, charts and histograms. The widespread use of this data analysis tool allows for a reduced cost (Green and Salkind, 2016).

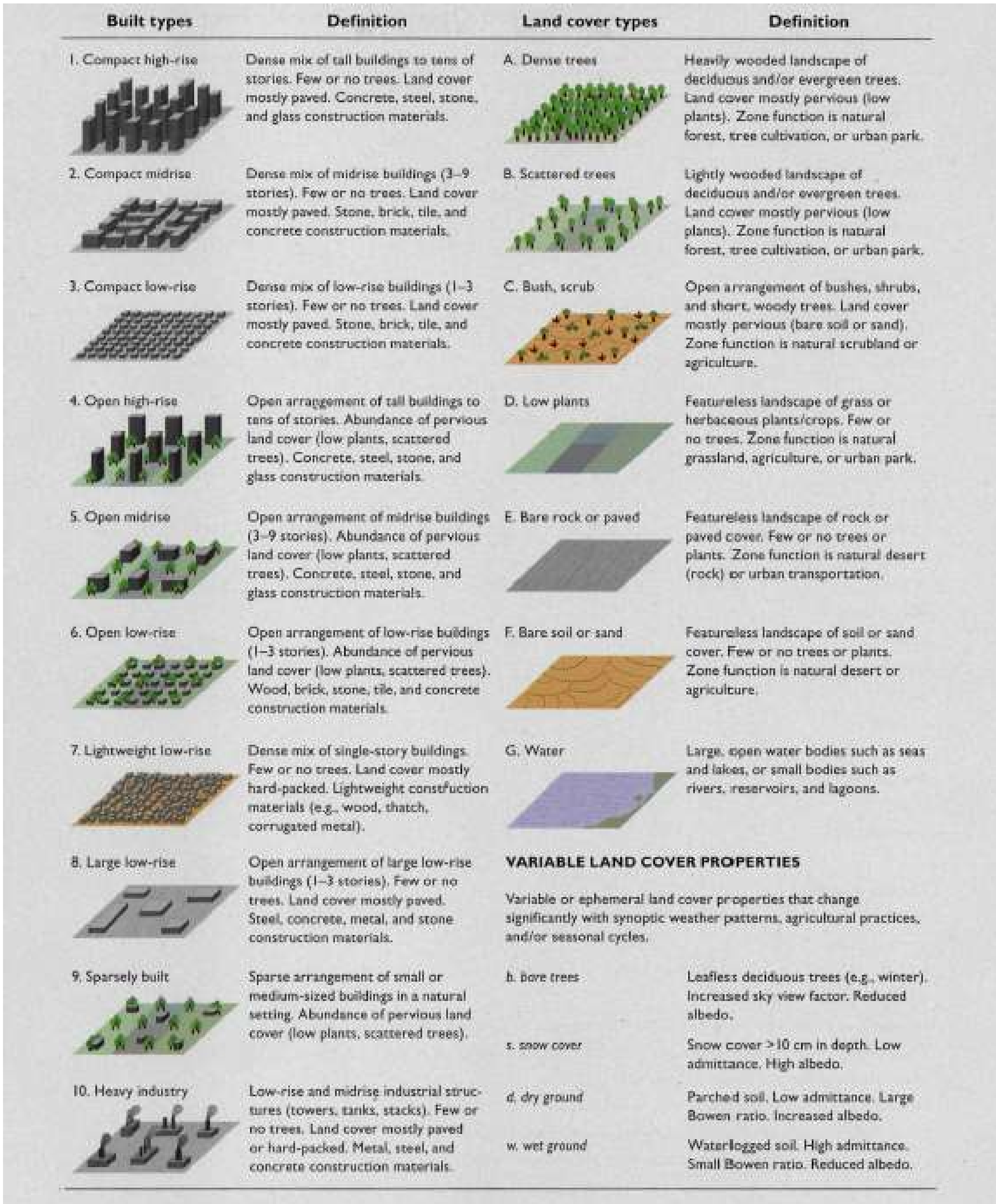
Spatial Analysis Tools applicable to planning practice and to this research are Geographic Information Systems (GIS) and Google Earth. Geographic Information Systems- it is a framework to collect and analyse spatial data to create maps and where applicable 3D scenes (Lai and Johnson, 2011; Maguire, n.d.). GIS allows for the insertion of different types of data linked to geographical referenced locations (Brewer, 2015; Krygier and Wood, 2016). The spatial analysis component of GIS provides the capability to evaluate spatial conditions for decision making. Based on the analysis capabilities GIS requires training and proficiency in geographical, social, economic and political analysis (Krygier and Wood, 2016; Lubis et al., 2017). Google Earth: is a software program that provides satellite imagery, GIS based data and aerial photography (Lubis et al., 2017; Pulighe et al., 2016). The program is open sourced and allows for minimal analysis of spatial conditions.

3.3 Spatial Planning Controls

Physical Planning as a function of adaptation is understood to be done at the local government level (Harris et al., 2006; Harris, 1983). For the purpose of this research, physical planning is a function of a community's physical capacity to foster economic development through accessibility to infrastructure services, diversity in transportation options and engagement in environmental protection (Harris et al., 2006; Choe, 2017; Gurran and Ruming, 2016). Therefore, inherent to the community's prosperity is the symbiotic relationships of economy, movement of persons within the space, infrastructure and the environment. The community reflects the interconnectivity of these areas and with consideration to climate change how these places connect have larger implications on the longevity of the community (Harris et al., 2006). The following are best practices in planning controls in the form of land classification systems that are applicable to protected areas (Harris et al., 2006; Harris, 1983).

3.4 Local/Micro Climate Zones

Comprehension of the Local Climate Zone (LCZ) characteristics of a region can provide guidance of the development of adaptation tools. Building upon the work of T.R. Oke's Urban Climate Zones where attention was placed in determining the surface roughness – the distribution of buildings heights within the urban setting and the ratio of impermeable to permeable surfaces (Oke, 1976; Matzka and Maher, 1999), the LCZ classification tool creates a method classify the Urban Heat Island (UHI) magnitude of an urban setting. It highlights the UHI magnitude based on an examination of the urban setting landscape and develops classes to emphasize a local scale, the nature of the climate within the zones. The LCZ system reviews the surface disturbance as a result of the inclusion of impervious surfaces in the natural, native landscape (Sanhueza et al., 2003). Figure 3-1 and 3-2 illustrate the definition of local climate zones – LCZ 1-10 are built types as they categorize the development landscape in urban areas, LCZ A-G are the land cover types as



Built types	Definition	Land cover types	Definition
1. Compact high-rise	Dense mix of tall buildings to tens of stories. Few or no trees. Land cover mostly paved. Concrete, steel, stone, and glass construction materials.	A. Dense trees	Heavily wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
2. Compact midrise	Dense mix of midrise buildings (3–9 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	B. Scattered trees	Lightly wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
3. Compact low-rise	Dense mix of low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	C. Bush, scrub	Open arrangement of bushes, shrubs, and short, woody trees. Land cover mostly pervious (bare soil or sand). Zone function is natural scrubland or agriculture.
4. Open high-rise	Open arrangement of tall buildings to tens of stories. Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	D. Low plants	Featureless landscape of grass or herbaceous plants/crops. Few or no trees. Zone function is natural grassland, agriculture, or urban park.
5. Open midrise	Open arrangement of midrise buildings (3–9 stories). Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	E. Bare rock or paved	Featureless landscape of rock or paved cover. Few or no trees or plants. Zone function is natural desert (rock) or urban transportation.
6. Open low-rise	Open arrangement of low-rise buildings (1–3 stories). Abundance of pervious land cover (low plants, scattered trees). Wood, brick, stone, tile, and concrete construction materials.	F. Bare soil or sand	Featureless landscape of soil or sand cover. Few or no trees or plants. Zone function is natural desert or agriculture.
7. Lightweight low-rise	Dense mix of single-story buildings. Few or no trees. Land cover mostly hard-packed. Lightweight construction materials (e.g., wood, thatch, corrugated metal).	G. Water	Large, open water bodies such as seas and lakes, or small bodies such as rivers, reservoirs, and lagoons.
8. Large low-rise	Open arrangement of large low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Steel, concrete, metal, and stone construction materials.	**VARIABLE LAND COVER PROPERTIES**	Variable or ephemeral land cover properties that change significantly with synoptic weather patterns, agricultural practices, and/or seasonal cycles.
9. Sparsely built	Sparse arrangement of small or medium-sized buildings in a natural setting. Abundance of pervious land cover (low plants, scattered trees).	*b. bare trees*	Leafless deciduous trees (e.g., winter). Increased sky view factor. Reduced albedo.
		s. snow cover	Snow cover >10 cm in depth. Low admittance. High albedo.
10. Heavy industry	Low-rise and midrise industrial structures (towers, tanks, stacks). Few or no trees. Land cover mostly paved or hard-packed. Metal, steel, and concrete construction materials.	*d. dry ground*	Parched soil. Low admittance. Large Bowen ratio. Increased albedo.
		w. wet ground	Waterlogged soil. High admittance. Small Bowen ratio. Reduced albedo.

Figure 3-1:Local/Micro Climate Zones (Stewart and Oke, 2012) ©American Meteorological Society. Used with permission.

a reflection of the native landscape.

The urban zones are sub categorized into six sections. Compact is defined as the dense

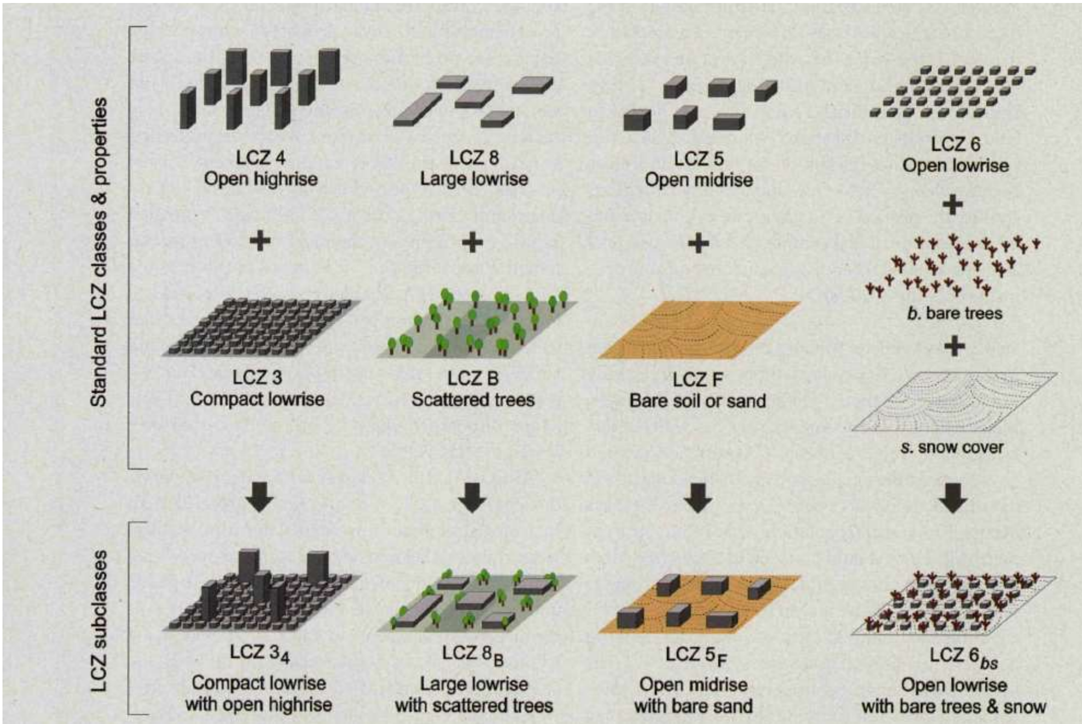


Figure 3-2:LCZ classes (Stewart and Oke, 2012) ©American Meteorological Society. Used with permission.

arrangement of buildings allowing for minimal flow of air based on high to low floor to area ratio and the use impervious construction material (Stewart and Oke, 2012). Open highlights the arrangement of the buildings to facilitate the movement of air based on aforementioned floor to area ratios also utilizing impervious construction material. Lightweight low rise is distinct in the use of penetrable construction materials such as wood, thatch and corrugated metal but a dense arrangement of the buildings (Stewart and Oke, 2012). Sparsely built reflects the typical suburban setting in the sparse distribution of buildings with larger accommodation for pervious surfaces (Stewart and Oke, 2012). Heavy industry accommodates for the industrial uses within the urban setting where all the land is typically covered by impervious surfaces.

The land cover zones are divided into seven categories largely emphasized in the functionality of each zone – dense trees – forested areas; scattered trees – urban parks; bush, scrub – semi-arid scrubland or agricultural land; low plants- grassland; bare rock or paved – urban transportation; bare soil or sand – deserts and; water – open bodies of water including reservoirs (Stewart and Oke, 2012). The climate classification determines how the seasons can alter the magnitude of the UHI particularly surface albedo. Broken into four categories, bare trees refer to the leafless trees during seasonal changes particularly winter or the dry season; snow cover reflects the snow greater than 10 cm in depth; dry ground is parched soil and wet ground is waterlogged soil (Stewart and Oke, 2012).

One LCZ classification of particular interest in developing regions like Latin American and the Caribbean is the LCZ 7 – Lightweight Low Rise. Its form is compactly arranged singe story, attached or detached buildings separated by narrow roads and alleyways (Stewart and Oke, 2012). There is limited infrastructure and the buildings materials are thin construction materials making the walls and roofs of the structures unstable. The function of this classification is the informal settlements apply referred to as shantytowns or slums (Stewart and Oke, 2012). According to the geometric data of the classification these areas are significant contributors to the UHI magnitude in LAC urban areas. LCZ 7 building surface fraction, which is the ratio of building plan area to total plan area is the highest among the other classifications, while its pervious surface fractions, i.e. the ratio of permeable surface to the total plan area could be greater than the rating for compact high-rise (Stewart and Oke, 2012).

Obtaining the LCZ is a function of examining the characteristics of the urban setting and the system prescribed geometric properties that are typically found in that zone

(Stewart and Oke, 2012). A comparison of LCZ 1 – Compact Low Rise and LCZ A – dense trees indicated the ways LCZ can inform the UHI impact in a particular area. These two categorizes have the same rating in terms of terrain roughness as the height variations of structures and trees are irregular creating large disparities overall height of the zone (Stewart and Oke, 2012). However, they differ greatly in pervious surface fraction LCZ 1 rating is less than 10 while LCZ A rating can exceed 90 exceeds and in anthropogenic output determined by fuel use from human activity and measured in W m^{-2} for LCZ 1 ranges from 50-300 while LCZ A rating is zero. Table 2 (Stewart and Oke, 2012) illustrates the combination of the LCZ subclasses as step towards determining the characteristics of urban setting (Stewart and Oke, 2012).

3.5 Smart Codes: environmental zoning

Smart coding is a transect based code developed to give communities an idea of the transitional areas that should exist between natural environments and the urbanized areas (Center for Applied Transect Studies, 2016). It was originally used to provide analysis of natural ecologies to highlight the changes between the shoreline to the uplands. In different environments, the transect planning looks different but in the case of planning it is typically set up in six zones with varying levels of intensity of their physical and social character. Smart coding develops a zoning category that ranges from systematically from the wilderness to the downtown core; it classifies different community patterns instead of creating communities with similar concentric growth patterns; it accommodates for different scales of zoning from regional to communities and individual lots; it intentionally integrates varying methods of “environmental protection, open space conservation and water quality control” it increases the options of categories available over conventional coding but does not presuppose to provide detailed zoning classifications as form based coding which is more applicable with the use of urban design in urban settings (Center for Applied Transect Studies, 2016). As zoning code, it can also double as a teaching tool on how planning principles are used to guide the environmentally conscious development (Figure 3-3). This form of coding is straightforward and easier to understand for ease to communication to communities, it is also flexible enough to be used by communities.

Figure 3-3:Transect Code (Center for Applied Transect Studies, 2016)

T1-Natural Zone: applies to lands in wilderness conditions, including natural land unsuitable for settlement based on topography (steep slopes, under sea level), hydrology (floodplains, wetlands), or vegetation (filtering plants, deep rooted trees to retain soils)

T2- Rural Zone: applies to woodland, agricultural land, grassland and irrigable desert. Typical structures in this zone are agricultural buildings, cabins and villas.

T3-Sub-Urban Zone: consist of low-density residential areas that are in close proximity to higher zones and can mean mixed use namely light industrial and suburban

T4- General Urban: primarily residential urban fabric but consists of mixed use

T5 – Urban Center Zone: consists of higher density mixed use building that accommodate retail, offices, row houses and apartments

T6- Urban Core Zone: consists of the highest density and height, with the greatest variety of uses and civic buildings

The creation of transects seeks to correct inappropriate intermixing of rural and urban settings, a phenomenon that occurs in unregulated and informal settlements. It is meant to mirror what occurs in nature as habitats grow in sequence and the sequences in a continuous manner. This type of zoning is applicable to study area due to its proximity to a conservation zone and should be viewed as an effective way to apply development principles to address the range of human habitats (Center for Applied Transect Studies, 2016). It allows for the transitional zoning which reduces the instance of one type of zoning in the urban setting.

3.6 Conservation Subdivision Design

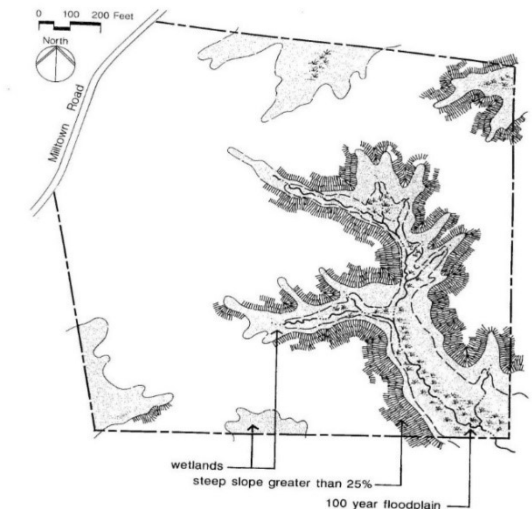


Figure 3-4: Image of site before development (Natural Lands Trust, 2010)

To manage the ecological impact of future residential development, we recommended that the town consider adopting alternatives for managing residential growth. The creation of an updated green space plan provides the unique opportunity to explore Conservation Subdivision Design (CSD). These guidelines con- serve and promote atheistic value to environmentally distinct areas of a community (Figure 3-4 and Figure 3-5). These environmentally distinct areas of a community include unique, irreplaceable, historic, ecologically valuable, and scenic (University of Buffalo, 2010; North Tonawanda History Museum, 2010; World Climate, 2008).

CSD differs from traditional Cluster development in three general ways.

- It establishes higher standards for the configuration and quality of open space. In cluster development, this figure is mostly based on acreage.
- It also the municipality task to exercise greater influence over the design of the new subdivisions. In the case of the town of Wheatfield, open spaces of interest can be identified in the green space plan.
- The protected land is configured to create an interconnected network of open space and particularly linking areas in adjoining subdivisions.

The initial step in the CSD process is to identify critical areas as ecologically

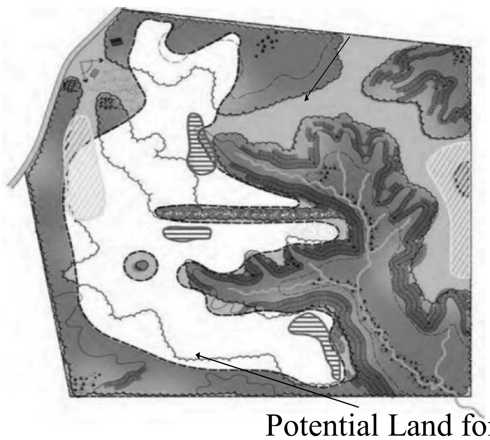


Figure 3-5:Development in Conservation areas (Natural Lands Trust, 2010)

sensitive and resources rich areas with an emphasis on connectivity. Ecologically sensitive areas include wetlands and floodplains, the process of identifying these areas is outlined in a previous chapter. Resource rich areas include mature woodlands, hedgerows, large trees, upland habitats, prime farmland, natural meadows, geological formations, and scenic views. Figure 3-5 and 3-6 identify examples of development in ecological sensitive areas.   To guide the overall design process of this program, municipalities may need to include illustrated design standards for each classification. The classification can be applicable to development within existing zones. Figure 3-6 provides examples the conventional/ unacceptable layout consists of fragmented green spaces green spaces in contrast to the conversation/ acceptable designs where the green space is consolidated.

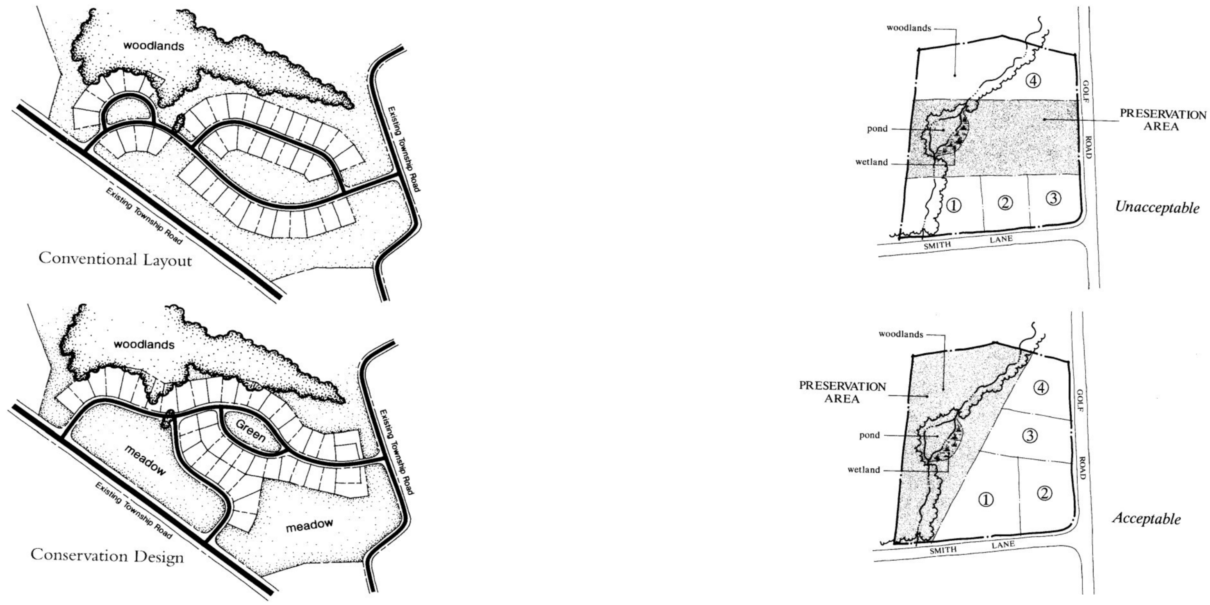


Figure 3-6:Comparison of Conservation and Conventional Subdivision guidelines (Natural Lands Trust, 2010)

CSD promotes ecological, social, recreational and economic value. The ecological benefits include ―wildlife management, greater water quality protection through improved buffers, higher aquifer recharge zones through improved stormwater management, and environmentally sensitive sewage treatment and disposal. The social and recreational benefits include ―pedestrian-friendly neighborhoods, eco-community activities, town-wide greenways and trails and communities with multiple conservation subdivisions. The economic benefits include ―lower costs, marketing and sales advantages, value appreciation and reduced demand for new public parkland (Natural Lands Trust, 2010).

Examples guidelines of Residential development in Conservation areas is the *Small Property Subdivisions*: The lots in this plan should be compact, with homes facing a centralized green area. This plan is parallels the current Cluster Development guidelines in that the minimum acreage is 20. The notable different is that there is no minimum open space requirement, but the plan does conserve a significant amount of green space (Figure 3-6).

- Open Space: The edges of the subdivision tract should be protected on at least three (3) sides. When that open space is combined with abutting open space in adjacent open space, significant areas of open space are formed to reinforce the rural character of the town.
- Streets: Houses should front the streets which can be enhanced by street trees, a sidewalk on one side, —planting strips and pedestrian scaled lighting.
- Buffering: Wherever the tract abuts a busy road, buffering should be used to soften the view

Site Requirements:

Minimum Size: 20 acres

Maximum Site Size: 50

acres

Open Space Development Ratio: No minimum

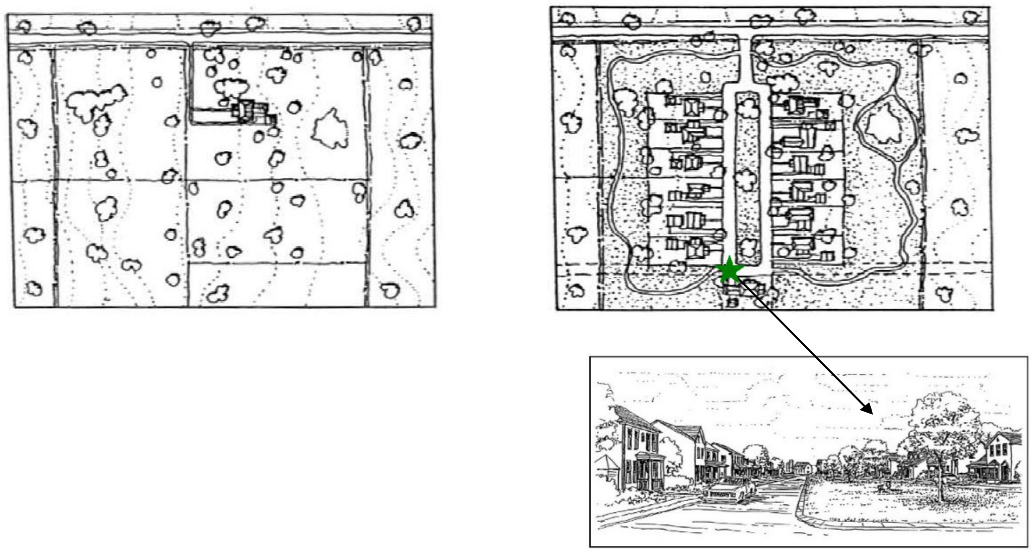


Figure 3-7: Small Property Subdivisions (Natural Lands Trust, 2010)

To implement the CSD a community will need to create:

A Conservation Subdivision Design guideline booklet including (Figure 3-7 and 3-8):

- Creation of a town wide map of remaining ecologically sensitive area
- Illustrated examples
- Outline additional conservation criteria, including conservation criteria for each existing residential zone
- Illustrated examples of Design Techniques

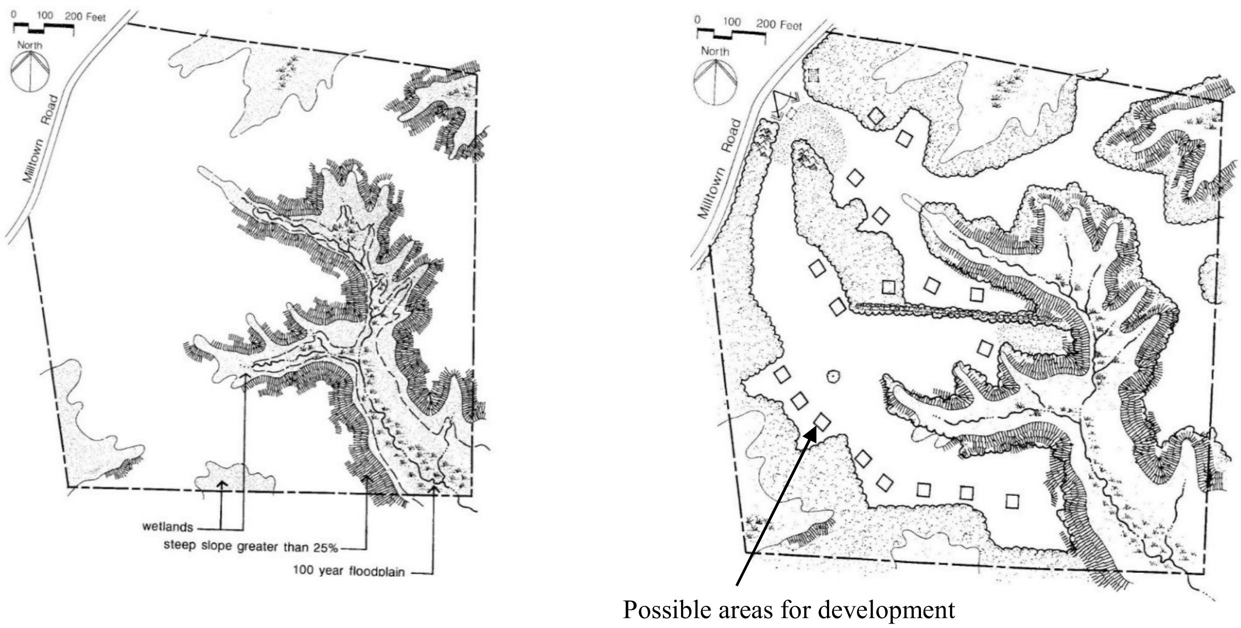


Figure 3-8:Examples of Before and After for Design Booklet (Natural Lands Trust, 2010)

3.7 Form based codes: climate resilient design in the built environment

As illustrated in Figure 3-9 Form based codes is a land development classification system that unlike conventional zoning focuses on the design elements of the community spaces (Form Based Codes Institute, 2017). It delineates public spaces standards and building standards rather than segregation of land uses. Although form-based codes utilize a large amount of technical information it is also accompanied with images for ease of awareness (Form Based Codes Institute, 2017). Form-based codes are best served as a tool for development in a community according to objectives of the community's plan for the future. In Figure 3-9 Form Based Codes uniquely includes the identification of architectural standards, landscaping standards, signage standards and environment resource standards (Form Based Codes Institute, 2017).

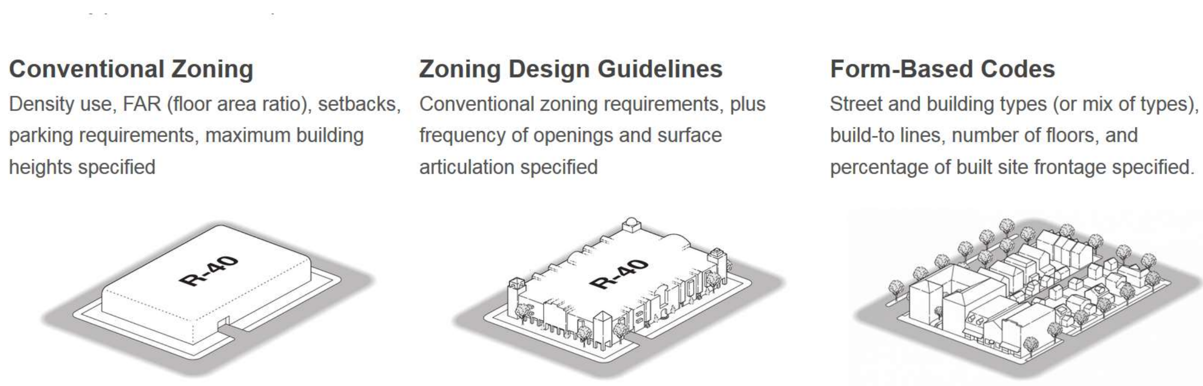


Figure 3-9: Form based codes *(Form Based Codes Institute, 2017)*

3.8 Key Findings

The purpose of this literature review was to extensively examine the ways in which planning theory emphasizes the need for community engagement and the role of planning support systems in decision making that the community level. Although there is a wealth of information in planning research, there is still limited provision of that information at the community level.

The very nature of planning seeks to develop theories based on pressing social issues in an attempt to establish change. Change in the communities cannot be effective without an emphasis on community engagement. Planning processes occurring in this community context should rely on the principles of coproduction as it allows for the community members to be an equal contributor to transformative change. This also allows for capacity building in strategic decision making at the community level without the reliance on external parties and interests. Crucial to this theory is addressing how communities are often times excluded from direct engagement in the planning process. With the need for addressing spatial challenges at the community level and the increased discourse on disaster risk reduction there is a growing emphasis for open science research (Fecher and Friesike, 2014). This gap between planning research and practice is addressed through the contribution of a theoretically supported, open science approach.

Case studies in marine spatial protected area planning (MSP) were previously conducted to determine how different approaches to MSP are developed to achieve different aims in each context (Jones et al., 2016). Case study revealed that in MSP decisions tend to be more top-down where stakeholders are merely consulting through means that did not represent a collaborative process (Jones et al., 2013). In the instances of more participative forums, these were disconnected from the final decision making. Those stakeholders who would be directly affected by the MSP enactment would opt to use sectoral connections to higher political levels to get influence on the policy actions in the plans (Jones, 2016; Qiu and Jones, 2013). The unmitigated development in these places persist due to the overriding public interest and limited engagement from the key stakeholders in all aspects of the protected area management. These nuisances in MSP are only chronicled through the case study approach. The Case study approach provides the opportunity for pertinent, context specific information to be obtained.

Additionally, the intersection between society and the built environment is community-based planning is seen as a decision-making decentralization process and an opportunity for localized engagement to develop a context specific model of planning (Page, Johnson, and Proosdij, 2014). Through co-production, community input is therefore necessary in the creation of community-based planning, based on its inherent requirement for their engagement. Based on the information obtained through the literature review developing an assessment is imperative for coastal communities throughout the Caribbean as it prioritizes their input in more aspects of the process. Assessment is an essential element of community planning as residents are better capable to understand conditions in their communities (Page, Johnson, and Proosdij, 2014; Manzo, 2006; Tierney, 2006). It is then understood that as the communities become more engaged in the decision-making processes, their interests are heightened, and their involvement can be maintained as they are the stewards for the community. This method of co-production also reduces dependency on government to determine the direction of physical development which in Caribbean SIDS is dependent on political factors (Dominguez, 1998).

For the purposes of this study the community will involve local government officials, private sector companies and residents. The goal is to obtain information on the spatial conditions that exist despite the existence of a protected area designation. The qualitative data collection provides an explanation of the encroachment based on the perspective of the community.

Open Science allows for the knowledge obtained through scientific research to be available to society (Fecher and Friesike, 2014). Based on the previous chapter in the literature review it was determined that existing protected area assessments conducted at the community level limited the use of quantitative data collection and comprehensive analysis to determine the effectiveness of protected areas. The inclusion of all the aforementioned principles guide the framework of the SECPA. To make strides towards addressing disaster risk reduction in the coastal zones of Caribbean SIDS this research will contribute a theoretically based, approach that can be utilized by the most vulnerable communities. The following chapter outlines the development of the SACPA approach by initially presenting research methodology principles that are applicable to any research endeavor and outlining the research methodology that is best suited for the aim of this research.

Chapter 4 : RESEARCH METHODOLOGY

4.1 Introduction

This chapter is a review of the theoretical framework required for this type of research as well as a review of the research approaches that will be utilized in the development of the spatial assessment. The chapter reviews the theoretical standards for conducting research to provide the framework for discussing the theoretical support to planning practices that are relevant in the use of conducting community-based assessments. The methodology of the SACPA approach is also outlined in the chapter to reiterate the theoretical underpinnings of the research endeavour.

4.2 Research Foundation

The need for research is at the centre of the obtaining knowledge (Black, 1994; Wee and Banister, 2016; Olson, 2016). Developing a targeted research methodology not only provides a systematic way to approach a research problem but also provides the researcher an opportunity to develop the procedure for getting all the relevant data (Rajasekar, et al 2006; Kumar, 2019; Kothari, 2004).

Although research requires the collection of information, research at its core requires that data is collected with a clear purpose towards an expected end, that information is then interpreted systematically even if obtained from different sources (Singleton, 1988; Patton, 1990; Institut Numerique, 2012). Research methods includes different forms of methods namely understanding, describing, criticizing, explaining and analysing (Ghauri and Gronhaug, 2005; Noor, 2008). Simply put research is the systematic collection and interpretation of information with the purpose of discovering the unknown.

When formulating research the researcher should be able to answer some very direct questions to have an increase knowledge on what they are doing, why they are doing it, related implications on what they are trying to accomplish, whether the research is related to any research already undertaken, that the researcher has determined how they collect the data to determine validity, reliability and ethical issues associated with the research (Brewer and Hunter, 1989; Trochim and Donnelly, 2001; Bell, E., Bryman, A., and Harley, B. 2018).

This insight will allow the researcher to obtain the required information to critically review the existing literature on the research topic. Comprehensive research will review the range of primary, secondary and tertiary literature from available sources (Oakleaf, 2010; Institut Numerique, 2012). It will help guide the formulation of the research methodology and design to help the researcher determine what approaches are necessary to complete the research; help exposed the possible issues related to gaining access and ethics; formulate the data collection techniques and finally the completion and dissemination of the report (Dana and Dumez, 2015; Staver et al., 2019).

The purpose to research is to uncover the unknown, to uncovered information that is hidden from the researcher at the beginning of the research (De Vos et al., 2011; Kothari, 2004). Developing research then requires a systematic process that requires a grasp of the nature of research, formulating and clarifying the research topic, critically reviewing the literature, cognition of research philosophies and approaches, formulating the research design, negotiating access and research ethics, data collection, analysis of data and dissemination of the report (Dubois and Gadde, 2002; Pay et al., 1998).

4.2.1 Ontology, Epistemology and Axiology

Philosophy is the study of the foundation of knowledge and comprises of ontology, epistemology and axiology (Rayner, 2011, Ruwhiu and Cone, 2010). Ontology examines the existence of or the 'study of being' (Blaikie, 1993; Euzenat and Shvaiko, 2007; Hart, 1971). Broadly, the discussion of philosophies is the dichotomy between positivism- that the research relating to schools of thought are independent of their subjects or interpretive- that the subjects of the research play an active role in the study and the work must be interpreted through their perspective for validity (Feather, 2012; Gruber, 1993).

Therefore, inherent to the examination of knowledge is the relationship between the subjective and objective principles of knowledge. At its core, Ontology is a function of how reality is identified through the subjective experience or whether reality that exists separate and apart from those who may live it (Bryman, 2012; Hyder et al., 2017). Ontologies exist in multiple classifications but the two that generally maintain prominence are the use of expressivity and formality in language in the expression of knowledge and the breadth of the subjects being described through knowledge exchange (Roussey et al., 2011; Bryman, 2012; Hyder et al., 2017).

The influence of the subjective versus the objective in determining the value of knowledge extends Ontology into the discussion of Epistemology which examines the legitimacy of knowledge (Easterby-Smith et al., 2008; Packer, 2000; Ayers, 1993). It highlights the sources of knowledge and what methods were implored to obtain such knowledge (Rayner, 2011; Packer, 2000). As put forth by Cook and Brown (1999) under the umbrella of epistemologies is the knowledge of possession and the epistemology of practice. The knowledge of possession is the attaining and retaining of knowledge whereas the epistemology of practice highlights that particular forms of knowledge are only attained through practice (Amarantunga et al., 2002, Ayers, 1993).

Axiology explores the role of the researcher in the process of discovery (Hart, 1971; Bahm, 1993; Klenke, 2016; Biedenbach and Jacobsson, 2016). The researcher is inherently an incubator for values that will in turn influence the way the research conducted. According to Hart (1971) The researcher is therefore an integral part of the way knowledge is obtained and disseminated. In order to maintain the integrity and strength of the research, the values of the researcher must be clearly stated to minimize the any bias in the research (Hart, 1971; Bahm, 1993; Klenke, 2016; Biedenbach and Jacobsson, 2016).

Considering axiology as an influence on the research, the value-free concept as not to insert the researchers own beliefs into the experience (Bahm, 1993; Hart 1971; Klenke, 2016; Biedenbach and Jacobsson, 2016). Whereas the value laden presupposes that the judgments of the researcher are inherently placed on the research and therefore influence the outcome of the research (Douglas, 2009; Baranov, 2015; Murphy, 2017).

According to Figure 4-1 the additional schools of thought fall within the spectrum of realism accepts that facts as there and do not presume to create alternate possibilities; objectivism supports an unbiased truth and examines the validity of the study against that truth; subjectivism depends on the influence of the subject's perspective as the base of the established information; pragmatism looks towards accepting practical consequences of the research and as such less practical reasons are not accepted; and functionalism accepts that role of a subject determines its validity (Saunders et al., 2012; Bell et al., 2018; Quinlan et al., 2019).

	Positivism	**Realism**	**Interpretivism**	**Pragmatism**
Ontology: *the researcher's view of the nature of reality or being*	External, objective and independent of social actors	Is objective. Exists independently of human thoughts and beliefs or knowledge of their existence (realist), but is interpreted through social conditioning (critical realist)	Socially constructed, subjective, may change, multiple	External, multiple, view chosen to best enable answering of research question
Epistemology: *the researcher's view regarding what constitutes acceptable knowledge*	Only observable phenomena can provide credible data, facts. Focus on causality and law like generalisations, reducing phenomena to simplest elements	Observable phenomena provide credible data, facts. Insufficient data means inaccuracies in sensations (direct realism). Alternatively, phenomena create sensations which are open to misinterpretation (critical realism). Focus on explaining within a context or contexts	Subjective meanings and social phenomena. Focus upon the details of situation, a reality behind these details, subjective meanings motivating actions	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data
Axiology: *the researcher's view of the role of values in research*	Research is undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Research is value laden; the researcher is biased by world views, cultural experiences and upbringing. These will impact on the research	Research is value bound, the researcher is part of what is being researched, cannot be separated and so will be subjective	Values play a large role in interpreting results, the researcher adopting both objective and subjective points of view
Data collection techniques most often used	Highly structured, large samples, measurement, quantitative, but can use qualitative	Methods chosen must fit the subject matter, quantitative or qualitative	Small samples, in-depth investigations, qualitative	Mixed or multiple method designs, quantitative and qualitative

Figure 4-1: Ontology, Epistemology, Axiology (Saunders et al., 2012)

4.2.2 The Research Onion

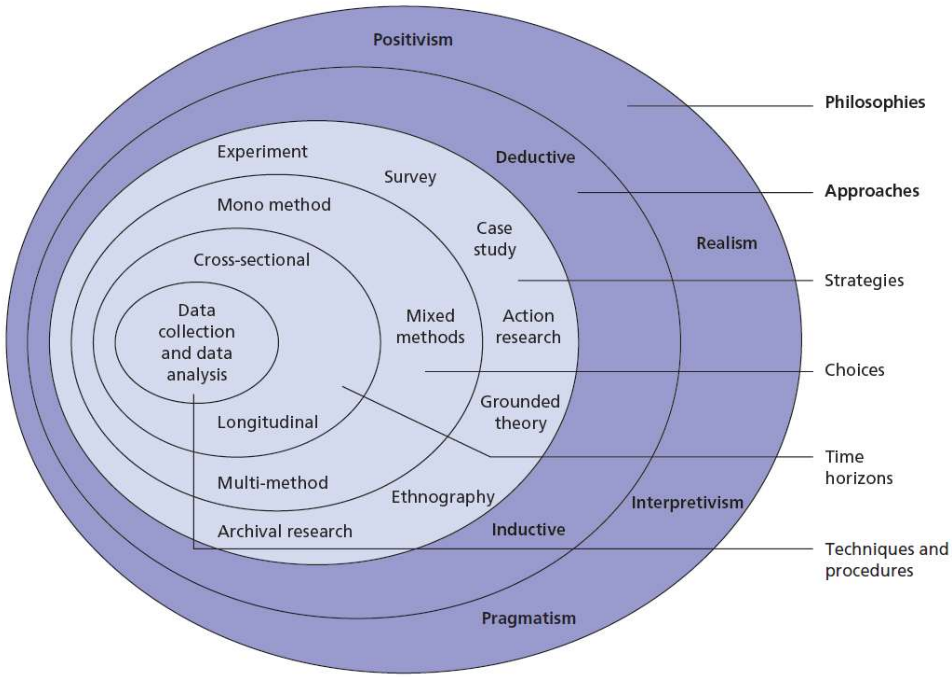


Figure 4-2: The Research Onion (Saunders et al., 2008)

Figure 4-2 explores the research onion as defined by Saunders et al (2008) to better understand research philosophies at the core of conducting research. Research practices are presented in concentric circles, highlighting how the concepts of each ring are dependent on the rings within it. At the core of the onion is the selection of how data is collected and analysed, but to determine the most effective method for research, the 'onion' should be explored deductively (Saunders et al., 2012; Bell et al., 2018; Quinlan et al., 2019). The research onion highlights detail in philosophies, approaches, strategies, choices, time horizons, techniques and procedures as a part of complete research (Saunders, 2008).

4.2.3 Philosophies

Under the category of philosophy are the terms of positivism, realism, interpretivism and pragmatism. Positivism prefers to work in an observable reality, only research observed will result in development of valid data (Shaffer, 1995; Baronov, 2015; Bell et al., 2018). The process looks at the generation of a research strategy and the collection of data that utilizes the theory which will then develop a hypothesis. After the development of the hypotheses it would be tested towards the further development of the theory and research (Remenyi et al., 1998; Shaffer, 1995; Baronov, 2015). Positivism requires the research to be value-free meaning that researcher must remain external to the data collection process and do little to change the substance of the data collected (Shaffer, 1995; Sanders et al., 2008; Baronov, 2015).

Realism insists that what is shown as reality is the truth and that objects are capable of existing independent of our human mind (Saunders, 2012; Sayer, 1999; Niiniluoto, 1999). In essence that reality is separate from the mind (Sayer, 1999; Fletcher, 2017). It is similar to positivism in that a scientific approach is necessary for the development of knowledge. Direct realism implies that things are pretty straight forward in that our knowledge and senses reflect an accurate depiction of the world (BonJour, 2004; Hoffman, 2002). Critical realism implies that what we experience are representations of what is actually real and not the real things directly (Niinuluoto, 1999; Fletcher, 2017).

Interpretivism explores the differences between humans and the role as social actors; how people interpret the social roles in relation to our own meanings (Williams, 2000; Goldkuhi, 2012; Saunders et al 2012; Sullivan, 2016). The idea of this philosophy is that the researcher enters the social world of the research subjects in an attempt to understand the world from their point of view. (Goldkuhi, 2012; Williams, 2000; Bell et al., 2018; Bryman, 2016; Goldkuhl, 2012). The emphasis is placed on the difference between conducting research on people versus objects. In human based research there is the recognition that people interpret their world in certain way and act according to that interpretation (Saunders et al. 2012; Bell et al., 2018; Bryman, 2016).

Pragmatism is philosophy that doesn't presuppose the option of just one philosophy, namely that studies are should be reflections of the study and where necessary variations are acceptable (Shusterman, 2016; Menand, 1997; Baker and Schaltegger, 2015; Goldkuhl, 2012). The study presupposes that mixed methods (qualitative and quantitative) can be very appropriate in one study and the use of multiple methods will bring about positive consequences (Baert, 2005; Baker and Shaltegger, 2015; Shusterman, 2016).

4.2.4 Approaches

Deductive approaches more associated with positivism philosophy initiates from a general direction, as the research progresses and additional information is received, the scope of the research can be narrowed (Antwi and Hamza, 2015; Holden and Lynch, 2004; Saunders, et al., 2012). Building deductive research has five stages: deducing a hypothesis – developing a testable proposition about the relationship between two or more variables; expressing that hypothesis – outlining exactly how the variable can be measured, proposing that a relationship between two variables; testing an operational hypothesis; examining the outcome of the research inquiry; and where necessary modifying the theory based on the findings (Sik, 2015). Deduction allows the research to explain causal relationships between variables utilizing a structure methodology with controls that allow for the testing of a hypotheses (Holden and Lynch 2004; Sutrisna, 2009).

As opposed to deductive, inductive research associated with interpretive philosophy develops a more specific problem and as the research progresses develop a more general theory (Ormston, Spencer, Barnard, 2014; Bam, 1992). Abductive approaches utilize both the tenants of deductive and inductive considering that both may be applicable and useful at different stages in research and allows the researcher the flexibility to use approach where necessary (Bam, 1992; Saunders, et al. 2012). The idea will be to get a better idea of the problem, the analysis of the data would then formulate a theory (Dikova and Van Witteloostuijn, 2017). This approach is likely to be utilized within the context of events that are already taking place and an infinity to generalise (Figure 4-3).

Deduction emphasises	**Induction emphasises**
• scientific principles • moving from theory to data • the need to explain causal relationships between variables • the collection of quantitative data • the application of controls to ensure validity of data • the operationalisation of concepts to ensure clarity of definition • a highly structured approach • researcher independence of what is being researched • the necessity to select samples of sufficient size in order to generalise conclusions	• gaining an understanding of the meanings humans attach to events • a close understanding of the research context • the collection of qualitative data • a more flexible structure to permit changes of research emphasis as the research progresses • a realisation that the researcher is part of the research process • less concern with the need to generalise

Figure 4-3: Deduction and induction (Saunders et al., 2012)

4.2.5 Strategies

Research strategies are typically applied to descriptive, exploratory and explanatory (Yin, 2003; Foster and Rzhetsky, 2015) and can categorized clearly under deductive or inductive approaches. Selecting a research strategy is based on the research question and the best strategy to meet the objectives of the research. It is also very possible to use one strategy as a part of another (Foster and Rzhetsky, 2015; Glaser, 2017). The following list of strategies are reviewed to develop the methodological stance for this research.

Experimental- studies the probability of an independent variable impact on dependent variable. An experimental strategy is a study on casual links, whether changes in one independent variable produces a change in another variable (Hakim, 1987; Zellmer-Bruhn, 2016). Experiments typically involve an explanation of a theoretical hypothesis; grouping of individual samples from established populations; allocation of samples from the experimental and control group to experimental conditions; manipulation of variables; the measurement of dependent variables and the control of other variables (Zellmer-Bruhn, 2016; Yin, 2003).

Survey – typically in the form of questionnaires is exploratory. Surveys allow for the collection of large amounts of data through quantitative analysis (Nardi, 2018; Yin, 2003). It is mostly used to answer who, what, how many, where, and how much. It is a preferred method to provide authority because it is easy to understand and explain. Surveys can be used to collect a large amount of data and analyse that information in a quick way (Nardi, 2018; Zhao et al., 2016; Yin, 2003). This data collected is quantitative and must be transferred quantitatively so it can uncover relationships in variables and appropriate models can be produced to reflect these relationships (Nardi, 2018).

Case Study – studies a topic within context or a number of contexts and doesn't presuppose to control the variables involved in the research (Yin, 2003; Morris and Wood, 1991). This strategy is best used if the researcher wants to build a comprehensive depiction of the context of the research and its related processes (Morris and Wood, 1991; Saunders et al., 2007). A single case study can be used to analyse a case that very few people have considered before (Saunders et al., 2007; Brannen, 2017). Multiple case study is utilized when the research wants to discover whether discoveries in the first case are applicable in other cases. Multiple case studies are therefore preferred as the findings from the cases can be generalize versus having to develop a strong justification for the single case choice (Brannen, 2017; Saunders et al., 2007).

Action research – develops solutions based on a collaborative process that depends on the different forms of knowledge of the participants (Yin, 2003; Saunders et al., 2007). It focuses on the purpose of the research that is research in action over research about action. It gives the researcher the opportunity to be a part of the research and therefore participate in the change taking place (Coghlan and Shani, 2005; Saunders et al., 2007). Action research therefore implies that there are implications beyond the project (Saunders et al., 2007)

Grounded theory – creates a process to define how people construct their everyday lives. It is the strategy more in line with the inductive approach (Glaser and Strauss, 2017; Dougherty, 2017). It is utilized to build a theory as an attempt to explain and predict behaviour. The collection of information begins without a theoretical framework and then the theory is created based on the data and related observations.

Ethnography – studies groups in order to obtain a representation of socio-cultural dynamics (Silverman, 2016; Saunders et al 2007). More aligned with anthropology in that they seek to describe the world in which the subjects live and explain the findings. This strategy takes some time and requires the researcher to get immersed in the social world of its research as much as possible (Silverman, 2016). This strategy is preferred when the research needs to be flexible and is subject to change based on what the researcher uncovers (Saunders et al., 2007).

Archival research – focuses on events of the past as part of the research and utilizes existing documents as sources of research (Saunders, et al., 2007; Ventresca and Mohr, 2017). Methods selected to obtain the research is at the discretion of the researcher and depending on the subject matter several methods can be utilized at the same time (Ventresca and Mohr, 2017).

4.2.6 Choices

All research lies within the spectrum of quantitative and qualitative methods. Quantitative methods are an evaluation of numbers while qualitative is an evaluation of narratives (Creswell and Clark, 2017). Selecting one method is referred to as the mono method meaning either qualitative or quantitative (Yin, 2003). The multi-method design may start with one method to but switch to another based on the data that needs to be gathered (Creswell and Clark, 2017). However multi-method studies must be either qualitative multi-method or quantitative multi-methods and can be utilized to avoid mixing qualitative and quantitative methods (Saunders, 2007; Creswell and Clark, 2017). The mixed methods are a combination of both quantitative and qualitative in the research design as it is needed and the more methods utilized the more complex the design of the research (Van Griensven, et al 2014; Creswell and Clark, 2017).

4.2.7 Time Horizons

Time Horizons is the time period which the research examines, whether it is a cross-sectional – examination of a phenomenon over at a particular time and typically involve studies conducted over s short period of times for example case studies that are based on interviews were the information is required for a small amount of time (Yin, 2003; Saunders et al., 2007). Longitudinal – examining the progression of phenomenon over a number of years, it can be easily imagined like a diary examining a change over a long period of time (Bouma and Atkinson, 1995).

4.2.8 Techniques and procedures

As a final stage of the research design selecting the techniques and procedures is inherently based on the research methodology. These techniques and procedures reflect the importance of establishing the credibility of the research (Noble and Smith, 2015; Leung, 2015). Reliability maintains that your data collection and analysis will remain consistent. The threats to the reliability are subject or participant error – based on participant perceptions; the subject and participant bias – that may affect the truth of the information given; observer error and; observer bias (Robson, 2002; Noble and

Smith 2015; Leung, 2015). Other things to consider are the validity – history, testing, instrumentation, mortality, maturation, ambiguity about casual direction; generalisability; logic leaps and false assumptions – identification of the research population, data collection, data interpretation and the development of conclusions (Saunders et al., 2008; Noble and Smith, 2015). Techniques are categorized in secondary data collection or primary data collection namely through observations, interviewees, questionnaires or sampling (Saunders et al., 2008; Noble and Smith, 2015; Institut Numerique, 2012).

4.3 Types of Research data

The structure of the data collection and analysis is therefore based on the design of the research. The type of research data selected is then able to achieve the goal of the research and verify its validity (Creswell and Creswell, 2017; Noble and Smith, 2015). It is imperative to conduct sound data collection as no amount of analysis can "make up for improperly collected data" (Tongco, 2007). Research data is largely categorized into qualitative and quantitative data and the methodology of data collection and analysis is dependent on the research data type (Noble and Smith, 2015).

4.3.1 Qualitative Data Collection

Qualitative research involves conversing with the subject to obtain information (Silverman, 2016; Flick, 2018) and is utilized in social sciences to understand population or people dynamics (Jackson et al., 2007; Rew and Sapp, 1993). It allows for the context analysis of text data or information for the purposes of research. Context analysis in qualitative research refers to the breaking down of data into sections that can be coded to establish patterns in the data set whereas conservation analysis examines the social use of language and the factors that contribute to the way people speak in different settings (Jackson, et al 2007; Flick, 2018).

For the purposes of this research the types of qualitative data collection discussed in detail are questionnaires and interviews (Krosnick, 2018; Adams and Cox, 2008). Questionnaires obtain information for the researcher but involves the completion of the information by the subject and therefore the structure of the questionnaire must consider the ability of the reader to understand interpret and answer correctly (Adams and Cox, 2008; Patten, 2016, Rew and Sapp, 1993). The size, number of questions and the way the questions are stated have a direct impact on how the subjects will respond and determine whether the information received achieves the goal of the research (Hair and Wolfinbarger, 2015; Krosnick, 2018; Patten, 2016). Questions can be categorised as simple factual- requiring yes/no responses; complex factual – requiring interpretation or analysis; opinion and attitudinal – requiring more concentration; and open ended – requiring full concentration to answer the question (Hair and Wolfinbarger, 2015; Krosnick, 2018). Questionnaire design also requires the researcher to establish validity and reliability. Validity addresses the ability to measure what the tool is supposed to measure, and reliability addresses the consistency of the measurement (Hair and Wolfinbarger, 2015; Krosnick, 2018).

Interviews is the form of data collection where the researcher participates in facilitating the discussion to receive the information from the subject (Silverman, 2016; King et al., 2018). Being able to share the purposes of the study is beneficial for the subject's cooperation and provides the background for the research. Using the proper techniques in interviews ensures that the right information is collected, provides the framework for better quality research and lends credibility to the findings (Silverman, 2016). Interviews are categorized by the amount of control the researcher has during the data collection stage (Silverman, 2016; King et al., 2018). For the unstructured interview the researcher develops a general guideline but has minimal control over the flow of the discussion and the respondent is able to have a free flow of information (Silverman, 2016). Semi-structured interview has questions and topics that must be covered but the interviewer retains some flexibility in when these topics are discussed during the interview. The structured interview occurs when the questions are fixed and asked in a certain way and it resembles a survey being asked out loud. Interviews can be conducted alone or with focus groups (Silverman, 2016; King et al., 2018).

Ensuring the validity of qualitative data collection requires the utilization of sampling. Sampling is an essential to qualitative research is the gathering of information an analysing to ensure that data is a valid representation (Etikan et al., 2016; Bell et al., 2018). Sampling allows for smaller group of subjects that are representative of the larger group. A sample size is then used to make the research more concrete by being able to analyse a size that is manageable but representative of the larger group. Representation is determined based on a ratio of the larger group (Bell et al., 2018; Flick, 2018). In order to determine the correct sampling size, the researcher must consider the many sites and the subjects and ensure that the reliability of the research conducted. There are two types of sampling convenience sampling – where members of the target population that meet certain criteria and easily accessible to the researcher; and purposive sampling which is the selection of a participant based on the qualities the participant possess and are sought out based on their direct contribution to the research (Etikan et al., 2016; Bell et al., 2018). Types of purposive sampling involves maximum variation- looking at the subject from all angles including the varying types of candidates; homogenous- candidates with similar, precise characteristics that related directly to the study; typical case – selection of candidates with that are considered a standard for the study; extreme/deviant - selection of candidates that are unusual for the study to highlight 'the worst case scenario'; critical case- selection of candidates based on critical cases to determine likelihood of occurrence, total populations – selection of the total population that met the criteria of the study and expert – calls for the selection of experts in a particular field and used to help investigate new areas of research (Etikan et al., 2016; Bell et al., 2018). When sampling it is necessary for the researcher to determine whether the research design requires a cross section of participants or a targeted group of people directly relevant to the research (Etikan et al., 2016; Flick, 2018).

4.3.2 Analysing Qualitative research

As qualitative data is a reflection of human interactions analysing the data is not a straight forward process of analysing numbers it involves a dynamic process (Basit, 2003; Popay et al., 1998). The real objective of analysing qualitative data is for the researcher to determine the assumptions that determine the respondents view. Determining that comes through a method of coding which is the establishing of links between the data itself and the concepts and ideas behind the data (Basit, 2003; Bilken, 1982). Coding essentially implores two analytic processes – the first pertains to making comparisons while the other pertains to asking questions (Dey, 1993; Coffey and Atkinson, 1996; Basit, 2003). Analysing qualitative data is a process that occurs through the life of the research and coding practices allow for the researcher to be cognisant of the themes that could explain the phenomena of the research (Basit, 2003). Developing themes as a way to understand the data is what make coding analysis useful in qualitative research (Basit, 2003).

4.3.3 Quantitative Research

Data in quantitative research is usually arranged in the form of numbers and statistics (Babbie and Benaquisto 2010; Hopkins, 2008). When conducting quantitative analysis, it is important to follow these steps "explain the data collected, report unanticipated events, explain your techniques, describe the assumptions, avoid inferring causality, use tables to provide exact values, always tell the reader what to look at in tables" (Babbie and Benaquisto 2010; Hopkins 2008). Utilizing these methods allows for the validity of the data. The four types of quantitative research methods are descriptive design, correlational design, quasi-experimental design, experimental design (Babbie and Benaquisto 2010). Descriptive design allows for the researcher to develop a hypothesis once the date is collected and is typically observational. Correlational design explores the relationship of variable through statistical analysis but does not highlight cause and effect (Babbie and Benaquisto 2010; Hopkins, 2008). Quasi-experimental is to establish cause and effect of two or more variable; in this case the independent variable is not being manipulated.

Experimental design examines the cause and effect relationship with manipulation of the independent variable (Babbie and Benaquisto 2010; Hopkins, 2008).

4.3.4 Analyzing Quantitative research

In order to analyse quantitative data, the data collected must be organized to in an understandable fashion then the researcher can determine whether to use descriptive statistics or inferential statistics (Blake, 2003; Bryman and Cramer 1994). Common forms of descriptive statistics are percentage – values as a part of a whole, frequencies- the count for the number of times a value is found in a data set; mean- numerical average; median- numerical midpoint; mode – common score for value, minimum and maximum – highest and lowest (Bernard et al., 2016). Inferential statistics allows for the further examination of the relationships between the quantitative data; particularly if the researcher is looking for significant differences between groups (Bernard et al., 2016). Inferential analysis can be univariate – one variable; bivariate – two variables; multivariate – multiple variables (Bryman and Cramer, 1994; Cramer, 2003; Creswell, 2002). Correlation is determining the relationship between two variables the determination does not highlight causation but can show strong, negative, positive, weak and statistically significant (Suen and Ary, 2014; Creswell, 2002; Cramer, 2003). The Analysis of Variance (ANOVA) determines whether the means of two sample groups is significant but does not indicate why (Bryman and Cramer, 1994; Suen and Ary, 2014). Regression is used to determine whether one variable is a predictor of another. T-test determines whether the difference of averages between two sample groups are significant (Blake, 2003; Bryman and Cramer, 1994). Pearson's chi-square also known as the test of independence allows the researcher to determine the relationship by comparing the observed patterns against the expected patterns if the variables where independent of each other (Creswell, 2002; Suen and Ary, 2014; Blake, 2003). Cross tabulation is used to understand the relationship between variables to determine trends and probabilities (Cramer 2003)

4.3.5 Mixed Methods Research

Mixed methods approach is the incorporation of qualitative and quantitative research methods in a single study (Creswell, 2002; Creswell and Clark, 2011). Mixed methods approach can be incorporated in a number of ways. The convergent parallel design allows for the collection of quantitative and qualitative data at the same time and prioritizing the methods equally, the data is analysed independently, and the results are converged in the interpretation of the data (Creswell, 2002; Walliman, 2017; Rucks-Ahidiana and Bierbaum, 2015). This type of design looks at the relationship between the two forms of data and the analysis is presented to determine the correlation between the forms of data.

Explanatory Sequential design is a two-phased design where the collection of data occurs at two different periods of time allowing for the qualitative data collection to rely on the qualitative results (Creswell, 2002; Walliman, 2017). When the quantitative data is analysed then the qualitative study is developed based on the analysis from the quantitative study. The qualitative study is therefore designed to further examine the results of the quantitative analysis. The qualitative analysis provides detailed explanation of the quantitative results (Cresewell, 2017).

Exploratory Sequential Design is the use of the qualitative analysis to establish the quantitative study (Creswell, 2017). The qualitative data is collected and analyse then the quantitative study is developed based on the results (Creswell, 2017; Walliman, 2017). The quantitative analysis is then utilized to test the validity of the qualitative results.

Embedded design implies that a single data set is not enough and allows for the collection of different types of data to answer different research questions (Creswell, 2017). There is no sequential order of the data collection and data sets may occur at the same time or at different times during the study (Creswell, 2002). It allows for a quantitative data collection within qualitative procedure and vice versa.

Transformative design highlights more the content than the methodology and is used to address social justice concerns namely to address underrepresented and marginalized populations (Creswell, 2017). It is more associated with feminist theory; racial and ethnic theory and it is possible to implement any of the other mixed methods within this design.

Multiphase design also goes beyond the basic designs it is combination of concurrent and sequential aspects of the other designs (Creswell, 2002; Walliman, 2017). It is typically used in multiyear projects as it has multiple stages, at each stage you can use a different design of project (Creswell, 2002). Single mixed methods studies can combine concurrent phases.

The design of a research endeavour is based on the information that the research is trying to obtain however research requires the forethought of the information trying to be obtained (Gunder, 2016). The development of a theoretically sound spatial assessment for use in practical planning applications is at the heart of this research. It is considered that planners and those in the field of urban planning do not need theory but use theory as a front to justify the decisions made as a pretense (Allmendinger, 2017). However, consideration must be given to the inherent problem between the two in the context that theory cannot be tested outside of the influence from society. Providing a theoretical test for an idea that has been developed by society can be difficult if not impossible as society has a tendency towards shifting values, actions and meanings. Therefore, the natural sciences cannot completely separate themselves from influence of societal norms and the subjects that are studying (Allmendinger, 2017; Grant, 2004). Theory in social science research requires recognition that theory itself is a social construct and rejects the ideal that there is an absolute truth. As such social science theory is a search for knowledge rather than an explanation and prediction of what we must accept (Allmendinger, 2017). Considering the theories covered in this chapter, the SACPA approach is a new contribution to research as it utilizes a philosophy and research design that addresses the disconnect between planning theory and practice.

4.4 SACPA approach

The SACPA is a novel approach developed by the researcher to address to address the exclusion of spatial considerations in protected area assessments. Integration of an open science, spatial evaluation through this approach supports the decision making towards improved management and disaster risk reduction. This approach can be integrated in the existing frameworks or stand alone.

This approach fills the gaps of current assessments through a spatial change evaluation with emphasis on community engagement. For this reason, SACPA includes coproduction as discussed in the literature review chapter and highlights the participatory approach through open-source planning support systems. The explanatory sequential design of the methodology is based on the initial collection of quantitative data to provide a measurement of encroachment over a period of time and a subsequent qualitative collection of interviews to provide an explanation based on the community's perspective. These aspects of the approach are the novel contribution to research in the field of protected area adaptation.

The SACPA tool was developed and tested to ascertain the factors that foster persistent human encroachment within coastal protected areas and increases the population's risks to disasters. This raises even more concerns about these unregulated development practices and their impact on adaptation within coastal ecosystems (Erwin, 2009). The implications of poor land management in fragile coastal zones are not only in terms of environmental issues but have a major negative impact on the local communities' wellbeing and quality of life (Adger etl.al, 2009). Healthy wetlands therefore support resilient coastal communities (Ramsar, 2017) as the degradation of ecosystems services increases natural disasters (Monty et al., 2016). An exploration of the interaction of protected areas and buffering communities is also important in determining management effectiveness (Stoll-Kleemann, 2010). A community may be reliant on the resources of the protected area and therefore will not support exclusion from access to these resources. Therefore, assessments need to emphasize an awareness of the socio-economic conditions, governance and equitable management (Moreaux, et al., 2018).

The details of this research design and the structure of the approach follows, it also outlines that steps required to conduct the assessment. These steps are written in a clear manner to allow for PAPs to be able to conduct the assessment with minimal training. Specific training activities are discussed further in the Conclusions chapter.

Developing a targeted research approach not only provides a systematic way to approach a research problem but also provides the researcher an opportunity to develop the procedure for getting all the relevant data (Rajasekar, etal 2006). Although research requires the collection of information, it is important to ensure that research collects data with an expected end. According to Ghauri and Gronhaug, (2005) research methods should include different forms of methods namely understanding, describing, criticizing, explaining and analyzing.

As a result, the researcher should be able to answer some very direct questions to have an improved cognizance of the structure of the research. This will allow the researcher to obtain the required information to complete the research. It guides the formulation of the research approach. Developing this research required a systematic process in obtaining knowledge on the nature of research, formulating and clarifying the research topic, critically reviewing the literature, gaining insight on research philosophies and approaches, formulating the research design, negotiating access and research ethics, data collection, analysis of data and dissemination of the report.

Based on the aim of this research the interpretive paradigm was selected to provide value for all the subjects, that is members of the communities as contributors to the research. As this research is meant to improve the way PAPs utilize theoretical approaches in collecting and analyzing data, there must accommodation for comprehending the community's context of space and its functions. The stance in this occasion does not lend itself to research that is not accountable to the perspective of its subjects. Knowledge is inherently a collective experience and therefore the obtaining of knowledge in this research occurred through a multi-method use of gathering information.

This research design also lends itself to abductive approaches as to not limit the collection and analysis of data as discussed in the Research Methodology chapter. Abductive approaches provides the flexibility to utilize both the tenants of deductive and inductive approaches where necessary. In terms of the most effective approach for this research design, multi-method approach is appropriate as it falls within the interpretivism stance. This research's design is outlined in Figure 4-4.

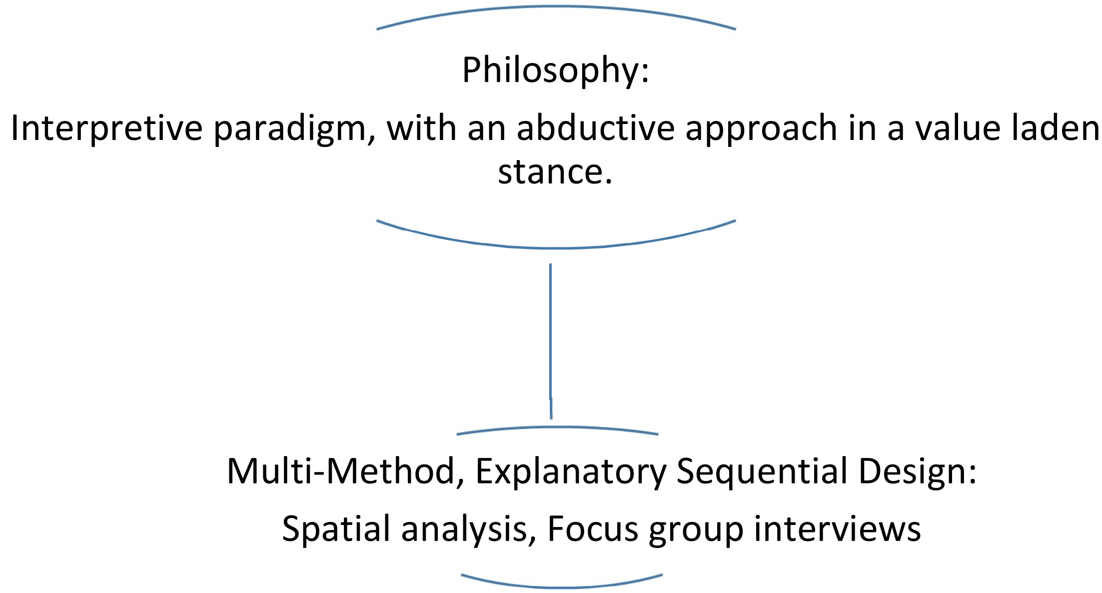


Figure 4-4: Philosophy and design (created by author)

4.4.1 Explanatory Sequential Design

Explanatory sequential design requires quantitative data to be collected and analyze then qualitative data collection and analysis to support the information discovered in the quantitative analysis. This design considers that spatial patterns are result of social phenomenon (Verburg et al., 2011). The data collection and analysis would therefore utilize an explanatory approach to ensure the objectives of the research are verified (Baxter and Jack, 2008). Figure 4-5 outlines how each method would be utilized in the research.

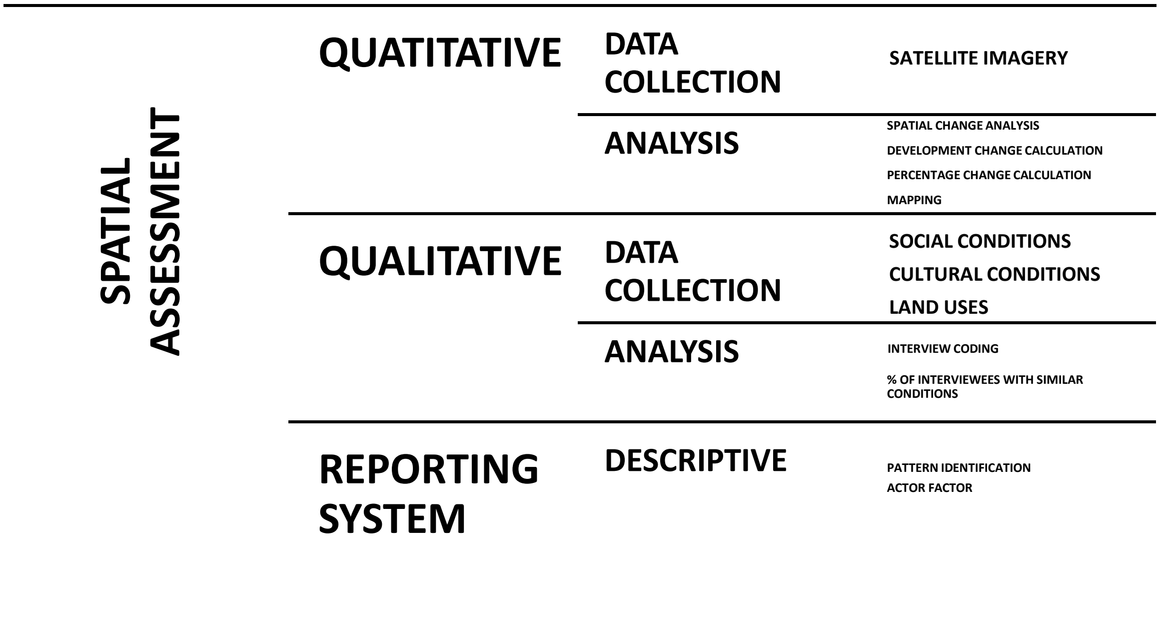


Figure 4-5: SACPA approach (created by author)

The quantitative data is collected via open-sourced, spatial analysis software. Utilizing open-sourced software ensures accessibility to all levels of society as this approach is meant to reduce the need for highly technical staff in the process. SACPA can be completed by staff at the protected area management agency or community residents. The open science aspect of the approach is established through data can be collected and analysed utilizing open-sourced software (Fecher and Friesike, 2014). The quantitative data is analyzed to determine development change calculation, percentage change and mapping. This analysis then determines the development of the interview questions to further explain the results. The qualitative data is coded to determine the percentage of interviewees that share similar social conditions. The reporting stage is a descriptive identification of patterns and the factors that play a role in protected areas. Multiple case studies in Trinidad and Tobago and Belize establishes external validity (Yin 1994). The units of analysis will be the **spatial change in coastal protected areas.**

Although the delivery of the approach is non-academically inclined the structure of the approach is theoretically sound. In this research the tool is being used for an assessment of Ramsar Sites in this research but it can be used to conduct spatial evaluations for other protected areas.

4.4.1.1 Quantitative data collection and analysis

The spatial data needed for this research utilizes maps via satellite imagery. The collection of this data through Google Earth was imperative because open sourced software is user friendly and promote usability. Spatial research process typically utilize GIS based programs that require technical proficiency, however in this design the use open sourced planning support systems intentionally support the inclusion PAPs and community members in data collection and analysis. Google Earth is widely used and easier to navigate for those with limited knowledge on spatial data collection and analysis

Data source	Spatial resolution	Spatial extent	Temporal resolution	Temporal extent	Thematic properties
Remote sensing/ Aerial photography	Dependent on sensor (remote sensing mostly between 0.6 m and 1 km)	Dependent on sensor. Coverage is limited in case of clouds (not for radar)	Frequent depending on sensor/satellite	Depending on launching and life time of sensor. Few remote sensing data are available before 1970s except for aerial photographs	Land cover classes. Classification is based on sensor characteristics and user preferences
Census/ survey data	Administrative units	Often national level	Infrequent depending on census, often less than every 10 years	Country specific depending on statistical system	Focus on economic sectors (mostly agriculture and forestry)
Land-use maps based on field survey	Dependent on scale of mapping (often between 1:25 000 and 1:1 million	Varying	Often made for 1 year only	–	Varying and fixed within a specific map
Participatory maps	Dependent on scale of mapping	Often restricted to territory of one or more communities	For one moment only	Participatory back casting possible	Depending on purpose of mapping
Cadastral information	Precise information at property level	Dependent on cadastral system	Continuously updated	Often available for long time period	Limited to tenure conditions with limited information about land use, especially in urban environments

Figure 4-6: Spatial data sources (Verburg et al.,2011)

(Verburg et al., 2011). Essentially the use of a spatial evaluation was to determine the spatial threats to the size and how the spatial differences can impact effectiveness.

As Figure 4-6 highlights the different data sources that were not selected based on the thematic properties that were not applicable to this research (Verburg et al., 2011). Remote sensing was not applicable because the spatial extent is limited in the case of clouds and the thematic properties of land cover classes are not based on social conditions but based on sensor characteristics and use preferences. For example, it can provide information on the whether a building is multi-story, but it will not be able to identify whether the building is single-use of multi-use without the support of a social survey (Verburg et al., 2011). Census/survey data is not applicable because the information is taken over a 10-year period in the Caribbean and a number of political changes occur during that time period that have an impact on spatial conditions (Verburg et al., 2011). Land use maps based on field surveys and participatory maps are only applicable at certain scales and rarely ever are used to engage communities to indicate losses to protected areas (Verburg et al., 2011). These are mostly used to identify areas of interest which would then require further spatial analysis to understand the extent of the land use change. Although precise cadastral information is limited to tenure conditions which is not applicable to encroaching development in protected areas which is not based on tenure but based on informal arrangements of settlement (Verburg et al., 2011).

4.4.1.1.1 Quantitative data collection – Spatial maps

Based on the explanatory sequential design, the spatial data collection and analysis is conducted first in this research. The spatial analysis involves land use/land cover analysis to conduct a spatial analysis. Google Earth was selected based on the its capability to conduct. This analysis is obtained through a comparison of imagery from Google Earth over a 13-year period from 2003-2016. Based on the explanatory sequential research design, this analysis was conducted in 2016. The analysis sought to understand developmental patterns at the community-scale in the midst of adaptation. When completed this information will give the community an idea of the trends in development and the shape of their community. The quantitative data collection provided a spatial measurement of encroachment.

4.4.2.1.2 Satellite Imagery Analysis

A longer time scales were determined because annual time steps in calculations hamper linkages with the actual decision making that can take a longer time to take route (Verburg et al., 2002). Namely in political decisions that are made and take a few years to be implemented or the changes in political regimes that hamper the continuity of environmentally friendly policies.

The Google Earth Pro interface was utilized for this spatial analysis based on its open source access to the public and it does not require technical training to use. The features of a timeline search and the georeferenced determination of the acreage of a space (Figure 4-7). These elements of Google Earth Pro are the basis of the spatial

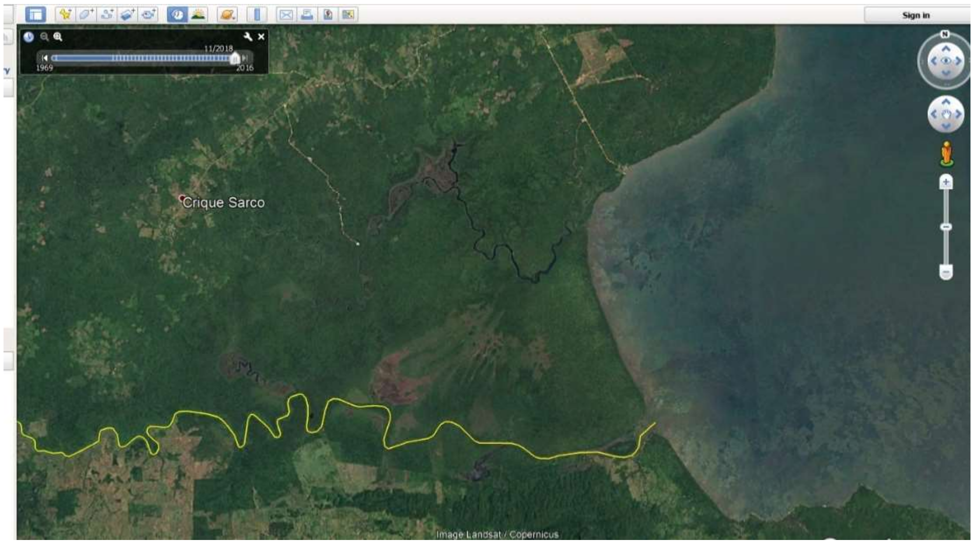


Figure 4-7: Timeline feature of Google Earth (Google Earth, 2016)

analysis for this assessment. To determine the selection of the satellite imagery the historic imagery tool was utilized. Imagery is available for over a 30-year period, but for the purposes of this study imagery was used for a 13-year period of 2003-2016.

After the desired year was selected the ruler tool was selected to sketch the size of developed area during that year of the satellite image (Figure 4-8). This tool allows for the use of a polygon feature to sketch shapes along with the physical features. The feature also provides measurements of the sketched polygon. After the size of the sketched polygons were determined, the information was then transferred to an excel document for calculation and analysis.

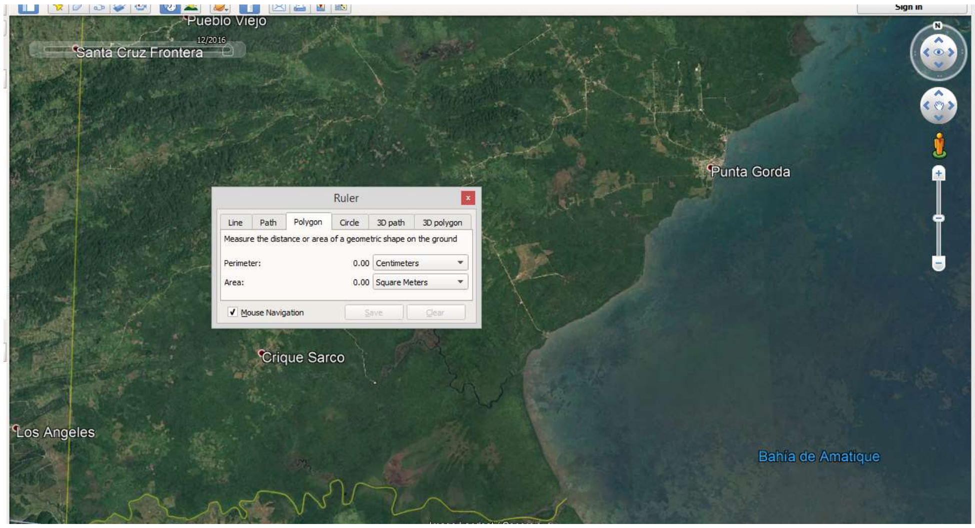


Figure 4-8: Measurement feature of Google Earth (Google Earth, 2016)

Based on the size of the protected area the image viewing settings were precise enough to distinguish between built areas and natural infrastructure. For the most appropriate viewing the eye altitude setting was set between two kilometres to forty kilometres above the surface.

4.4.2.1.3 Encroachment Rate Calculation

Determining the trends of encroachment utilizes the formula for calculating growth rates in planning analysis (Parker, 2002) and provides visual, quantitative analysis of the rate of development in case study locations. The formula determines the percent change from one period to a next and annual percentage growth rate. Figure 4-9 and 4-10 highlights the calculation percentage rate of a period of time by a calculation of present value minus past value over past value. That final figure is multiplied by 100. When calculated these figures will give communities a better idea of

$$PR = \frac{(V_{Present} - V_{Past})}{V_{Past}} x 100$$

PR = Percent Rate
$V_{Present}$ = Present or Future Value
V_{Past} = Past or Present Value

Figure 4-9: Formula for percent change (Parker, 2002) how rapid they are expanding. To then calculate the annual percentage growth, the inclusion of the time into the above formula in the form of N. N then symbols the number of years in the period of time being examined. The use of these calculations provides evidence of maladaptation in Caribbean coastal settings.

For the purposes of this research the calculations were completed in Excel based on the accessibility of the software program and east to conduct analysis of higher sums of information in a short period of time. The above formulas were inserted in Excel with the information obtained from the Google Earth. The calculations determine the distance of the development to the nearest water course and overall size of development over the 13-year period. The percentage growth rate and the distance in kilometres were determined. Based on the yearly growth rate of the distance of the development is from the river, the time for development to reach the nearest water course was also determined (Figure 4-11). This calculation was included to signify when the human encroachment directly intersects the water course.

$$PR = \frac{(V_{present} - V_{past})}{V_{past}} \text{ X } 100$$

tage change

Length of time to reach the water	
2017	0.0922
2018	0.0762
2019	0.0602
2020	0.0442
2021	0.0282
2022	0.0122
2023	-0.0038
2024	-0.0198
2025	-0.0358
2026	-0.0518
2027	-0.0678
2028	-0.0838
2029	-0.0998
2030	-0.1158
2031	-0.1318
2032	-0.1478
2033	-0.1638
2034	-0.1798
2035	-0.1958

Figure 4-11: Calculations on "time to reach the river" (created by author)

4.4.1.2 Qualitative data collection and analysis

The questionnaire was developed to give an explanatory perspective on the conditions revealed in the quantitative analysis. The questions were structured with multiple types of questions to not make the experience monotonous for interviewees. Each interviewee was assigned an alphanumeric number to keep their information confidential. At the beginning of the interview an introduction of the study was discussed, and the rights of the interviewee was reviewed.

The first section reviewed questions on the vulnerability of the built environment of the community. The questions ask whether the interviewee lives or work in the buffering community; the age of the property they reside/work in; how long the interviewee has worked there. The following questions revealed whether the property is prone to flooding; whether there has been damage to the property as a result of floods and whether the larger community is prone to flooding. This information was meant to determine whether the houses in the buffering community were built in a manner that increases the vulnerability of the residents and reduces the capability of the protected area to continue natural processes (See Appendix One).

The questions are then focused on describing the built environment of the community with the questions on the materials of houses and buildings in the community; whether the structures are single story or multiple story; if they are built at grade of elevated; the overall age of development in the community and how much of each property has a pervious surface. This information is meant to further understand the development trends in the community has an impact on the vulnerability of the community residents (See Appendix One).

The coastal zone questions are focused on establishing certain conditions in the coastal zone. The questions look at unearthing whether the interviewee is aware that they live in a coastal zone, swamp, flood zone, mangrove, river basin or lagoon. An identification of the most significant industry in that community; if they are aware of any planning regulations in the community; and whether the development in the buffering community has grown in the last 5 years with an indication of how much it has grown. This is to determine despite the protected area designation whether planning regulations are enforced to restrict development (See Appendix One).

The final group of questions look at the implementation of adaptation practices. The questions include how flooding have been addressed; are there any open parks or spaces in the community; whether the interviewee is aware of ways to protect property from flooding and whether under the threat of flooding during every rainy season whether the interviewee would prefer to move or to find solutions to alleviate the flooding. This examines whether flooding is addressed at an individual level or at the community level. It also takes a detailed examination at whether retreating adaptation options discussed in the literature review are a viable option. It is labelled toolkit section as at the moment this research was conducted a toolkit was developed as a part of the future work. The structure of this questionnaire is available in Appendix One.

4.4.2.2.1 Interviews

The targeted community stakeholders included associations of the industries operating case study areas to gauge their knowledge of climate change and the built environment. These interviews included stakeholders from agriculture, manufacturing and import/export; municipal corporations namely all key stakeholders engaged in the built environment form. Sampling for the interviews were based on the purposive sampling as the participants were selected based on their proximity to the protected areas.

They were selected based on whether they live or work near the protected areas discussed in the previous chapter.

Although the questionnaire was structured the questions were framed to avoid assumptions regarding what the community knows about adaptation but to assess it on a whole. These were conducted through an interview system to as it is a beneficial way to get information from community members. Although interviews were originally planned to be done in a group setting during the initial set up of group interviews it was suggested that sufficient information will not be shared for the study as individuals are not inclined to be truthful in group settings. As the study depends on people truthful expressing their thoughts on their conditions providing a judgement free method to share their feelings was important. So, the delivery system was adjusted to conduct single interviews with respondents. Those interviews were delivered in person, over the phone and through online surveys. These adjustments were made to ensure that respondents were comfortable in their environments to provide the right amount for the study. Ethical approval for the questionnaire was received in the first quarter of 2017 and the interviews were conducted that year. A completed interview questionnaire is included in Appendix Two to reflect the notes of the interview were written and provide the background needed for the building of codes.

4.4.2.2.2 Coding

A consideration in the gathering information is the existence of ecological validity - way the researcher structures the research and conducts their questioning has an impact on the responses received in the interview (Hammersley and Atkinson, 1983). The structure of the interviews and the types of questions would have an impact on the respondents and also lends to the challenge of the interpreting correctly what the respondents portrayed in their responses. Although this style of disseminating data is typically used with anthropologists, it is applicable in this study because of discussion around the contribution of anthropogenic forces that impact the changes on the climate and natural habitats (Marcus, 1986).

Throughout the analysis stage of the project researchers try to get a deeper awareness of their study area and constantly refine their interpretations (Basit, 2003). "The object of analysing qualitative data is to determine the categories, relationships and assumptions that inform the respondents' view of the world in general and of the topic in particular" (McCracken, 1988). This research involved the coding of interview results to uncover the prominent themes in each case study site and for this research the qualitative coding outlined by J. Saldana (2015) is utilized. The interview questions were structured around pre-set codes as the questions are largely multiple choice the pre-set codes are already determined as the answers (Saldana, 2015). During the interview the respondents were asked additional questions for clarification and any emerging codes were obtained then. The coding was organized by two categories-built environment vulnerability and coastal zone adaptation, all codes are then aligned with either category as shown in Figure 4-12. Under the theme of knowledge of wetlands were the categories of what is it with the codes of coastal zone, flood zone, swamp, mangrove and river basin. There is also the category of wetland clearing with the codes of less than 25%, 25-50% and 75%-100%. Under the built environment vulnerability were the categories of flooding occurrence with every time it rains, and heavy rains. The category of housing stock were the codes of wood, concrete, corrugated metal. The category of infrastructure has no codes as it is a straightforward consideration of roads in Caribbean settings. The category of land use had the code residential, commercial, mixed use and industrial. Under the theme of coastal zone adaptation were the categories of hold the line or retreat.

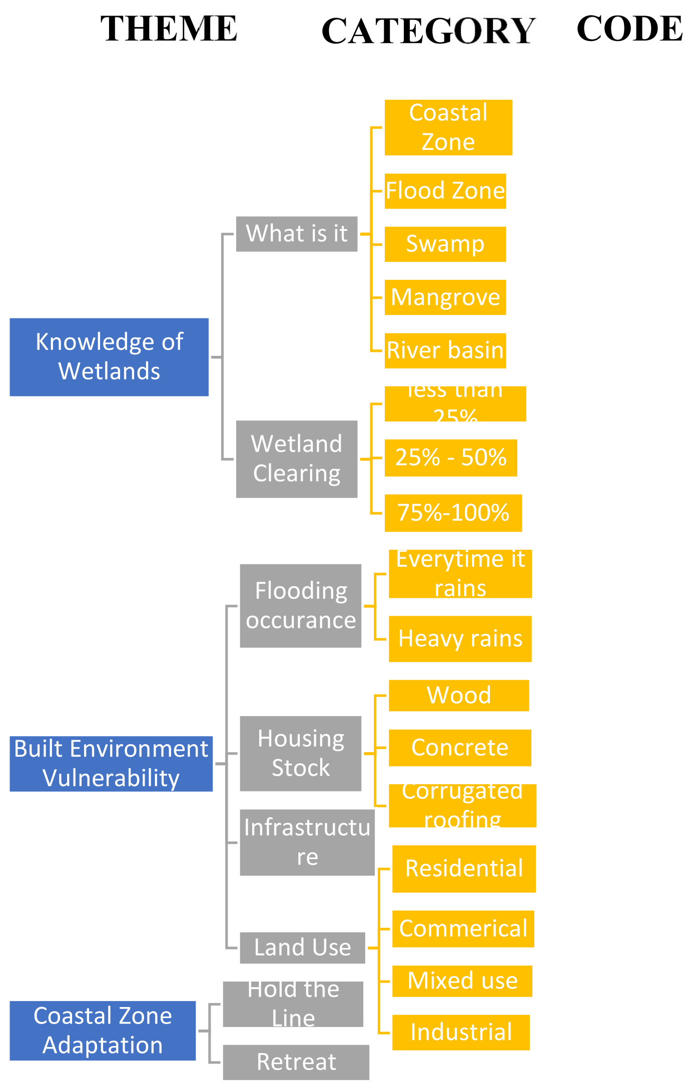


Figure 4-12: Example of coding for this research (created by author)

To better identify the patterns each code is given a numerical value and those values are counted. The higher the frequency of the code, the higher priority it is given to the problem. Emerging codes will be developed as the interviews progress (Saldana, 2015). After the interviews were conducted the coded data was then inserted into an Excel sheet for analysis. To further test the validity of the data a T-test was conducted.

4.4.2.2.3 Reporting

The spatial assessment involved an analysis of land use/land cover; settlement patterns; infrastructure conditions; housing stock; rate of encroachment; environmental conservation; flooding vulnerability; flood mitigation; integrated coastal zone management and community awareness. The outcome was a combination spatial analysis and coded interviews to provide a comprehensive evaluation of community conditions.

With the collection of varying forms of data there was no rating system as a result of this analysis; rating systems are of little benefit when they are given an overall scale. Rating systems do not always provide opportunities for a full comprehension of conditions whereas descriptive reports can account for information excluded in the rating system. As a result, the findings of the assessment were better understood through a final report versus a rating system. The findings reviewed the data analysis in the following sections: Ramsar designation; integrated coastal zone management; flooding vulnerability; housing stock; flood adaptation; development patterns and informal settlements; LULC analysis; political conditions; infrastructure conditions; and protected areas. A completed report provides an in-depth view of the social, cultural and political conditions that impact the protected area and the spatial changes in the land as a result.

4.4.1.3 Multiple case studies

It was determined that the validity of the research would be better achieved through the development of a case study approach. Utilizing two locations was important to establish validity of the research as multiple case studies allow for the verification of findings in one case to the findings of another. In this instance, the research wanted to evaluate whether the case study communities' awareness of the adaptation is similar and evaluate the effectiveness in the management of the protected area. Based on the need to conduct a comparative analysis in multiple sites, the use of documents, archival research, spatial analysis and interviews are utilized to support theoretically sound research. The case studies were selected based on their varying geographic conditions, size and demographics.

One of the case study sites is an island in the Southeastern Caribbean, Trinidad and Tobago, the other a mainland country in the Northwestern Caribbean, Belize. The population on the island nation is greater than the population of the mainland country. Although English is the main language in both locations due to the geographic location, the mainland country has a larger indigenous demographic. The existence of coastal Ramsar sites with encroaching buffering communities was central to the selection and subsequent evaluation of these case studies.

Of the Caribbean countries Belize is the only country to acknowledge the importance of risk reduction outlining the importance of the mangroves surrounding its largely populated city but noted that poorly planned causeways have reduced functionality of these wetlands (IUCN, 2016), conversely Trinidad and Tobago did not produce a report to discuss the strategy for ecosystem-based disaster risk reduction.

Belize is the only Caribbean country with an established effectiveness assessment, however it does not comprehensively evaluate spatial fragmentation. Belize was selected to ascertain how a spatial evaluation would support existing effectiveness assessments. Trinidad and Tobago boasts to be the location of the oldest protected reserve as the Tobago Main Ridge Forest Reserve was established on April 13, 1776. However, it does not have an established assessment tool for its protected areas. With such a legacy for protected area designation, Trinidad and Tobago was selected to determine whether the spatial assessment can contribute any inform the effectiveness of their protected areas management. For the stark differences in the adaptation strategies and the aforementioned reasons those two countries were selected as the locations for the research.

Examples of increased development in each of the study locations included the installation of groyne to reduce the impacts of erosion leads to further erosion of the beach 'downwind' causing the further loss of land occurring in the coastal areas of Belize (Belize, 2015); and the filling of a coastal wetlands to reduce the impact of 'flooding' on development that impedes drainage capabilities for coastal areas and causing flooding further inland (Juman and Ramesak, 2012).

Designated coastal protected areas exist in both countries under the Ramsar Convention to foster the designation of protected areas to reduce the loss of these fragile ecosystems (Ramsar, 2017) yet regional inconsistencies in the spatial organization of protected areas increase vulnerabilities to climate related risks. At the regional level the limited opportunities for collaboration between countries also reduce the knowledge exchange between practitioners and coordination of activities. Central to this research is the use of theoretical support to conduct an assessment to be used in a practical application and to encourage the development of research based tools with practical applications in protected areas management.

4.4.1.3.1 Trinidad and Tobago

Trinidad and Tobago is a twin island republic off the coast of Venezuela; Trinidad covers 4,768 km2 and is the larger of the two islands, whereas Tobago covers only 300 km2. In 2010, the population of Trinidad and Tobago was 1.34 million people. The climate is tropical dominated by northeast trade winds and sits on the fringes of the Atlantic Hurricane Belt and apart from is natural ecosystems of tropical forests, freshwater, coastal lagoons and mangroves the country sits above sizable oil and gas reserves (Maharaj, 2014). These reserves have been a significant part of the country's success and notably a hindrance in the economic diversification or national interest in the use of emerging technologies (Office of Disaster Preparedness and Management, 2014).

In 2014 the Central Statistical Office reported coastal zone demographics as follows: 70% of the population resides; 80% of the urbanized land; 80% of industrial activities; 60% of small economic activities; 50% of infrastructure (roads, bridges and ports); 90% of tourist facilities and 90% of annual fish production occurs within the coastal zone (Office of Disaster Preparedness and Management. 2014).

In terms of natural hazards Trinidad and Tobago experiences high levels of flooding as a result of heavy rainfalls, or larger storms of earthquakes. The most significant flooding event in recent years occurred during the early hours of the morning, when heavy rains cause flash flooding the community located at the foothills of the

Northern mountain range, in Diego Martin (Clyne, 2013). Residents were awakened by floodwaters rapidly entering their properties leaving almost 3 feet of water in its wake. The community is known for its cul-de-sacs with multiple dead-end roads, one lane roads. In the case of this emergency it was noted that emergency services were unable to reach residents in need because the only route in was blocked off and the floodwaters rose unexpectedly high in households as the houses in the community are built at grade and are one story (Clyne, 2013). Flooding in this community cause widespread concern about other communities in Trinidad and Tobago that were built in areas prone to natural hazards.

In Trinidad and Tobago, the vulnerability is assessed by identifying the hazards and developing a priority list, in our study area flooding was identified as the largest risk areas and comparatively the impact of risks is high within the community (Maharaj, 2014; Office of Disaster Preparedness and Management, 2014). Critical infrastructure was identified as structures, institutions, networks of communications were identified and although no formal list of critical infrastructure has ever been created an analysis done for this research identified that over 80% of critical infrastructure around the island is located in the coastal zone (Longmann, 2007).

Due to these pressing changes, Trinidad and Tobago developed adaptation strategies centred on data collection, policy development and environmental protection – seen as an integral part of coastal adaptation (Maharaj, 2014). To date, these strategies are mainly focus on building capacity through citizen awareness programming and disaster preparedness policies (Office of Disaster Preparedness and Management, 2014). The work towards adaptation however falls short in the active protection of natural coastal resources, managing coastal development and strengthening the capacity of communities in the coastal areas.

The study area includes Caroni Swamp is a “mangrove forest, herbaceous marsh, interrupted by numerous channels, and brackish and saline lagoons, and with extensive intertidal mudflats on the seaward side” (Bacon, 1987). The benefits of the mangrove forest to address climate change is a result of the roots holding sediments and their ability to handling varying salinity in water ways. The growth of marshes also improves the existence sediments.

4.4.1.3.1.1 Political conditions during that time

Trinidad and Tobago is a unitary state regulated through a parliamentary democracy. It is a multi-party state with two predominate parties along ethnic lines. The majority of Afro-Trinidadians support People’s National Movement and the majority of Indo-Trinidadians support the United National Congress. General elections are held every 5 years. During the study period 3 elections were held where one of the two prevailing parties gained control 2007-PNM; 2010-UNC; 2015-PNM. During that time there were four changes of the ministers with the portfolio of Planning and Development. Under that ministry are the quasi-government authorities in charge of environmental controls. The Environmental Management Authority and the Institute of Marine Affairs. Management activities for marine and coastal areas.

Informal settlements near protected areas are considered to be squatting as land tenure rights are not distributed. Based on national pressure, informal settlements receive electricity infrastructure but there are typically no paved roads in informal settlements.

4.4.1.3.1.2 Integrated Coastal Zone Management

The government of Trinidad and Tobago identified human use and exploitation of marine and coastal resources as creating a negative impact degrading the coastal ecosystems and in response, they developed an Integrated Coastal Zone Management Policy Framework in 2014. The coastal zone was defined as the geographical area that covers the terrestrial and maritime areas of the shore which also applies to wetlands, off-shore islands, salt-water ponds and areas above the high-water mark that influence the make-up and quality of coastal waters and the coastal zone or under the influence is indicated in Figure 4-13.

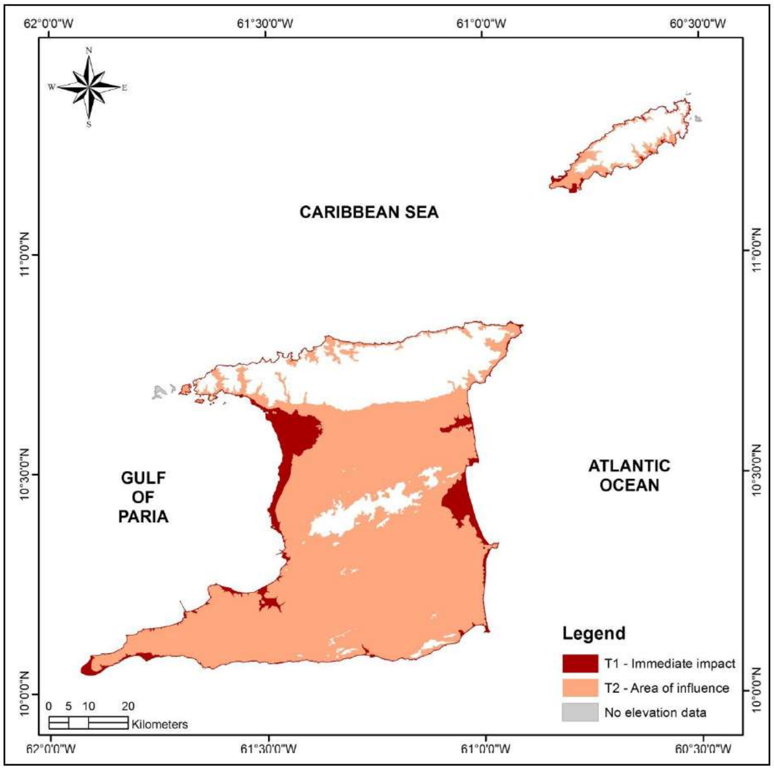


Figure 4-13: Coastal Zone of Trinidad and Tobago (Office of Disaster Preparedness Management, 2014)

Eleven objectives and related strategies were developed to integrate coastal zone management (OPDM, 2014). Objective one to promote a dedicated approach to coastal zone planning and management through efforts like strengthen enforcement and voluntary efforts. Objective two looks at management of development within the coastal zone through the establishment of setback and buffer zones and Marine Spatial Planning for coastal areas. Objective three focuses on poverty alleviation through the coordination of coastal zone planning with economic development strategies. Objective four reduces the risks and hazards to coastal development through vulnerability and risk assessments and coastal zone protection. Objective five promotes continuous research through monitoring and evaluation and funding to assist with these tasks. Objective six identifies partnerships to provide engagement processes with stakeholders. Objective seven encourages the capacity building and public awareness to build coastal zone planning and management. Objective eight maintains the health of the coastal ecosystems by promoting sustainable practices. Objective nine looks at rehabilitation of damaged ecosystems through management of protected areas. Objective ten promotes the reduction of activities that have adverse impact on the coastal zone. Objective eleven looks at steps to completing the international responsibilities. All of these are the strategies towards the development of the management of the coastal zone.

4.4.1.3.1.3 Ramsar designation Information

Figure 4-14: Ramsar designated Caroni Swamp (Longmann, 2007; Google Earth, 2015)

Caroni Swamp (Figure 4-14) is located on the western coast of Trinidad and Tobago and is 8,398.1 ha in size (Ramsar, 2005). The largest river in Trinidad and Tobago, the Caroni River with a catchment area of 600 km^2 drains in the Caroni Swamp. Twelve tributaries from the northern range and six tributaries from the Central plains and mountain range drain into the Caroni River (Phelps, 1997). Ramsar designation was obtained in August of 2005 based on a total of 20 endangered bird species recorded to live within the site (Ramasr, 2005). It was noted in 2005 that the original size of the swamp was reclaimed for seasonal cultivation and it is an economically viable site for oyster and fish harvesting (Ramsar, 2005).

According to the Ramsar information fact sheet for Caroni Swamp, the swamp is utilized for fishing and eco-tourism and supports the agricultural and industrial activity (Gyan and Juman, 2005). Although 8.398 ha is designated only around 38% of the land is nationally considered a Forest Reserve; approximately 23% is state lands while percent of the site is owned while approximately 12% is private land (Gyan and Juman, 2005). The remaining 27% is coastal water and mudflats and uninhabitable (Gyan and Juman, 2005).

Caroni has 336 avarian species, 114 mammalia, 18 amphibians, and 217 marine species. While using the BIOPAMA tool, discussed in the literature review section, there was no available data on the Caroni Swamp but there was available data of other protected areas in Trinidad and Tobago. The inconsistency of available data highlights the gap in monitoring the effectiveness of the Caroni Swamp.

The buffering community to the Caroni Swamp sits to the northeast and is the closest settlement to the Caroni River, the largest tributary running through the Caroni Swamp. Bamboo is sits on the southern end of the San Juan-Laventille regional municipal area in the flood plains of the Caroni Swamp. In the 2010 Census the total population for the entire municipal area was 157, 258 with a population density of 175 people per kilometre squared. Their community is known as haven for informal settlers.

4.4.1.3.2 Belize

Belize is located on the southern half of the Yucatan Peninsula and has a land mass of 22,810 square kilometres. The easterly border of the country abuts the Caribbean Sea while the western edge borders Mexico and Guatemala. The main rivers historically flowed northward but then diverted easterly as the northern part of the country experience slight lifting due to the movement of tectonic plates. The most prominent feature of the mainland Belize is the mountainous south-central region known as the Maya Mountains. Belize also has the largest barrier reef system in the hemisphere and it lies on the edge of a continental shelf 257 km by 15-40 km wide depending on the location. This is area is home to extensive sea grass running from the edge of the reef to the coast where the natural ecosystems include mangroves, wetlands, and lagoons. The zone of influence within the coastal zone was noted as 3km from the coast (Figure 4-15).

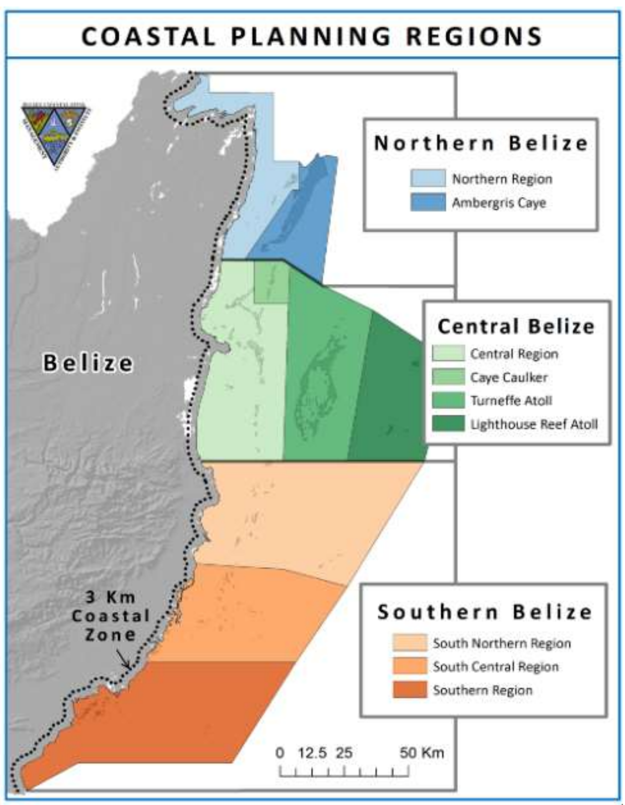


Figure 4-15: Belize's Coastal Zone (CZMAI, 2016)

Belize's population density is relatively low with an average of 380, 000 people nationwide due to increased development in low-lying areas near rivers and the coast. The population is susceptible to the high rainfall events were water courses are inundated caused by flooding. In 2008, a tropical storm flooded several water courses throughout the country but most notable destroyed Kendall Bridge a connection for Southern Highway cutting off access for emergency services for 12% of the population (CZMAI, 2016). In recent times, during the hurricane Earl of 2015 caused flash flooding and high-water levels persisted until a week after the storm. The estimated damage of the hurricane to the country was $100 million and with over 80% flooding in the centre for commercial activity (UNICEF, 2016).

In the Integrated Coastal Zone Management Plan the vulnerability of the coastal zone was determined in an analysis of the sea level rise in different scenarios with projections for multiple options. Within the coastal zone of Belize are a number of varying ecosystems - agricultural, coral reefs, lowland dry forest, lowland moist forest,

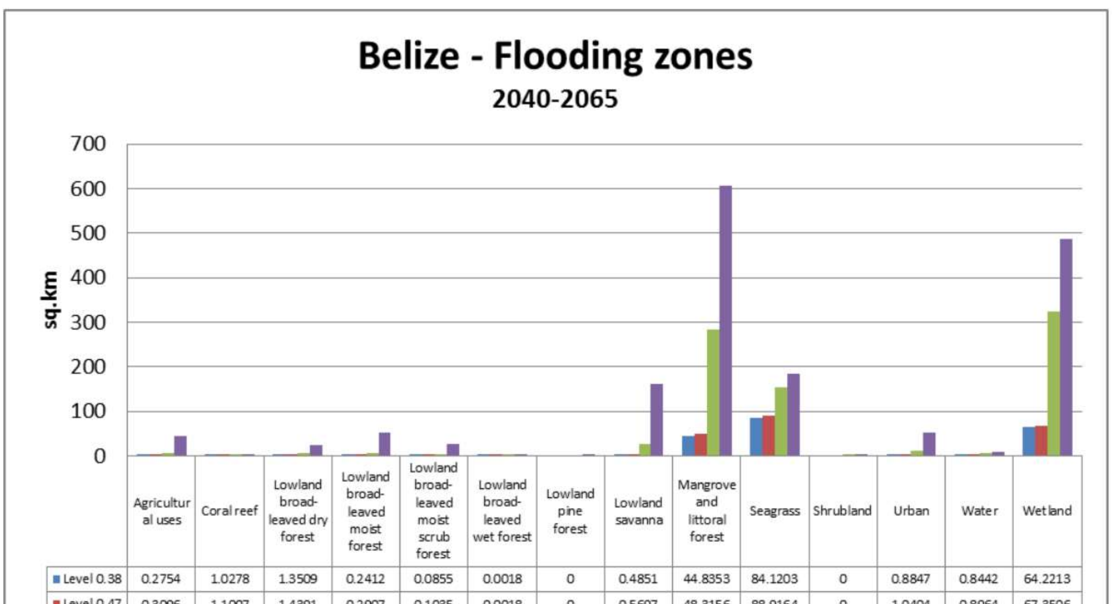


Figure 4-16: Scenarios of coastal flooding in Belize (CZMAI, 2016)

moist scrub forest, wet forest, lowland pine forest, lowland savannah, mangrove and littoral forest, seagrass, shrubland, urban, water and wetlands (CZMAI, 2016). Each scenario is measured through meters and the resulting flooding shows each land use will be impacted by a rise in the sea level (Figure 4-16). These scenarios outlined in the chart under the climate change scenarios the mangroves and wetlands will experience the largest amount of flooding. The flooding of wetlands and mangroves are a part of the natural cycle, but with an increased clearing of the mangroves and wetlands for coastal development there is a heighten risk for human activity in these coastal zones.

Agriculture

It was noted that the impact of climate change to the agricultural sector in Belize further reduces the sustainability of the industry within the country (CZMAI, 2016). Climate change studies have shown that there could be reductions in the yields of sugarcane and citrus (UNICEF, 2016) and citrus is exports account for the highest contributor to the agricultural sector. The seasonal changes have impacted the sector for crops that rely on rainfall for harvest and fostered adjustments in the calendar. These changes impact the way the sector's agricultural practices and including increased irrigation strain on water courses and the use of chemicals to support expected production. On the other hand, strong rainfall events foster an increase of diseases, pests and weeds in yields. In 2012, there was a 20% drop in the yield of all diseases. Heavy rainfall also exacerbates soil drainage and erosion problems particularly in banana crop. Although this crop requires a lot of water, without proper drainage these trees are susceptible to a fungus and controlling the spread of the fungus means that the leaves should be cut off. Cutting off the leaves on the banana trees impact the growth of the fruit. These conditions have a severe impact on the food security of the country, already reliance on the agricultural imports from neighbouring Guatemala and Mexico to support the lower diversity in crop (CZMAI, 2016). To try an address, the climate change impacts the government have engaged on study programs typically funding by international funding institutions to provide stability to the sector through the development of new crop varieties and the provision of weather predictions to farmers in order to provide them with sufficient data to support growing periods (CZMAI, 2016).

The conditions of potable water as a result of climate change are of increased concern to Belize. Namely in the Cayes off shore who already have limited access to the potable water and with the salinization of aquifers, the increase instances of saltwater intrusion and rising water tables. Villages within the river valleys still depend on water from the corresponding water courses and this water is contaminated from agricultural practices upriver. The availability of water throughout the count.

4.4.1.3.2.1 Political Conditions

Belize is a parliamentary representative democratic monarchy based on the Westminster model. Therefore, Queen Elizabeth II is the head of state with the prime minister as the head of government. There is a multi-party system with the People's United Party considered as the left party and the United Democratic Party considered as the right party. General elections are held every 5 years and municipal elections are held every 3 years (CZMAI, 2016). During the study period from 2003-2016 there have been 4 general elections 2003, 2008, 2012 and 2015. During that time the Ministry in charge of protected areas management changed its executive team two times and received increase in the portfolio. Every time an executive staff is changed the he/she is given a year to get a complete handle of the departments under their responsibility (CZMAI, 2016).   Under this ministry is the quasi-governmental agency of Protected Areas Conservation Trust (PACT) that oversees the government's investments in protected areas. Non-governmental agencies are given co-management agreements with this ministry to co-manage protected areas around the country (CZMAI, 2016). The Department of Forestry handles the co-management of terrestrial and coastal protected areas and the Department of Fisheries handles the co-management of marine protected areas. Based on indigenous land rights, communities can live in or near to the boundary line of the protected area based on its national designation (CZMAI, 2016).

4.4.1.3.2.2 Integrated Coastal Management

The coastal zone in Belize is seen as the greatest asset and the Belize Barrier Reef system and it runs along a World Heritage Site and the longest reef system in the Western Hemisphere. The barrier reef is approximately 280km long and supports complex marine ecosystems. In 2016 it is estimated that $350 to $400 million BZD was generated from resource based economic activity within the coastal zone including the industries of tourism, dredging for development and fisheries (CZMAI, 2016). The plan for Belize highlights the need for an integration of current management activities – as each government agency working within the coastal zone conduct their activities independently of each other; identifying management gaps – as current management programs do not provide services to all stakeholders within the coastal zone; resolve conflicts over uses of the coastal zone – where industries and related stakeholders are in conflict over the variety of uses namely the multiple human uses and benefits; ensure a sustainable future – to maintain long term protection of the coastal zone for future generations (CZMAI, 2016).

4.4.1.3.2.3 Ramsar Designation Information

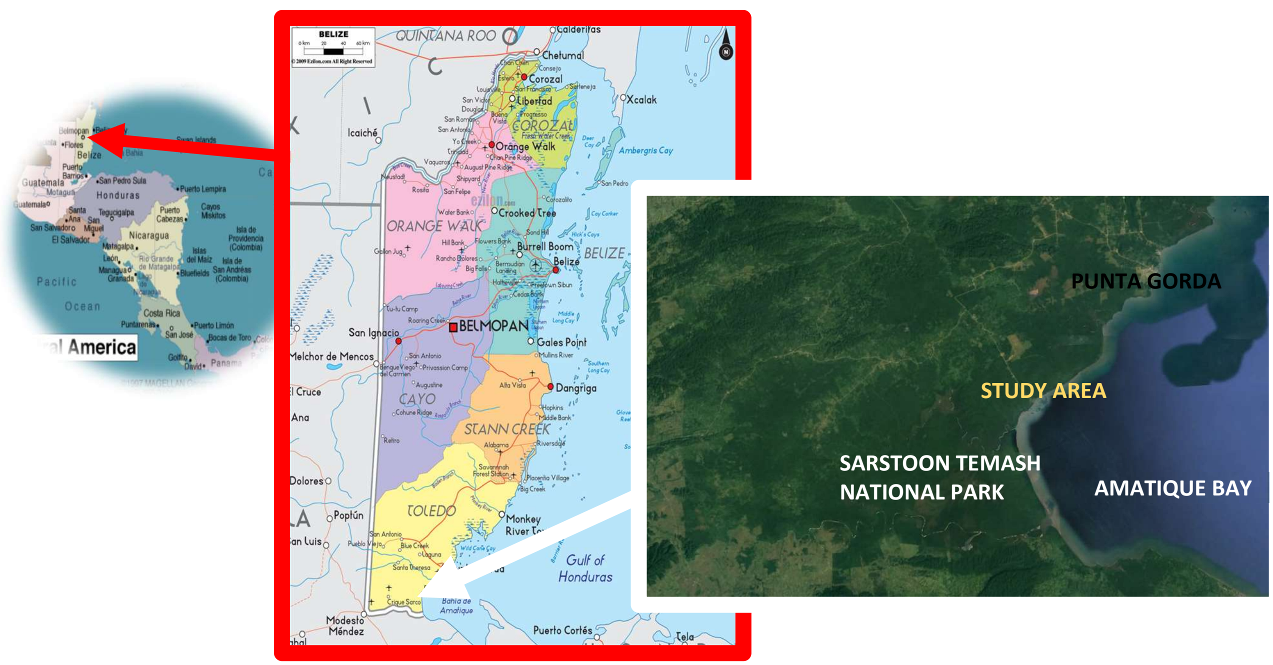


Figure 4-17: Ramsar designated Sarstoon Temaash (Rainforest Realty, 2016; Google Earth, 2016)

As indicated in Figure 4-17 Sarstoon Temash National Park (STNP) is located in the Toledo District of Belize and has an area of 16,995 ha (Ramsar Convention, 2005). Its outflow to the sea is by way of two major rivers – The Temash and Sarstoon River which river stages vary as much as 10m (Ramsar Convention, 2005). It was designated in the October 2005 and was selected for its ecosystem significance and the habitat to several threatened species within the country including the West Indian Manatee (Ramsar Convention, 2005). The surrounding community is the predominately indigenous Maya and Garifuna people of the region (Statistical Institute of Belize, 2013). Both groups have historic residency before the designation of the site as a protected area (Government of Belize, 2011). As a result, despite its designation indigenous communities are settled within and buffering the designated area. These communities retain their residency through laws that protect the settlements of indigenous communities. The area is largely utilized for subsistence farming, hunting and fishing.

Figure 4-18: BIOPAMA data on STNP (DOPA, 2017a)

BIOPAMA (Figure 4-18) presents data on the biodiversity inventory of Belize Protected areas including the national land cover of protected areas from 2000 and 2005 (DOPA, 2017a). To note, the DOPA explorer site indicated that there was no land cover change for Sarstoon Temash National Park during the period of 1995 and 2015 (DOPA, 2017a)

The STNP has 384 avarian species, 151 mammalia species, 22 amphibians and 198 marine species. The average temperature is between 22.5 to 27.5 degrees Celsius and rainfall is typically the highest in July and the lowest in March (DOPA, 2017a). The average elevation is about 15 m above sea level. STNP average population density pressure is 25 people per km2 land area. The index for agricultural pressure is 50.4 calculated as the percentage of cells with high human influence was counted within each 1 km buffer (from 1-30 km) and inversely weighted by the distance to the protected area boundary (Hartley et al. 2007 and Dubois et al. 2013). The last management effectiveness study for the STNP was completed in 2005.

The buffering community for the STNP is Conejo which sits to the northeast of the park. In 2010 the population of Barranco was 157. Although the land adjacent to Barranco is officially the protected area, the Government of Belize has de-reserved land on the fringes of the protected area due to political pressure on the cultural lands (explained more in the next chapter).

4.4.2 Sample size

The sample size was determined based on the available population data. There is no statistical data available on the size of the population for the buffering community for the Caroni Swamp. A calculation was done based on the available 2010 population density data of 175 people per km2 in Trinidad and Tobago (Central Statistical Office, 2011). Making the estimated population in that community at 236. The community has no official name and is known by most as the El Soccoro Extension. In Belize, there are multiple buffering communities however the closest is Conejo. In 2010 Conejo's population was 210 (Statistical Institute of Belize, 2013). The entire population to the sampled for this research was 446. Expert, purposive sampling was applied in this case to utilize a size of the population considered to be experts in the field. For the purposes of this research residents living and working in the community for over 6 years were asked to contribute to the research as they would have a better expertise in the seasonal changes and development trends. Expert sampling was also utilized as it is commonly used when new areas of research are being investigated. The feedback of 12 experts were reviewed in the findings chapter for this study.

4.4.3 Conducting the approach

Based on the required data collection and analysis conducting the approach can be completed by staff at protected area management agencies, government agencies in conjunction with community members. The approach is not meant to be completed as a yearly assessment but should be done periodically to determine the effectiveness of the protected area management practices. Based on the type of assessment it can be done every 3-5 years. This assessment should be conducted by local, national or regional PAPs. Essentially using SACPA can also be used as a case study at national and regional levels to allow for comparison of the effectiveness of the protected area policies and processes. The assessment is based on theoretical planning approach with community participation practices.

Following the design of the quantitative data collection first, getting familiar with the capabilities of Google Earth can be down by reviewing the tutorials. Utilizing the historical imagery tool allows for the review of imagery over a period time as the basis of the quantitative analysis. Google Earth also has the capabilities for determining the size of the built environment and the size of the undeveloped area. Determining the size of the built environment allows for the insertion of the formulas to calculate the encroachment rate.

The qualitative data collection processed can be completed in multiple ways through group interviews or individual interviews. It was initially formulated as a data gathering through group interviews, but it was suggested that more information would be gathered in one-on-one interviews based on the stakeholder's preferences. The goal of the interviews was to understand why the encroachment happened in the location. The questions for the interviews were a guide to the conversation with the stakeholder and obtaining further information is encouraged during the interview. It is imperative to conduct these interviews to avoid assumptions and validate the findings of the quantitative data collection. Based on the design, the qualitative data information was not meant to be a separate set of data from the information discovered in the quantitative analysis. Regardless of the extent of persistent encroachment, a research based recognition of the reasons was relevant to chartering the way forward.

Key to this assessment is the reporting aspect of approach, it was not written in a rating form as most assessment result is disseminated. The written report format provides detailed information and is especially important for the qualitative data analysis. Descriptive information on the community perspective provides the information required for addressing built environment encroachment more effectively at the community level.

4.4.4 Risk Mitigation Strategy

As with any research, there any instances where issues may occur in the research design. The flaws in this research design may be evident in the archival research and documents which is essentially of the data collection. The difficulty of data collection is the availability of sufficient documentation of regional research, although documents have been written there is only one regional organization responsible for the archiving of related information. This regional organization is located in Belize and during this stage of the research, the researcher selected to live in Belize to have direct access to the organization's in-house database.

The additional instance where particular attention is required in the focus group interviews, obtaining responses from the targeted stakeholders are key to depicting how the community understands climate change adaptation. A necessary risk with the collection of qualitative research was the extent of participation from the interviewees. Based on the purposive sampling strategy it was more important for the qualitative part of the assessment to be conducting with 4 residents of the community and 1 practitioner, namely a staff member of a community-based organization with key stakeholders from the community. This low number of sample group highlights an expectation that a low number of community residents may want to engage in the study due to lack of interest.

4.4.5 Obstacles to research

The implications of reflexivity in social research practice can be addressed by rather trying to eliminate the effects of the researcher we should try to understand the role of the researcher in within that context. The straightforward approach to taking data while ignoring the researcher's influence cause the task of social research to fail as it was relevant to account for the researcher's role in the research the language utilized in interviewing whether it made the respondents feel like they were supposed to answer in a certain way; discrepancies between attitude and behaviour and whether these observations changed during the course of the interview and; even the problems of non-response whether there were external factors that caused the respondents to not want to respond to the questions posed. These factors should not be ignored but understood as obstacles to efficient research.

The assumptions in the research was that each country had similar models of development but after the analysis was completed there where two separate models of development. It was seen in this research to encourage spatial evaluation patterns per country based on the different spatial.

The major constraint to the research in Caribbean SIDS is the availability of data to achieve the research objective. Although raw data may exist, obtaining relevant data may be a challenge. As a result, the most effective approach for this research design was mixed method approach is appropriate as it falls within the interpretivism stance. The data collection stage is the gathering of quantitative and then qualitative data. This research utilizes the explanatory sequential design allowing for the spatial data to be collected and analyzed first then the creation of the qualitative study based on the findings of the quantitative study. The quantitative data collection was in the form of gathering and analyzing satellite imagery data of the protected area and the buffering communities over a period of 13 years. After the spatial data is analyzed the qualitative data collection was in the form of a questionnaire to understand the social conditions, cultural conditions and community's awareness of the land use changes in their area.

Community input is therefore necessary in the creation of community-based planning, based on its inherent requirement for their engagement. Assessment is an essential element of community planning as residents are better capable to understand conditions in their communities (Page, Johnson, and Proosdij, 2014; Tierney, 2006).

4.4.6 Research Ecological Validity

The challenge of ecological validity was very present in the research where respondents were under the impression that there were right answers in the interview or given the ability to speak with some knowledge on the matter. Whether social standing has an impact in the interview would be considered. This dynamic is understood and account for in the research and noted in the interview notes particularly the interviewee's demeanour during the course of the interview.

4.5 Summary

Research design is an integral part of the research process to outline how the methodology of the research contributes to new evidence. A sound research design allows for a valid contribution to academic research. Based on the aim of this research the interpretive paradigm will be utilized as it allows for the value of the subjects - the members of the communities as contributors to the research. As this research is meant to understand the spatial conditions in buffering communities of protected areas, co-production theory is applicable.

The idea of research is to unearth information and disseminate the new knowledge. Unearthing the information was the collection of data while the dissemination of new knowledge was the sharing of the data to the target audience. The SACPA relies on the explanatory sequential design to unearth information. A quantitative study followed by a qualitative study provided a clearer depiction of why the encroachment is persistent in protected areas throughout the Caribbean.

The quantitative study utilized open sourced software like Google Earth to conduct spatial data collection and analysis through simplified formulas to determine the growth of the built environment and development trends. However, the spatial analysis could not provide explanations for the spatial change. The qualitative study utilized interview questions built around obtaining further information regarding the spatial change.

The approach also utilizes a case study to test the differences in results within the Caribbean SIDS. Within these countries Ramsar designated sites were the selected case study locations as they are the region's most uniform tool for adaptation of coastal ecosystems. The other aspect of this research is the dissemination of knowledge through planning support systems. Utilizing open sourced software, the SACPA will allow for PAPs to utilize a theoretically sound research approach to increase their knowledge of spatial conditions in protected areas. It also provides PAPs with the robust methodological approach required to foster sound decision making regarding disaster risk reduction.

Chapter 5 : ANALYSIS AND DISCUSSION OF RESULTS

5.1 Introduction

Despite the existence of vulnerability studies, the involvement in Ramsar designation, and the development of Integrated Coastal Zone Management (ICZM) policies, there is still an increase of development in coastal protected areas in within Caribbean SIDS. Examples include the installation of groyne to reduce the impacts of erosion leads to further erosion of the beach ‘downwind’ causing the further loss of land (Belize, 2015); and the filling of a coastal wetlands to reduce the impact of ‘flooding’ on development that impedes drainage capabilities for coastal areas and causing flooding further inland (Juman and Ramesak, 2012).

SACPA is a new approach to determine the extent of the impact of unregulated development of coastal protected areas in Caribbean SIDS. This established theoretical approach of explanatory sequential design, discussed in the previous chapter, was conducted through a case study to highlight the inconsistencies in data; comprehension of community members and confirms the validity of the study. The descriptive reporting allowed for comprehensive description of the conditions. This chapter includes analysis reports organized in three sections, two country analysis and the case study analysis. The country analysis reports are descriptive review of conditions with pertinent details. As the data collected through an explanatory sequential design, the reporting will follow that organization. Each report contained a review of the country’s statistics, political conditions, Integrated Coastal Zone Management (ICZM) strategy, Ramsar designation and data available through Biodiversity and Protected Areas Management (BIOPAMA) and Digital Observatory for Protected Areas (DOPA) tools, flooding vulnerability, housing stock, flood adaptation, development patterns, LULC analysis and infrastructure conditions. The case study analysis was a comparative review of results from each location and reveals the nuances within the conditions in Caribbean SIDS.

<u>5.2 TRINIDAD AND TOBAGO</u>

5.2.1 Spatial Analysis on what is happening

Based on the spatial analysis of the study area, the changes in the informal building settlement pattern is evident and there was a 57% percent growth of encroachment in the area during the 13-year period. Figure 5-1 provides compelling evidence of the growth of development from 2003 to 2016.

				%		KM	
	2003	2016	13Year Growth	Total growth rate	Rate per year	Growth	Growth Per Year
Distance from River	0.51	0.3	0.412	41.18	3.18		
Size of development	0.86	1.35	0.56977	56.976744	4.38283	0.49	0.03769

Figure 5-1: Encroachment Calculations (created by author)

The distance from the nearest river calculation in the case of Trinidad and Tobago meant the distance of the development from the Caroni River, which is the largest tributary through the Swamp. In 2003 the distance from the Caroni River was .51 kilometres, by 2016 it was .3 kilometres. The growth rate of the development towards the Caroni River, which sits near the northern edge of Caroni Swamp, per year was reflected as a 3.2% growth which translates to an expansion of the human settlement by .038 km per year (Figure 5-1) towards the main artery of the swamp. The Caroni River is the largest river in Trinidad and Tobago and runs for 40 km with multiple tributaries following from the Northern mountain range to drain into the Caroni Swamp. The section of the Caroni River that is within this study area is highlighted in Figure 5-2 to illustrate that the location of community exposure flooding hazards. With increased development towards the river, the risks these hazards increase and so to the likelihood of disasters. As indicated in Figure 5-2 there are locations along the river where the human settlement is already adjacent to the river and those communities experience flooding during every rain event.

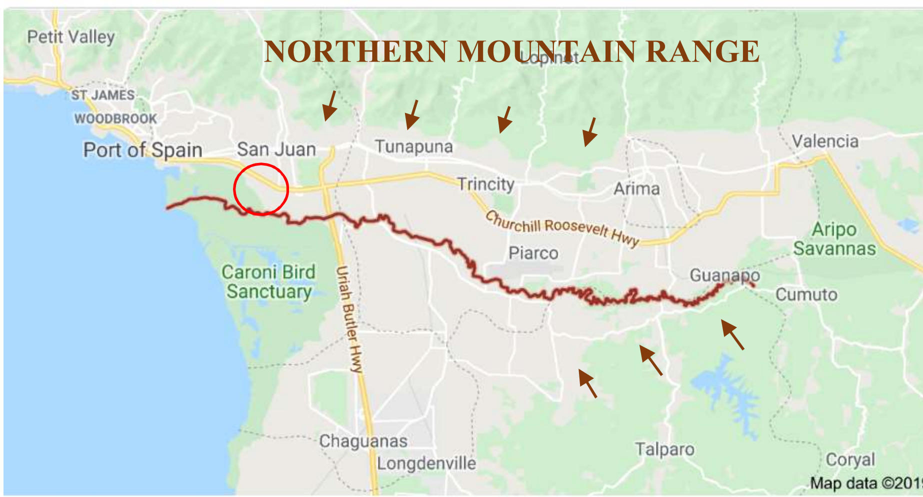


Figure 5-2: Illustration of Caroni River and tributaries following from the Northern Range (created by author)

As illustrated in Figure 5-3, there is a stark change in the spatial organization of the human settlement with increasing expansion south into the Caroni Swamp. The image was obtained by outlining the development footprint during the study period. In 2003, the development footprint of the buffering community was .86 km^2 and by 2016 is was 1.35 km^{2,} that reflects a growth of 4.4% per year. At the time of the study in 2016 the development was .3 km from the river by 2019 as illustrated in Figure 5-2 the development reached the river.

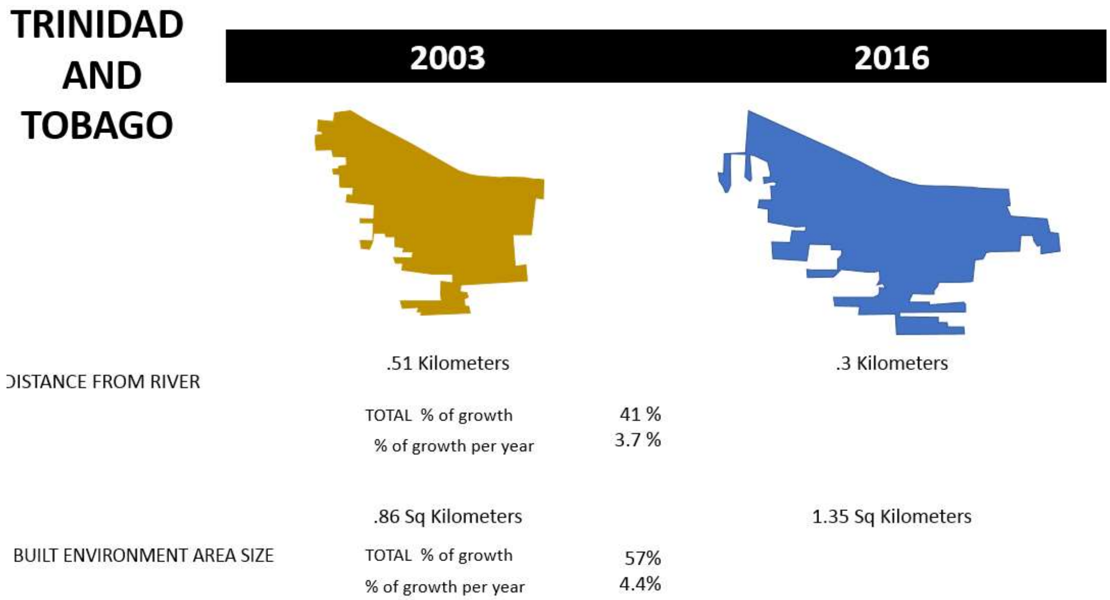


Figure 5-3: Trinidad Encroachment analysis (created by author)

5.2.2 Qualitative Analysis on why it is happening

5.2.2.1 Flooding

The interviewees were asked whether the community was prone to flooding to assess the flooding vulnerability of the study area. The respondents noted the community is prone to flooding based on its adjacency to the Caroni Swamp and the water level rises during high tides. Respondent 121524 also noted a susceptibility to flooding as all the drainage from the entire municipality is directed through the community to drain into the Caroni Swamp. There are instances when this community experiences flooding from two sources, the rising tide within the swamp and overflowed drains from extended rainy periods. The respondents largely understood that they lived in a coastal zone and flood zone with higher points going towards both areas but lower responses were given to identifying this area as a mangrove.

5.2.2.2 Housing Stock

The interviewees were asked specific questions regarding the types of materials used in the structures throughout the community to develop a typology of the housing stock. It was noted from respondents that the housing stock in the community was a combination of wood and concrete with mostly corrugated steel roofing, poorly construction, old structures, houses that need to be rebuilt. The structures were mostly single story but a considerable amount of structures is elevated. The existing multiple stories structures are mixed used where residences are intermingled with businesses. There were mainly impervious surfaces in the neighbourhood.

5.2.2.3 Land Use Land Cover Analysis

This question was asked to assess the majority use in the community. The respondents noted that there is a mixed of land uses in the study area namely industrial, commercial and agricultural. Although the larger scaled industrial structures are typically on stand-alone lots namely DHL mail company, the small-scaled industrial, commercial and agricultural uses are actually mixed-use lots. These patterns include residential and commercial structures or industrial and residential structures on the same lot namely a common mixed-use practice of automotive shops with residential structures on the lot.

5.2.2.4 Infrastructure Conditions

Low capacity infrastructure exists in the study area as the drainage and roads were installed after the residents were already in place. The roads in the community are the standard width of carriageways that accommodate lower volumes of traffic. The increase flow of traffic requires widening of the roads which can no longer occur because properties are built up on both sides of the road. Along these undersized streets are the need for effective drainage to handle the overland flow. To account for drainage and traffic along small roads lead to the minimizing of traffic and further impedes the movement of emergency vehicles. It is also a prevalent practice for people to double park along these streets further reducing the capacity of traffic along the street. Where shallow drains were placed as a temporary measure trash and other debris collects. As this community is at sea level the grading of drains is not standard practice. Respondents noted when waters collect in these areas, there is minimal drainage.

In Trinidad and Tobago there is also accommodation for communities to complete infrastructure upgrades. There were a number of funding options for community members to improve their structures but these funds were used to provide material for construction and does not assist with building the adaptive capacity of community residents through training and understanding building standards (Government of the Republic of Trinidad and Tobago, 2014). Therefore, the citizens without the resources to hire a contractor have minimal interaction with planning policies especially if they do not follow the lengthy approval process of their proposed upgrades. This flawed regulatory relationship does not provide opportunities for the transfer of knowledge from the planners to into the hands of the community. The system only distributes general guidelines on planning policies when approved by individuals and the information is not disseminated in an understandable format, this only ensures that the information is not utilized. It therefore necessary for an increase transfer of information to communities giving them more responsibility in the utilizing planning and design principles. This would afford communities with opportunities to build spaces that are sustainable and increase their resiliency.

5.2.2.5 Flood Adaptation

The question was asked to better understand the current practices of the government and the community to address flooding. During rainy season, the municipal corporation distributes sandbags to help mitigate flooding. In the study area, a flood gate was installed to aid in the drainage and aiding the community. However, the use the floodgate is monitored and controlled by municipal engineers of the national government and no community members were taught on how to operate it. When there is flooding, the community has to wait until a municipal engineer is on hand to open the gate.

But most importantly, the respondents noted that relocation was not a cultural consideration, as most of the people in flood zone areas are squatting and any relocation would be seen as a violation of rights and action against the marginalized. There are squatter regularization laws in Trinidad and Tobago that allow for settlers to receive land tenure after living on a site for a minimum of 15 years.

5.2.2.6 Informal Settlements

An anecdotal account reveals that the development in the community follows the patterns of historic shantytown (informal settlements) but there were large amounts of undeveloped land. Currently there are public investments as the paving of minor roads and the installation of drainage. Steps are being taken to regularize squatting in the communities.

Historically the study area was largely industrial use and therefore minimal infrastructure/ accommodation was set up for residential development. Respondents revealed that over the years increasing amounts of mixed-use development has been included intermittently between industrial uses. The mixed-use development is typically a commercial structure in the lot frontage and a residential structure behind. The commercial activity is mostly bars or small-scale food service shops. The overdevelopment of lots and these non-adjacent uses provide a list issues including exacerbated flooding: increased difficulty in stormwater management. Informal settlements around the Swamp are largely elevated structures but these structures are more viewed as historic structures and a sign on a social status. Historically as it was mostly built by rice farmers.

<u>5.3 BELIZE</u>

5.3.1 Spatial Analysis on what is happening

Unlike Trinidad and Tobago, date regarding the Sarstoon Temash protected areas in Belize was available via the Digital Observatory for Protected Areas developed by the WCPA. The information available detected no land use change during the period from 2000- 2015 (Figure 5-4) but does state that there is a loss in forest cover of 2.3%. To note, the DOPA explorer site indicated that there was no land cover change for Caroni Swamp during the period of 1995 and 2015 (DOPA, 2017b)

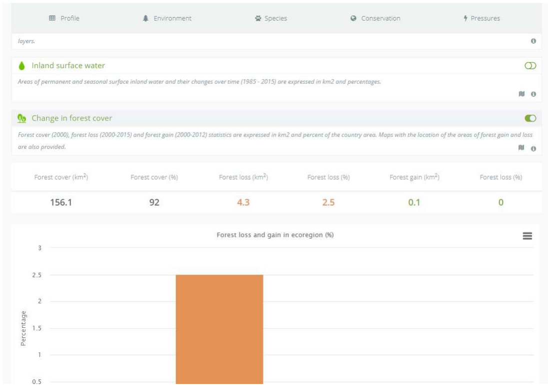


Figure 5-4: BIOPAMA data on Caroni (DOPA, 2017b)

Based on the analysis conducted with the SACPA approach a more accurate depiction of development patterns was revealed. Reflected in Figure 5-5 human settlements experienced a 55% growth of development in 13 years.

				%		KM	
	2003	2016	13 Year Growth	Total growth rate	Rate per year	Growth	Growth per year
Distance from River	1.1	0.1	1	0.1	0.00769		
Size of development	58.96	91.19	32.23	54.664	4.2049	32.23	2.4792

Figure 5-5: Encroachment calculation (created by author)

The calculation of the size of the built environment was based on obtaining the development footprint during the study period. In 2003, the development footprint of the buffering community was 58.96 km^2 and by 2016 is was 91.19 $km^{2,}$ that reflects a growth of 4.2% per year. In 2003 the distance of development from the Temash River was 1.1 kilometres, by 2016 it was .1 kilometres. The growth change was reflected as a .008% growth of development towards the location of the river per year. The Temash River is the artery of the protected area and it meanders west to east through the width of the protected area towards the coast. As illustrated in Figure 5-6 the development of roads within the protected area have already intersected with the Temash River.

Figure 5-6: Satellite clearing near the Temash River (Google Earth, 2019)

Further to this is the evidence illustrated in Figure 5-7 that highlights an expansion of roads throughout the protected area between 2003 and 2016. To note, there was an increase in development along the main centre access road along the western edge of the protected area as well as a new road within the protected area as an indication of further expansion. At the time of the research the new road within the protected area was .1 kilometre from the river, by 2019 as illustrated in Figure 5-6 there is a clearing of over 1.74 acres.

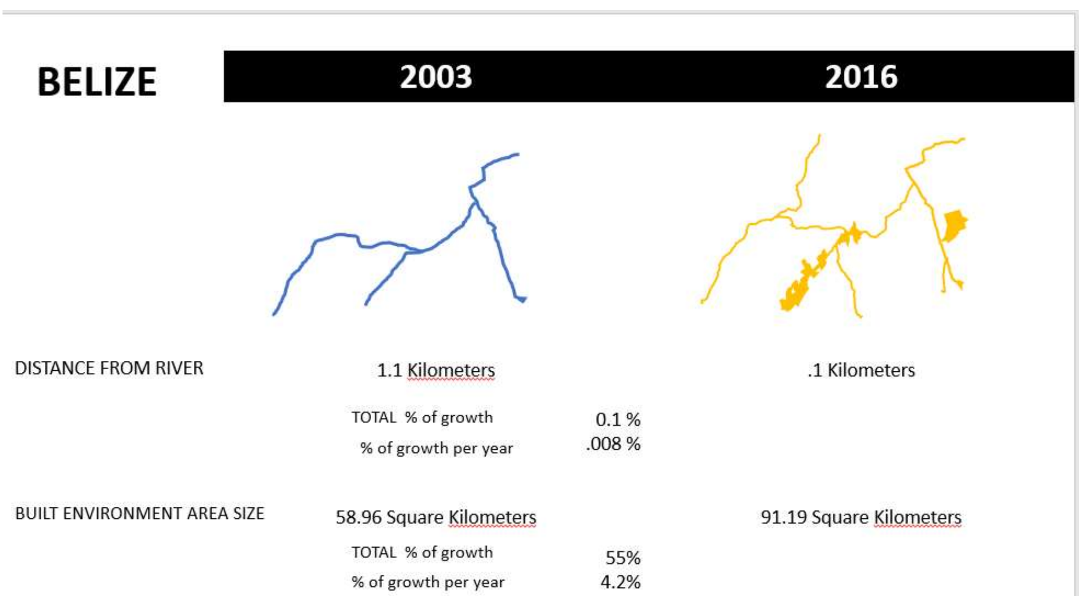


Figure 5-7: Belize Encroachment analysis (created by author)

5.3.2 Qualitative Analysis on why it is happening

5.3.2.1 Flooding Vulnerability

Within the coastal zone the geophysical conditions have a diverse ecosystem with a largest barrier reef system in the hemisphere, island Cayes and mountainous, forested inland areas. These coastal ecosystems are vulnerable to sea level rise and changes in rainfall patterns. Also, the increased frequency and severity of storms have an impact on coastal ecosystems in Belize. Respondents noted that flooding only occurs during heavy rains but when they do road access is blocked.

5.3.2.2 Housing Stock

The housing stock is a mix of concrete and wooden structures. During the interviews it was noted that two very distinct reasons are behind the choice of housing material. Cultural traditions played a significant role in the material used for the construction of homes. The indigenous population utilizes wooden structures based on traditional Palapa style homes, these Palapa style homes have thatch roofing and are built at grade. Income was also a factor but not at the extent of cultural traditions. Lower income residents also utilize wooden housing based on material availability however these homes would have corrugated roofing. The distinction between the roofing identifies whether the choice of material used was based on cultural traditions or income. Additionally, the concrete homes are built my more affluent residents in the community and those are a mixed between corrugated roofing and concrete roofing. It is a common practice of residents to build the first floor of their home with a concrete 'ceiling' to accommodate for building an upper floor in the future. Where roofing is not corrugated metal, it is an unfinished floor of the structure.

5.3.2.3 Land Use Land Cover Analysis

A hundred percent of respondents noted that the land use in surrounding communities is residential. Settlers there would then access services in the nearest town of Punta Gorda. With all commercial activity occurring in Punta Gorda there is minimal need for most services. There is a school and convenient store but these are arranged within the residential housing and there is no defined commercial area. Within the last five years respondents living nearer to the national park noted a 25% clearing of land versus those nearer to the village noted a change over 75%.

5.3.2.4 Infrastructure

Respondents noted that roads are not paved in these communities and are therefore impassable during rains. These roads are sized for one-lane traffic and follow the natural terrain. This infrastructure makes boat the preferred means of transportation to Punta Gorda. Private buses are available for travel into the town by road but the frequency depends on the conditions in the road. Emergency transportation is handled by local residents by boat to the town. There are cellular and internet capabilities in the village.

5.3.2.5 Flood Adaptation

Respondents were more inclined to stay in their location regardless of the threat of flooding. The land ownership is not clearly defined as the community sits on indigenous land and the ownership is more communal. Decisions to move are not individual but that of the larger community and indigenous communities are not inclined to move based on the cultural and religious significance of their locations. Any costs associated with repairing properties are not deterrents.

However, respondent #101707 noted that it was difficult to choose between the questions because although relocating was not a preferred option, in the long-term residents would always be repairing building to alleviate flooding - will be too expensive because inhabitants will always be adjusting since climate change is inevitable and will exacerbate the situation.

5.3.2.6 Settlements

As mentioned briefly above the land surrounding the site is largely indigenous communal land. Therefore, is not applicable to identify these settlements as informal/squatting as planning laws do not apply to communal land throughout the country. The land is therefore settled in no particular pattern, with intermittent clearings in the littoral forest cover where thatched houses are arranged together. These communities receive on electricity or road infrastructure. Within the nearest village of Barranco settlement is legalized and minimal planning laws are in place. Land plots are designated, and housing is arranged along streets.

5.4 T-Test

A T-test analysis was conducted in Microsoft Excel to show whether there was much difference in the view of respondents. The t-test and it revealed a point score of .059 indicating that there was not much difference in the view of respondents. In the qualitative study a t-test results were largely insignificant. The geographic, cultural and political differences are only revealed in a report format where key points discussed in the interviews can be presented.

5.5 Case Study Analysis – Report

5.5.1 Geographic and demographic conditions

Based on observations conducted during the interview stage of this research the population density and land mass are significant factors in the availability of land and land functions. Whereas Belize's land mass is over 4 times larger than Trinidad and Tobago, its population is 28% the size of Trinidad and Tobago. The population density of Belize is 16 people per square kilometer versus Trinidad and Tobago's 264 persons per square kilometer. Lower population density then reduces the stress of the demand for land and provides opportunities for larger tracks of land to designated and maintained as protected area.

The largest industries in Belize are agriculture and tourism, apart from the trend of residential sprawl, large tracks of undeveloped land are cleared agricultural and tourism based purposes (Zapata, 2015; Dowlat, 2010). Whereas the industries in Trinidad and Tobago are oil extraction and manufacturing and making land demand based on the residential and manufacturing commercial activity. All of the aforementioned land functions have extensive environmental impact on the soil and water quality in both areas. Poor low flow conditions in the Caroni River (Lucas and Atkins-Koo, 2009) and increase in sedimentation in the Sarstoon River (Crossland etal., 2005; Dowlat, 2010).

The based on the land use demand the geographic locations of the protected areas are under threat from different factors. Due to a budding manufacturing industry the residents near the Caroni Swamp are more dependent on commercial based activity for their livelihoods. There are major highways in close proximity to the Swamp that increases transportation access and movement. Although it was outside of the scope of this research it was observed that encroachment along the Caroni Swamp is occurring along the southern edge as the towns to south expand upward. With a larger indigenous population in Belize, cultural traditions foster the encroachment in the Sarstoon Temash National Park. The residents there rely on subsistent agriculture and continue to uphold traditional practices. There are smaller feeder roads throughout the National Park that limit access and movement.

5.5.2 Political Conditions

Although the countries have different political systems their political conditions are the same where politicians in the ruling party are able to provide greater public support for their constituents. Therefore, greater economic opportunities are based on the political distributions in the population. In Belize where political parties retain power for multiple election cycles communities with less political influence are left without any capital investment for over a decade. In Trinidad where political influence changes more frequent, inconsistent capital investments leave communities with incomplete infrastructure until their political part regains influence. In both locations political influence allows for the clearing of large tracks of protected area land through leases and concession agreements for the extraction of a resource.

5.5.3 Integrated Coastal Zone Management

Both countries have available ICZM policies and the implementation of these policies vary greatly. In Belize there are several stakeholders involved in coastal zone management – the line ministry, the quasi-governmental agency and non-profit organizations given the task of co-managing the site with the line ministries. Due to population disbursement most, climate change adaptation projects occur in the coastal zone projects are focus on densely populated communities. Rural populations in the coastal zone receive less investment and therefore there is limited in country data collection and monitoring of the biodiversity of Sarstoon Temash National Park.

In Trinidad and Tobago there are fewer stakeholder groups and the line ministry and quasi-governmental agencies assume responsibility of all coastal resources. The non-profit groups have more limited involvement than their counterparts in Belize. Extensive research is conducted by the government, or national university but there are limited opportunities for community-based projects in climate change adaptation projects.

Although the challenges for ICZM in both countries are different they yield the same result for buffering communities of the protected area. Regardless of the international designation of these protected areas, limited national investment and/or interest controls the success of the designation. Even while conducting this research it was interesting to discover that through the BIOPAMA site, information on Trinidad and Tobago was largely unavailable while information on Belize was outdated.

5.5.4 Protected Area management

Although both sites are designated Ramsar sites there is inconsistent availability of information on each of these protected areas. Sarstoon Temash has extensive information available on multiple open sourced, online databases whereas Caroni Swamp does not. However, the information is Sarstoon Temash is not up to date.

Additionally, the management arrangement of each site is unique. In Government of Belize (GOB) developed a co-management arrangement with Sarstoon Temash Institute for Indigenous Management (SATIIM) with the majority of responsibility for the management on SATIIM. The Co-management agreement was to ensure that a local organization would handle the operations of protected area management and report to GOB management activities. In this arrangement the GOB maintained the responsibility for the policy decisions. However, in 2012 rescinded the management agreement with SATIIM and retained sole management responsibility for the area.

In Trinidad and Tobago, the management for the Caroni Swamp is the Forestry Division of the Ministry of Agriculture, Land and Fisheries. As the management agency for all the protected areas in the country they handle coordination of all protected area activities. Non-governmental interest groups lobby for greater involvement of the Forestry Division for increasing information regarding the Caroni Swamp protected area management. There is no co-management arrangement in Trinidad and Tobago for the management of protected areas.

Without more direct oversite from Ramsar the integrity of these sites are under serious threat. On the Ramsar site for Belize, SATIIM is still listed as the organization responsible for research and management under a co-management agreement with the government. However, there is no co-management agreement. It also lists that the most recent information from Ramsar was 2005 when the site was designated. Caroni Swamp was designated in the same year by Ramsar as an area of international significance. However, since then, there are limited required updates on the integrity of the organization of the protected area. The information uncovered in this research investigation reveals that significant changes occurred in each site but there is no information about these changes on the Ramsar site.

5.5.5 Encroachment Patterns, Land Use Land Cover Analysis

Based on the land laws and social conditions the communities are arranged differently. In Belize the buffering communities of the protected areas are living on communal lands. Communal land allows for the settling of indigenous populations based on cultural significance and historical settlement patterns of ancestors. Barranco is a Garifuna community with communal land rights to settle near the protected area. Increased development noted in the Belize spatial analysis is the establishment of a Maya village known a Conejo which buffers designated protected area. During the study period this village has grown exponentially faster than the rate of Barranco.

In Belize the infrastructure is place first and within the Sarstoon is the majority of development that occurs is road expansion occurred during the study period. The trend is that housing will follow the establishment of infrastructure. In Trinidad and Tobago however, infrastructure follows the housing. Land is cleared for a house and only after a few houses are erected public infrastructure follows. Based on the land use laws and social conditions the communities are arranged differently. In Belize communal land allows for the building of multiple structures and minimal land clearing increasing the opportunities for the percolation in the soil. However, in Trinidad informal settlements are illegal but not enforced. Informal settlements on the edge of Caroni Swamp are originally settled in a haphazard manner. With increase social pressures the government then provides electricity to informal settlements or people take the time to extend the existing electrical lines to obtain service.

Housing near and within the protected area in Belize is largely residential whereas in Trinidad residential structures are used as mixed-uses for commercial activity namely bars and restaurants for workers in the nearby industrial structures. The land use demand and trends are based on the different industries in each country. Despite these countries being both Caribbean, their development practices and land use trends differ greatly.

5.5.6 Flooding Vulnerability

Development in both communities is prone to flooding. In Trinidad and Tobago as there is larger number of people living within hazard proned areas. Flooding occurs when the tide rises and when the rains in the upland areas drain into the swamp basin. With extended periods of flood waters in the community there is a higher probability of disasters for the residents living in near the Caroni Swamp due to their exposure. Although flooding occurs in the community near the Sarstoon, the flooding largely limits access along the road to the nearest town. During flood events the community is only accessible by boat from the nearest town. A smaller and more indigenous population in Belize provides less reliance on the public assistance. One respondent noted that in the event the home is destroyed by hurricanes, the materials are easily sourced to build another.

5.5.7 Housing Stock

The building styles of the buffering communities differ based on their socio-cultural considerations. In Trinidad and Tobago recycled corrugated metals and wood are more affordable and can be found in scrap yards, or in refuse areas. These houses are typically along informal roads along the edge of the swamp. People then build houses out of any available material they can find making houses susceptible to floods, hurricanes and other natural disasters (Fendell, 1973). Additionally, there are houses in the community that are built with concrete and newer corrugated metals. This type of building material allows for faster runoff and increase contamination in the water courses.

However, in Belize the residents living in the protected area are indigenous people who are dependent on wood and thatch for the building their houses. Thatch roofs allow for the slower flow of stormwater runoff and earthen floors allow for water to percolate into the soil. This difference in the housing stock and reduces the likelihood of flooding in Belize during storms, while in Trinidad flooding occurs more frequently.

5.5.8 Infrastructure

The infrastructure is the Sarstoon is largely feeder roads as significant road expansion occurred during the study period. The trend is that housing will follow this clearing of land. In Trinidad and Tobago however, infrastructure follows the housing and so the development patterns clear larger plots of land at a time.

5.5.9 Flood Adaptation

Addressing flood adaptation in each location has unique challenges. The retreat option in Trinidad and Tobago would be politically difficult situation as the movement of informal settlers is not preferred by the population. In Belize, there is a cultural and religious connection to the land so residents are not likely to move from the place where their ancestors settled. The other consideration is the adjustments to building styles and whether it may be plausible to build elevated structures. In Trinidad and Tobago, the population uses the material available to them and elevated structures are typically one room; larger structures are built closer to the ground. In Belize however, traditional building styles do not require the additional need for flood adaptation.

5.4.10 Emerging Codes

Coding in this research expanded this research beyond an explanatory sequential design towards the development of the solutions to reduce exposure to natural hazards. Based on the results of the coding the best practices recommendations must highlight how to address flooding after heavy rains; there should be the provision of more information on wetlands; in terms of adaptation there is significant interests by respondents for holding the line and retreating; there is a need for increased adaptation practices for residential properties and ways to minimize the impact of largely concrete housing. Additional emerging codes from frequently discussed topics during the interviews were:

- Political influence on the success of protected areas management and disaster risk reduction
- Land tenure rights namely what is considered squatting versus unregulated settlement on communal land and the settlement patterns of indigenous and cultural groups.

- Frequent flooding as it relates to the flooding occurrences- interviewees saw flooding as a frequent occurrence and not just limited to particular storms
- Increase of mixed residential land uses - prevailing land use codes were obsolete as community residents were largely engaged in commercial activities in their residential spaces therefore seemly residential areas were actually local commercial corridors
- Indigenous housing practices supports minimal land clearing and the use of thatch roofing and earthen floors reduces the impact of stormwater runoff
- A limited interest in relocating as a result of cultural connections to the land and accommodation for the land to be the home for their future generations. For the respondents, their settlement patterns were largely cultural and/or historical.
- PAPs could benefit from learning more about resilient infrastructure and adaptive architectural practices so they can share with community member's solutions to reduce risks to disasters

5.6 General research findings

As outlined in the research problem, the underlying challenge to addressing continued habitat loss in the protected areas of the Caribbean SIDS was the lack of a spatial evaluation to determine the extent of habitat loss. The lack of an evaluation to determine spatial change limits the structured approach to decision-making for protected area practitioners.

Following the analysis and the testing of the SACPA this research unearthed the extent of loss of the protected areas in Caribbean SIDS during the period of time; and the socio-cultural conditions that directly challenge the spatial organization of the protected area. These findings were not previously identified in the existing IUCN-WCPA assessments on protected areas. However, combining the quantitative and qualitative analysis in one assessment allowed for a more comprehensive report of the human behavior that drover spatial change in the case study communities. This knowledge is very relevant to increasing the research and supporting best practices in utilizing protected areas to promote biodiversity and disaster risk reduction.

Calculating spatial change to determine the effectiveness of a protected area revealed whether the organization of the site still promotes biodiversity and the protection of coastal resources. In the case of Trinidad and Tobago the northern encroachment of mixed residential, commercial and light industrial land uses highlighted the instances of contamination in the waterway. Concurrently the population growth within the floodplain of the Caroni River inevitably increases the vulnerability of the communities to the occurrences of natural disasters. The overall size of the protected area is greatly reduced. That information is not reflected within the records of the designated management agency.

In relation to Belize the expansion of roads throughout the protected area and growth of buffering indigenous communities within the designated area highlighted the challenges of cultural considerations in protected area management. For generations indigenous communities resided in these rural locations, that were then designated as protected areas due to international pressure. The cultural connection to the land allowed for a more sustainable approach to development reducing the residents' exposure to natural disasters. This research brought a spotlight to the stark results in spatial change based on the socio-cultural influence of the buffering communities. changes in these protected areas that will severely impact their effectiveness.

SACPA is a new contribution to the research on evaluating protected area effectiveness as the application of the open-sourced mapping and quantitative analysis provides evidence of the extent of pressure as a result of human encroachment while the interviews and qualitative analysis describe the reasons why the change has occurred. The general findings of the test of the SACPA was the use of a quantitative analysis followed by a qualitative analysis revealed the conditions that influence the spatial change are context specific. A cultural connection to the land makes settlers not see themselves as encroaching but retaining land possession for their future generations and preservation of their culture. Which then brings into question whether indigenous settlements are considered encroachment and if indigenous settlements can be identified as a factor in the spatial fragmentation of protected areas.

The use of explanatory sequential research design was beneficial in this research. Interviews were developed based on an initial analysis of conditions and the qualitative findings provided a comprehensive depiction of the unique challenges for each case study. The interviews went on longer than the prescribed time because of general interest the discussion and the interviewee's comfort in sharing pertinent information. Community experts were very interested in the subject matter and several respondents appreciated being considered an expert based on their connection with the community. This research was the first time most respondents were engaged in a research topic that directly explored the extent of human encroachment in a protected area.

For example, in the interview with respondent #121524 (See Appendix Two) additional socio-political factors arose as the need for this community to become more resilient and the role of political watch dog groups as an advocate for rights in the community.

The interviewee also noted that this research would generate great interest for not only the residents but also the government agency wanting to be involved in increasing relationship with community members. Due to the open science aspect of the evaluation respondents did not feel like the research was another tool that restricted their settlement. Although the political challenges are beyond the scope of this research, the structure of the interviews were able to unearth opinions on the political influences that impact spatial fragmentation and undermine the continued protected area management in both countries.

Conducting the research in the case study format was a comparative analysis of conditions in the Caribbean region. One size did not fit all when conducting research in Caribbean SIDS and the cultural differences were significant enough to impact the trends of development. Land use demand was directly connected to industry in Trinidad and Tobago, however in Belize cultural considerations motivated development. Context specific research throughout the Caribbean SIDS will greater inform decision making and encourage tailored solutions to support disaster risk reduction for buffering communities of protected areas.

5.7 Adaptation recommendations towards disaster risk reduction

This research has shed light on conditions in each location that has not been discussed in other studies and as such contributes to the preservation of coastal habitats in the midst of human encroachment. During the qualitative analysis of this assessment it was determined that in order for the assessment to be used by protected area managers, additional information should be provided on built environment adaptation practices to build an awareness of sustainable development. This research endeavor would be incomplete if plausible solutions to the conditions identified are not presented. These solutions include resilient engineering and adaptive architecture that can be applied to the Caribbean context and integrate the connections between planning, sustainable development and natural conservation (Harris et al., 2006).

These practices emphasize the preservation of natural resources and the reduction of development impact. The following recommendations were included in this document to provide context for the type of adaptation practices that could be developed in Caribbean communities.

While discussing the built environment principles it is important to cover the engineering measures that are typically used in coastal defense. These strategies cover the topics of doing nothing through abandonment; managed retreat or realignment by adaption vertically by elevating land and buildings; holding the line through armouring by constructing seawalls and other hard structures; moving seaward constructs defences seaward of the coast; and limited intervention as in duplicating natural processes (Figure 5-8). Managed retreat allows for erosion to occur and flood to foster the growth of new shorelines; it mainly looks at restoring the sediment budget. Costs associated with relocation. Holding the line as another strategy looks at inserting structures to stop erosion and loss of land though hard – seawalls, groynes, breakwaters and soft-beach nourishment and

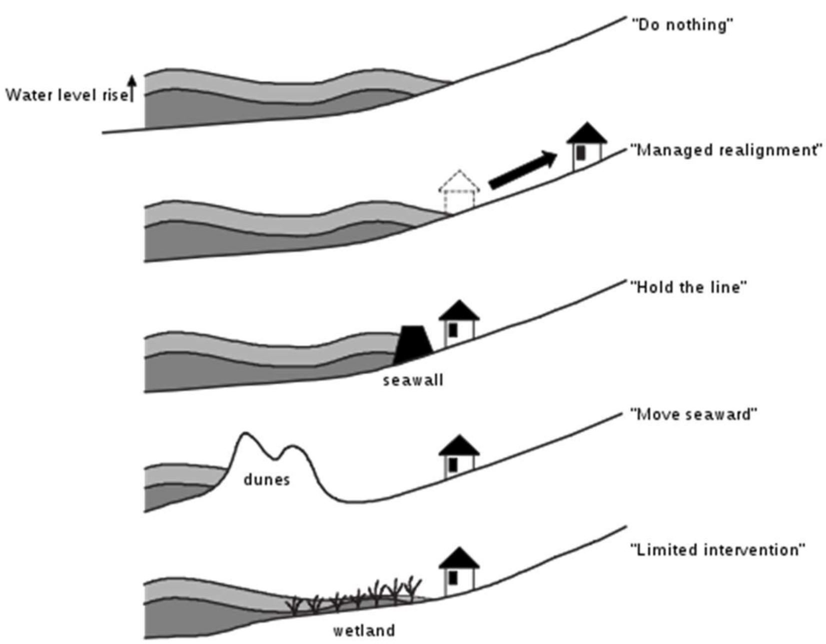


Figure 5-8:Resilient Engineering (Australian Coastal Councils Association, Inc., 2017)

sand dune stabilization (Australian Coastal Councils Association, Inc., 2017; Morgan et al., 2002). Moving seaward is the riskiest of all measures looks at building measures further out to the sea as in the creation of sand dunes further out to sea in an attempt to move the land seaward as a protective measure (Australian Coastal Councils Association, Inc., 2017; Morgan et al., 2002). The limited intervention is well inline environmental engineering principles utilizing natural processes as means to coastal protection as in the regrowth of wetlands within the coastal zone (Australian Coastal Councils Association, Inc., 2017; Morgan et al., 2002).

These types of houses in Caribbean countries are situated along floodplains in mostly undesirably land for settlements (Oxfam America, 2004). It is noted in the IFRC that construction of mangroves along with harder engineering structures provide lines of defence against disaster and understood that when considering the adaptability to disaster lines of defence are the more appropriate response (IFRC, 2002). Not just one solution both a collection of choices to work in tandem during a disaster. As an example, the country of Vietnam cultivated mangrove swamps to protect a se dyke system in an effort to reduce the height of typhoon waves (IFRC, 2002).

5.7.1 Natural infrastructure for coastal zones

According to the Center for Watershed Protection (2011), stormwater runoff is a very significant cause of water pollution in urban areas. In addition to low impact development and environmental site design strategies, green infrastructure improvements focused on treating runoff from impervious surfaces are an effective way to address contamination to a local marine ecosystem (Benedict and McMahon, 2012; Gill et al., 2007).

Green infrastructure is used to address contaminated runoff from cities by mimicking natural microbial, soil and planting cleansing systems. Green infrastructure design principles incorporate the use of natural processes into urban settings to improve and restore ecological conditions in these areas (Center for Watershed Protection, 2011; Benedict and McMahon, 2012; Gill et al., 2007). This principle includes: (a) features the natural environment, (b) features the urban environment and (c) features Green infrastructure examples in the urban setting. Along with other environmental benefits, strategically designed green infrastructure can reduce the concentration of pollutants in stormwater and delay the collection of large volumes of stormwater at any given instance of rain (Benedict and McMahon, 2012; Gill et al., 2007; Cummins, V., Mahony, C., Connolly, C. 2002). This discussion on green infrastructure is utilized under private sector and not public sector because stormwater runoff can also be addressed by private landowners before the stormwater enters the combined sewer outflow (CSO) (Erie County GIS department, 2008). Since the runoff is treated at the street level and no longer sent to the treatment site, the strain on the municipality's CSO is reduced (Brombach etal., 2005; Rizzo et al., 2018; Huber, 2010). This allows for the wastewater to be effectively treated before it is discharged to the nearest water body. In the absence of green infrastructure to support the CSO, untreated wastewater is discharged into the nearest water body when excess stormwater overflows the system (Brombach et al., 2005; Rizzo et al., 2018; Huber, 2010). The effective design of green infrastructure can also provide a basis for recreational opportunities by encouraging the interconnection of natural spaces in an urban area. Prominent green infrastructure strategies that manage wet weather and alleviate the strain on CSO systems include:

Trees: The rate at which heat penetrates a building determines the heat exchange behind the building and surroundings (Akbari, 2002; Norton et; al, 2015; Meerow and Newell, 2017). Due to the process of evapotranspiration, the presence of shade trees encourages the "oasis effect", cooling the surface temperatures significantly. The buildings surrounding these trees consume less energy to cool the interior rooms and increase the comfort for the surrounding environment (Norton et; al, 2015; Meerow and Newell, 2017). The best arrangement of the shade trees in an urban environment is an urban park. The arrangement of trees in the one area allows for a greater impact to reduce the effects of UHI and lower the surface temperatures (Yu and Hien, 2006; Norton et; al, 2015; Meerow and Newell, 2017). Parks are able to have this type of impact as there is a greater density of trees with zero anthropogenic heat outputs (Stewart and Oke, 2012; Norton et; al, 2015; Meerow and Newell, 2017). With an increase in parks in an urban setting the UHI magnitude can be mitigated through and increase in instances of evaporation.

Determining the best trees for the city is dependent on the climate of the location. In the mid latitudes, deciduous trees are beneficial as they shade during the summer and in the winter the bare trees allow for an UHI magnitude to make the city warmer and increase the thermal comfort for its residents (Akbari et al., 2016; Santamouris, 2013). In tropical climates trees that are able to withstand the harsh conditions of the dry season are a more prominent consideration. In tropical climates shading is best on the roofs and along the north and western walls of buildings (Environmental Protection Agency, 2016; Akbari et al., 2016; Santamouris et al., 2015).

Shading is not the only area of consideration when dealing with urban trees as plants also have the capacity for sequestering carbon and filtering particles from the air particularly vehicle emissions. In a study to examine the proximity of a tree to the roadside and the amount of dust particles found on the tree it was noted that trees nearer to the road side were found with greater amounts of dust particles which highlights the abilities of trees to reduce the airborne particles in the urban canopy layer (Matzka and Maher, 1999; Smardon, 1988). The preferred configuration of trees in the urban setting to reduce the impact of UHI is in parks as the collection of trees provides a zone of cooler ground level temperatures. In the instance where parks do not exist, a connected network of street trees provides shade for pedestrians and cools the ground level temperatures along transportation networks (Akbari et al., 2016; Santamouris et al., 2015).

Green Roofs: It is plausible for roofs to represent a maximum of 32% of the built areas in urban settings and they are important source of radiation absorption into a particular building (Costnazo et al., 2016; Rosenzweig, 2016). In LAC, the typical use corrugated roofing material in residential construction is a significant contributor to the UHI and is a key element of the impact of UHI in the urban boundary layer in urban and peri-urban settings (Costnazo et al., 2016; Rosenzweig, 2016; Besir and Cuce, 2018).

Green roofs lower the heat transferred to the building by increasing the surface albedo of the surface and evaporation of the radiation for the sun before it can penetrate the building (Van Mechelen et al., 2015). Green roofs are also capable of improving the life span and durability of roofs due to the reduction of exposure from UV radiation and; reducing the rate of storm water runoff which is a contributor to flooding events (Simmons et al., 2008). In urban settings, the use of green roofs has resulted in as much as a 2-degree reduction in temperature when used on at least 50% of the buildings. Green roofs have also encouraged the emergence of insects and the ability to attract avian species as they use the roofs to nest (Oberndorfer, et al., 2007; Beradi, 2016; Maclvor, 2011) improving the natural ecosystem in urban settings. Due to the multiple direct benefits of green roofs, installation should be based on needs of the municipality (Oberndorfer, et al., 2007; Beradi, 2016).

There are two different categories of green roofs that can aid in the reduction of the effects of UHI, extensive and intensive. Extensive green roofs are more effective as they are shallow and low growing requiring minimal maintenance. There are mainly functional and provide greater surface areas in thermal protection from the sun's radiation (Coma, 2016; Mchelen et al., 2015). They are categorized by shallow vegetation that can tolerance higher levels of sunlight and require less maintenance (Macivor and Lundholm, 2011; Coma, 2016; Mchelen et al., 2015). Due to their configuration, they are more lightweight and require less irrigation. Vegetation across roof of a structure allows the surface to absorb radiation from the sun and reduce the rate of stormwater that reaches the drainage or sewage systems. Due to these functions, extensive green roofs have been compared to climatic skin based on intrinsic climate change adaptation ecosystem functions namely storm-water management and reduction of impact from UHI (Macivor and Lundholm, 2011; Coma, 2016; Mchelen et al., 2015).

Intensive green roofs are modern versions of the ancient Semiramis, hanging gardens (Kohler et al., 2002; Silva et al., 2016), and provide more of an aesthetical benefit to the roof top (Oberndorfer etal, 2007; Silva et al., 2016). They also provide similar cooling effect through the use of shade trees but require deeper substrates to accommodate for roots. As more soil is needed to accommodate the use of trees that can provide shade and ecosystem benefits, the weight of intensive roofs has to consider the load on the building (Kohler et al., 2002; Oberndorfer etal, 2007; Silva et al., 2016). They also require more maintenance and irrigation.

A green network is created in an urban setting when the inclusion of street trees, parks and green roofs exist in a contiguous pattern throughout the urban fabric (Costanzo et al., 2016; Kabisch et al., 2016; Aronson et al., 2017). Balance in the urban setting and reduction in the magnitude of UHI can be achieved with green network projects to provide coverage for all areas impacted by anthropogenic activity (Costanzo et al., 2016).

Vegetated swales: a vegetated swale is a sloped, but shallow channel of vegetation designed to trap pollutants and to promote infiltration and reduce peak flows of storm water runoff (Wu and Allan, 2018; Sabbion and Perini, 2016). It is designed to hold the runoff from the street in a short-term detention pool. The water stays in the pool until it is slowly infiltrated into the ground (Fig. 5-9).

Rain Gardens: provide the same function as vegetated swales but they are built to mimic the enclosed shape of gardens instead of channels (Chaffin etal, 2016; Church, 2015; Mehring and Levin, 2015; Fremont Universe, 2009; Leroy et al., 2016). These gardens are meant to treat pollution sources in smaller quantities than vegetated swales because they do not have deep slopes to accommodate retention pools for slower infiltration channels (Chaffin etal, 2016; Church, 2015; Mehring and Levin, 2015; Metropolitan Council, 2010). However, there is a shallow slope to move the runoff towards the centre of the rain garden where the water is allowed to infiltrate into the ground

Green networks as described by the American Society of Landscape Architects describes green infrastructure as an integrated network of open spaces that foster the generation of clean air, water and carbon sinks (American Society of Landscape Architects, 2015; Vogt, 2004). The concentration of the pollutants within the urban canopy layer can be reduced by the inclusion of a green network namely trees as they provide spaces within the urban form to facilitate the passage of air and disbursement of pollution. The inclusion of a green network within an urban setting can play an integral role in reducing the impact of UHI by increasing opportunities for evapotranspiration processes and increasing the surface albedo (Voogt, 2004).

Figure 5-9:Vegetated Swale (Cayuga County Planning Board, 2013)

Green infrastructure improvements are a more affordable alternative to hard engineering, full reconstruction projects which lay separate pipelines to transport wastewater and stormwater in separate pipes. Green infrastructure strategies are becoming viable options for cities trying to actively address the pollution of their waterways without the budget for full reconstruction. Returning to use of natural treatment systems can also provide recreational benefits for the community’s residents. Increase investment in the waterfront public spaces can foster recreational activity and improve the quality of life for community residents.

5.7.2 Living shorelines in the Caribbean: wetlands as green infrastructure

Wetlands are able to serve as protective barriers and absorb the shocks of weather-related disasters. Wetlands within river basins perform as sponges absorbing rainfall and reducing flood impact (Gittman et al., 2016; Currin, 2019; Mitchell and Bilkovic, 2019). They do that through mangroves and coral reefs that absorb the storm surges, impact of tsunamis and rainfall and wind damage from hurricanes. According to research completed by RW Parkinson et al (1989) mangroves are historically known to adapt to sea level changes through landward and seaward migration (Gittman et al., 2016; Currin, 2019; Mitchell and Bilkovic, 2019).

With an increase of seal level rise, Mangroves are able to grow within the peritidal zone. This is a result of mangroves being able to show a blend of positive and negative results in response to climate change (Gittman et al., 2016; Currin, 2019; Mitchell and Bilkovic, 2019). Mangroves growth can benefit from sea level rise based on the levels of temperature and CO_2 but they are also susceptible to lost from erosion and saline intrusion which stunts its growth (Saenger, 2002; Gittman et al., 2016; Currin, 2019; Mitchell and Bilkovic, 2019). Therefore, restoring and protecting vast amounts of mangrove habitats (Erwin, 2009; Erdle, 2006) can be a key tool in climate change adaptation.

Mangroves serve as a buffer zone to tidal changes and are the first line of defence when considering coastal management (Barbier, 2016; Sarker et al., 2016). When ensuring the buffer zone, it is important to retain natural defences for coastlines and build around it. These natural defences adapt quickly to changes and minimize the loss of human life and losses to human investments. Designated protected areas are either post-colonial decisions or pressured from international standards and therefore there is minimal local assimilation of the importance of the protected area (Bacon, 1987). Protecting existing mangroves is very important as it provides two possible solutions in the short term protecting these areas can mitigate against floods and hurricanes. In the long term reducing the pressure of human development along the fringes of the mangroves so that as sea levels rise mangroves are able to replenish themselves towards the landward extent of the intertidal zone (Barbier, 2016; Sarker et al., 2016). It is common practice to replenish the mangrove on the seaward extent growing the mangrove out further to sea, unfortunately this reducing the mangrove extent (Erwin, 2009; Barbier, 2016; Sarker et al., 2016)).

Municipal Sewer Waste (MSW) disposal also impact the environmental conditions. Most water bodies remain vulnerable as MSW dumps are chosen for convenience and not environmental considerations and these leachates easily find their way into water bodies (Henry, Yonsheng, and Jun, 2006). Residents that live in the catchment area of poor waste management upstream are definitely more vulnerable as they build, live and grow food in zones downstream in the areas where are contaminated by practices and further degrades the environment. Natural processes for filtering these contaminates are then not able to flourish and resident live in contaminated conditions (Erdle, 2006).

An additional element to living shorelines are beaches (Gittman et al., 2016; Currin, 2019; Mitchell and Bilkovic, 2019). Beaches are dynamic areas and can serve as dynamic as buffer zones and/or possible absorbers of shock from wave attack. The effectiveness of the beach depends on the size of the grain of the sand which determines porosity, penetrability, permeability of the sand (Schooler et al., 2017). The finer size has greater porosity whereas the larger san has less porosity. Permeability is the rate of drainage of water through sand therefore finer sands is lower than larger grains. Penetrability is important to micro fauna as it allows for` these organisms to borrow within the particles. These characteristics also determine the reflectivity of the sand. Reflectivity occurs when the sand is course and the conditions are calm whereas there is no surf zone and a major part of the wave is reflected. Where the grains are fine, a dissipative beach is created where are the grains are fine and the maximum erosion is achieved, the majority of the sediments are stored in the broad surf zone and there are multiple sandbanks parallel to the beach (McLachlan and Brown, 2006). Living shoreline are also applicable to private sector as a larger number of coastal lands within the Caribbean is in the hands of the private sector beaches (Gittman et al., 2016; Currin, 2019; Mitchell and Bilkovic, 2019).

5.7.3 Adaptive architectural styles for coastal zones

Floatable development also known as Aquatecture allow for structures to float on the surface reducing the vulnerability during instances of flooding or varying tides (Tong, 2012). The creation of floatable cities has even been explored to address the need for housing for growing populations in coastal zones. It also encouraged the revival of Chinampas (floating gardens) as the practical need for agricultural landscapes in these aqua-communities (Figure 5-10).

Elevated developments are constructed at predetermined heights (Tong, 2012) to reduce the loss of life and property that can occur when a structure is built at ground level. This form of development was historically used for residential structures in rural, low lying communities of the Trinidad and Tobago and provides lessons for commercial development.

Figure 5-10: Example of floatable development and elevate development (Tong, 2012)

Chapter 6 : CONCLUSION

Studies of the built environment particularly in urban planning is complex, evaluation methods which do not oversimplify planning issues should be utilized to strike a balance between too much information and the inadequacy of too little (Bracken, 1981). Research and recognition the factors that foster drastic, rapid or minor changes of land use systems over time is still of one of the challenging aspects of this field (Basse, 2014).

Although there are a number of tools that determine the management effectiveness of protected areas these tools are lacking in providing theoretically supported spatial assessments of effectiveness. While they include aspects to addressing the knowledge gaps in the communities regarding the information on protected areas, they do not consider how a spatial analysis can measure of the effectiveness of the protected area. Efforts have not been made to develop an in-depth assessment of the spatial conditions in these spaces.

As research is at the centre of the obtaining knowledge developing a targeted, systematic way to approach a research problem allows for the researcher to develop an extensive procedure for data collection. Utilizing the research onion guided the formulation of the research into a multi-method approach. Comprehensive collection of information cannot only be obtained through one medium and the collection of information through multiple mediums allows for the development of a complete story. This combination of methods highlights an examination of the social construct that impacts the form of the built environment and would need to rely on review of historical documents to outline the impact of climate change and development standards.

Based on the aim of this research to determine the spatial effectiveness of designated protected areas in Caribbean SIDS, the interpretive paradigm was selected and although the approaches were mostly inductive through qualitative analysis, the spatial data however required a deductive approach as it analyses settlement patterns and trends. By examining settlement patterns there is an inherent integration of spatial data in qualitative methods that allowed for the researcher to illustrate the spatial dynamics of a social processes as well as quantitative analysis.

6.1 Addressing research objectives

This research was structured with seven objectives to address the aforementioned gaps in the protected area management studies. A critical review of the climate change vulnerability principles at the global and regional level was completed in the first literature review chapter. It provided an overview of terminology central to this research and the gaps in existing protected area assessments that foster human encroachment. This chapter outlined the basis of the new contribution of this research to the current discourse on protected areas review of the existing forms of management effectiveness evaluations of protected areas is discussed. Based on the WCPA resources all the existing management effectiveness frameworks were discussed to identify the gaps in the current practices. The Caribbean SIDS context is then discussed to provide the foundational context to the research.

The second literature review chapter introduced the concepts that were several to the development of the research design. It was imperative for this research to not only be a new contribution to the field but to also be developed within a theoretical framework. It reviewed existing approaches to theoretical spatial planning and spatial planning controls; and provided in depth information on planning theories and planning support systems that were relevant for the use of spatial considerations at the community level.

This research methodology chapter outlined the standard requirements for conducting research and addressed the objective to develop the theoretical approach for SACPA. It discussed how the SACPA theoretical approach is a new contribution to the literature on protected area management effectiveness and outlined how this assessment emphasized public access through open sourced planning support systems.

This analysis chapter explained the analysis and addressed the objective to test the SECPA on the basis of its application to two selected case studies in Trinidad and Tobago and Belize, two SIDS within the Caribbean. It also addressed the objective to collate the information obtained in the case study in a report format to revealing the differences in conditions in both locations. The method of reporting used revealed how the political, cultural and economic conditions impact the development in both countries and highlighted the stark differences in Caribbean settings.

6.2 Recommendations for future research

The findings of this research yielded a wealth of information to guide future research in this field. Protected area designation is a useful strategy to preserve natural habitats; it is also useful with reducing human development in hazardous zones. However, reliance on the protected area designation was not sufficient to deflect encroachment of development in the Caribbean SIDS. Based on the research encroachment still occurred within protected areas for a number of political and cultural reasons. Without oversight of the protected area from the designating agency development will persist. Continual assessments are required to monitoring the activity surrounding the protected area. Utilizing a community based, open science approach supported constant monitoring of the activity surrounding the protected area.

Building evaluations that are accessible empower community members to obtain and analyze data to assist with decision making. When developing an assessment for this type of research reliance on quantitative studies for adaptation assessments is insufficient, there should also include a qualitative aspect to the study to obtain a comprehensive depiction of conditions. Multi-method studies are an efficient approach to conducting assessments for protected areas.

The pervasive disconnection between theory and practice is addressed in this study in the development of a theoretically sound research approach with an open science delivery to ensure that PAPs can utilize it in their work. This approach was developed due to the ideas that PAPs are not keen on learning theory to conduct their work but fail to see the benefits of developing sound theoretical support for their work. In an effort to develop an accessible theoretical sound evaluation, emphasis was placed on the planning support system that is open sourced and used by PAPs. Despite the sue of open-source software, the data on changes to spatial organization obtained was effective to determine spatial change.

The standard practice for effectiveness assessments was the development of a score however the use of a score limited the presentation of the research findings. Descriptive reporting of the results of the assessment provided a more in-depth review of the challenges to protected area management and fostered more informed decision making.

The principle of human encroachment does not consider the cultural connections with the land. Indigenous people cannot encroach on their ancestral lands. Any attempts to address spatial fragmentation without these cultural considerations can result in the displacement of people from their ancestral lands. Future research on human encroachment in protected areas must be more cognizant of the settlement of indigenous communities.

In places where the communities are new settlers, the placement of the community at the forefront in planning decisions will foster the creation of sustainable places and reduce the exposure to natural disasters. As the community then assumes responsibility for the betterment of the community, their adaptive capacity will increase. This is not to make the role of researchers in the formulation of sustainable communities obsolete but creating communities with the community members as an integral part of the design develops spaces that are truly participatory (Chi and Yuen, 2005). It is therefore important for physical planning researchers to adopt approaches that engage community members at every stage in the research process.

6.3 SACPA contribution to research

SACPA was developed as the method to address the gaps in protected area effectiveness assessments particularly the collection and analysis of spatial information. The research design was developed to comprehensively collect information on the spatial effectiveness of coastal protected areas. The explanatory sequential design research design depended on the collection of information through multiple mediums that allows for the development of a complete story. This combination of methods highlighted the impact of human behavior on spatial effectiveness of protected areas. Utilizing this robust theoretical approach made the SACPA a new contribution to research. SACPA stands apart from all the other existing tools. It can also be utilized as a supplemental assessment that can be done in conjunction with existing effectiveness tools. Although the theoretical support for SACPA is based on academic standards, the application of it is based on accessibility to PAPs. Similar to the other assessments that require the PAPs to collect the information for the assessment, SACPA's can be conducted by PAPs. By examining settlement patterns there is an inherent integration of spatial data in qualitative methods that allows for the researcher to illustrate the spatial dynamics of a social processes as well as quantitative analysis.

Although traditional research looks to the participation of community members as instruments with a reduced amount of community input and even participatory research studies lend themselves to minimal contribution from the community, it is important to engage the community's input in the research at every stage ensuring that the research is truly participatory (Macaulay, et al., 1999). It is important as researchers with community-based research projects to engage and maximize the involvement in the community in all aspects. This would minimize community disenfranchisement and incorporate a social context to the research.

This research revealed the gaps in the inclusion of academic research on the practice protected area management to address disaster risk reduction in developing countries. One clear difference is the creation of vulnerability indexes that are largely developed for academic research based on the strong reliance on theoretical support for the data collection and analysis processes and the community-based qualitative approaches to adaptation assessments. The theoretical support to data collection and analysis allow for robust data to inform the extent of climate change based on evidence. Conversely, community-based adaptation assessments are the essential focus is the collection of qualitative data to obtain a picture of the success of the use of adaptation principles. Therefore, adaptation assessments largely suffer from the lack of theoretical support to the collection of data analysis. The lack of theoretical support therefore limits the capacity of adaptation assessments to develop comprehensive analysis of conditions and therefore impacts the reliability and validity of the information collected.

Of equal importance to the research was the inherent gaps in the IUCN framework on protected areas management as a result of the lack of a more structured methodology for evaluating the spatial change in protected areas. These gaps include but are not limited to understanding the extent of loss in protected areas; determining how spatial fragmentation reduces the viability of the natural habitat and determining the impact on disaster resilience. Evaluating spatial change provides opportunities to address the aforementioned gaps.

Protected areas that were designated to preserve the biodiversity of flora and fauna also present key opportunities for climate change adaptation. This is applicable in coastal protected areas in that they provide ecosystem services and infrastructural benefits to the impacts of climate change. Coastal zones can be utilized as a line of defense against the impact of climate change namely the increased intensity of storms and sea level rise. However increased development in coastal zones reduces the ecosystem's ability in providing ecological functions that inherently balance out the climate change impacts. The provision of a more in-depth spatial evaluation of the effectiveness of coastal protected area management is necessary for the future of research on protected areas management. The SACPA is a new contribution to research because it addressed the aforementioned gaps. As a new contribution to research the spatial evaluation relied on the creation of a theoretical approach for data collection and analysis. When tested the SACPA unearthed the spatial change in protected areas in the Caribbean through a quantitative analysis and identified the socio-economic causes through qualitative analysis. The resulting reporting strategy provided a comprehensive representation of the challenges to protected areas management to foster more effective decision making. This new contribution to the IUCN-WCPA assessment framework highlighted continual challenges in management effectiveness of protected areas and revealed pervasive socio-cultural vulnerabilities to natural disasters in the buffering communities.

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APPENDIX

ONE: INTERVIEW FORMAT

Interview reference number

The interview guideline

Introduction

The objective of this interview is to gauge the interviewee's understanding of coastal zone conditions in their community. It is meant to understand their vulnerability of flooding and climate change adaption, it is by no means a tool for teaching these terms but to get a snapshot of what community members understand about their community and the role of the government in the development trends of the community and the capacity building of the community residents and their role in understanding how they can develop resiliency to the impact of climate change.

Your rights

You may decide to stop being a part of the research study at any time without explanation. You have the right to ask that any data you have supplied to that point be withdrawn or destroyed. You have the right to omit or refuse to answer or respond to any question that is asked of you. You have the right to have your questions about the procedures answered (unless answering these questions would interfere with the study's outcome). If you have any questions as a result of reading this information sheet, you may query the researcher at any time.

Vulnerability of built environment:

As noted above this questionnaire tests your knowledge of Coastal Zone Management in Trinidad and Tobago

- Do you live or work in the El Soccoro/ Bamboo or Barracnco communities?

- What is the age of your property?

- How long have you worked there?

- Is your property proned to flooding? Have you experienced damage to your property due to floods/ heavy rains? / To the best of your knowledge is that area proned to flooding? PLEASE DESCRIBE.

- How would you describe the housing stock in that community (check all that apply)?

	Wooden		0-15 years
	Concrete/ block		16-30 years
	Single story		31-45 years
	Multiple story		50+ years
	At grade (sits on the ground)		0-25% of open yard on property
	Elevated (built on stilts)		50

Coastal Zone adaptation:

- Do you believe you live or work in: (check all that apply)?

	Coastal zone		Flood Zone		River basin

	Swamp		Mangrove		Lagoon

- What is the most significant industry in that community?
- Are you aware of any planning regulations in that community?
- Has development in that community grown within the last 5 years? If so, please indicate whether it has grown 0-25%, 50-75%, 75%-100%.

Adaptation practices

- How has flooding been addressed in that community?
- Are there are open areas/parks in that community?
- How have you address flooding on you personally?
- Are you aware of ways to protect your property from flooding?
- If under the threat of flooding every rainy season:

  (a) would you rather move to a community on higher ground?

  (b) retrofit your property to alleviate flooding

TWO: INTERVIEW SAMPLE

Interview reference number: 121524

The interview guideline

Introduction

The objective of this interview is to gauge the interviewee's understanding of coastal zone conditions in their community. It is meant to understand their vulnerability of flooding and climate change adaption, it is by no means a tool for teaching these terms but to get a snapshot of what community members understand about their community and the role of the government in the development trends of the community and the capacity building of the community residents and their role in understanding how they can develop resiliency to the impact of climate change.

Your rights

You may decide to stop being a part of the research study at any time without explanation. You have the right to ask that any data you have supplied to that point be withdrawn or destroyed. You have the right to omit or refuse to answer or respond to any question that is asked of you. You have the right to have your questions about the procedures answered (unless answering these questions would interfere with the study's outcome). If you have any questions as a result of reading this information sheet, you may query the researcher at anytime.

Vulnerability of built environment:

As noted above this questionnaire tests your knowledge of Coastal Zone Management in Trinidad and Tobago

- Do you live or work in the El Soccoro/ Bamboo communities? Respondent works at the San Juan/Laventille Regional Corporation in a capacity that requires visits to communities for various projects

- What is the age of your property? / How long have you worked there? 4 months

- Is your property proned to flooding? Have you experienced damage to your property due to floods/ heavy rains? / To the best of your knowledge is that area proned to flooding? PLEASE DESCRIBE. Respondent noted that there has been a lot of flooding; El Socorro pretty close to the Caroni River and high tides may impact runoff from rainfall events.

- How would you describe the housing stock in that community (check all that apply)?

	Wooden		0-15 years
	Concrete/ block	x	16-30 years
	Single story		31-45 years
	Multiple story		50+ years
	At grade (sits on the ground)		0-25% of open yard on property
	Elevated (built on stilts)		% 50

COMBINATION of all three, poorly construction, old structures, houses that need to be rebuilt. Suggested for houses to be rebuilt, wanted to provide technical assistance. The roofing and foundation, but flooring was not at ground level. Concrete have sealed walls

Mostly single story but a considerable amount of structures is elevated. The existing multiple stories are also business, car parts and aquaculture
More elevated in the El Soccoro south, more are elevated and Bamboo there is a mixture of elevated (how high is another questions; structures are not elevated at varying heights)
16- 30 years
Mainly impervious surfaces

Less fencing as you go further into the community (people are less proned to fence along dead end streets and also have limited economic ability to fence property; those areas are more residential and farming

Coastal Zone adaptation:

- Do you believe you live or work in: (check all that apply)?

	Coastal zone	X	Flood Zone		River basin
	Swamp		Mangrove		Lagoon

Mangroves are little further out from the community

- What is the most significant industry in that community?

  Bamboo – automotive most proprietors live on the compound; El Soccoro – entertainment/bars; manufacturing/ warehousing; supermarkets

- Are you aware of any local planning regulations in that community?

  Non; everything follows national regulations

- Has development in that community grown within the last 5 years? If so, please indicate whether it has grown 0-25%, 50-75%, 75%-100%.

75% or more; the community historically a shantytown and underdeveloped; recently alot of investments of minor roads and drains were created; and squatting regularized

Toolkit

- How has flooding been addressed in that community?

  Construction of a flood gate to regulate the flow of the river into the communities; but when the floodgate malfunctions it is difficult to get ministry officials to repair it. The community spent a day or two with flooded streets and there is no existing disaster management plan; Operations/ maintenance of the flood gate are not under the control of the Corporation.

  Desilting of the rivers and the construction box drains but the drains are under sized and typically constructed by estimation.

- Are there are open areas/parks in that community?

  Respondent noted that the community is popular for cricket players, Bamboo has big parks. No parks or open spaces exist in El Soccoro.

- How have you address flooding on you personally?
- Are you aware of ways to protect your property from flooding?

  Respondent noted construction related mechanisms would be best, height of structures and drainage on the properties is needed. The corporation distributes sandbags to help mitigate flooding; lack of building codes and stricker regulations is a weakness. Falling short

- If under the threat of flooding every rainy season:

  (c) would you rather move to a community on higher ground?

  Respondent noted that relocation was not a cultural consideration, as most of the people in flood zone areas are squatting and any relocation would be seen as a violation of rights and action against the marginalized (squatter regularization 15 or more)

  (d) retrofit your property to alleviate flooding

  Respondent would favour this option but developing a wider approach to drainage would accompany this, i.e. a 5, 10-year plan to address flooding- the flooding was so heavy in the usual in the regular areas that it started backing up into higher elevated communities