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Sustainable Islands: Defining a Sustainable Development Framework Tailored to the Needs of Islands

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Acronyms

BCR	Blue, circular, resilient
BPOA	Barbados Programme of Action
CARICOM	Caribbean Community
COP	Conference of the Parties
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GHG	Greenhouse gas
GNI	Gross national income
ICESDF	Intergovernmental Committee of Experts on Sustainable Development Financing
IDB	Inter-American Development Bank
IFI	International financial institution
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
MVI	Multidimensional Vulnerability Index
ODA	Official development assistance
OECD	Organisation for Economic Cooperation and Development
OECS	Organisation of Eastern Caribbean States
R&D+i	Research and development and innovation
SIDS	Small Island Developing States
SIP	Sustainable Islands Platform
UN	United Nations
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
WHO	World Health Organization

Executive Summary

Executive Summary

Small is Beautiful but Challenging

Like other Small Island Developing States (SIDS), Caribbean island economies have intrinsic characteristics that make them vulnerable to external shocks. The recent pandemic highlights the structural problems of small island economies. Due to their remote location and small size, islands lack economies of scale and rely on global supply chains, which are currently disrupted. Islands depend either on service-based economic activities like tourism, which are being affected during the current crisis, or on a single commodity, which makes them extremely vulnerable. Islands must rethink their approach to development, adopting one of sustainable development. This approach is defined as follows:

"*Meeting the resources and services needs of current and future generations without compromising the health of the ecosystems that provide them, and more specifically, as a condition of balance, resilience, and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by our actions diminishing biological diversity*" (Morelli J. , 2011).

Caribbean Islands and Climate Change

Climate change is another external hazard that threatens the existence of SIDS. Climate change impacts, such as more severe and longer lasting extreme weather events, heat waves, drought, and torrential rain, are already being felt throughout the Caribbean. Ocean thermal expansion and glacier melting could result in sea levels rising one meter by 2100. This could be catastrophic to islands, especially in the Caribbean, where half of the population lives within 1.5 kilometer from the coast (Kaito, et al., 2014). Development approaches, policies, and financing must be designed to combat climate change, both in the adoption of science-based targets and in the adaptation to the inevitable consequences of climate change.

Caribbean programs and initiatives aimed at developing resilient infrastructure and policy must integrate climate resilience into them. Financial tools must be transformed to make then more resilient to the physical hazards of climate change by, for example, creating market insurance and catastrophe risk insurance facilities. Collaborative approaches should be developed to increase economic resilience by increasing access to climate financing in exchange for fiscal adjustments.

Systems Thinking Approach

The Sustainable Islands Platform aims to create a new approach that targets the needs of Caribbean islands and prescribes circular economy-inspired interventions in key areas such as sanitation, waste management, agriculture, fisheries, tourism, energy, transportation, and health. Traditional approaches

have not proven successful in solving developing problems on SIDS. Therefore, a new concept that considers islands in a new way should be considered.

Islands are living organisms where each sector is part of a larger interconnected system. In this regard, a systems approach considers the interaction between sectors and island issues as a whole rather than concentrating on issues on a sectoral basis. This approach also considers the relationship of interdependence between human beings and nature, which is essential to understanding the complexity of sustainable development on islands.

From Small Developing States to Big Ocean Countries

A paradigm shift must occur, and islands must be reframed to capitalize and protect the wealth of resources offered by the oceans that surround them. Expanding sustainable island vision to marine territory is fundamental for the future of islands. Moving forward, a shift in the *small island* concept must be expanded to more accurately consider islands as *big ocean countries*.

This approach would allow for sustainable economic growth while restoring and regenerating ocean ecosystems, which is not always prioritized in the current model. The transition to a blue economy model would promote innovation in topics like aquaculture, marine renewable energy, biotechnology, and ocean-related tourism and leisure. The ocean is largely overlooked as a source for its potential to boost economies and for its importance in maintaining a healthy global climate. Integrating oceans into this narrative will help islands achieve their developmental and climate goals.

New Approaches to Old Problems

Islands have long targeted basic service development as a key priority area for island prosperity. Due to the unique characteristics of islands, access to services like clean water, sanitation, energy, food, housing, connectivity to telecommunications infrastructure, financial services, and road networks is complex and expensive to develop. Blue economy and circular economy approaches offer a new way of thinking about these issues and provide new, innovative solutions to island development.

These concepts embody a *systems thinking approach,* which focuses on an island's *big ocean* rather than its small landmass. When combined with a climate resilience pathway, these concepts can be used to target some of the biggest issues that islands face while complementing each island's existing approaches to its particular needs.

Money, Money, Money… Show Me the Money

Shifting island economies to a sustainable model through blue and circular economies with a focus on climate resilience requires high-level expertise and financing. In recent years, islands have experienced a reduction in trade and access to foreign assistance. Instead, these resources are pledged to low-income countries and countries in post-conflict situations. In many cases,

Caribbean countries are not eligible to receive concessional financing because of their development classification, which relies on GDP or GNI—not ideal indicators of development. In reality, islands face natural disasters, which limits their ability to develop sustainably.

To solve financing issues for islands, multiple approaches and financial instruments should be adopted. International financing focused on expanding resilience to territories that face elevated risk to natural disasters is one approach that could open up financial streams to islands. Inter-island collaboration and dialogue could also help islands learn about new financial instruments and share best practices and lessons learned.

Looking Toward the Future of Islands

Islands are beautiful, interconnected, living organisms that differ from mainland countries in a variety of ways. Their differences contribute to the distinct barriers that islands face, which require a new approach to achieve sustainable development. Understanding this is the first step to delivering a sustainable development pathway that makes the most of island opportunities to best overcome their challenges. The next step is to deliver a transformative paradigm shift capable of developing, implementing, and financing innovative initiatives through island collaboration and international support. There is no better time than the present to begin addressing the needs of islands through a tailored *island*-sustainable development framework created for and in coordination with island countries themselves.

Introduction

1. Introduction

Islands face distinct sustainable development challenges, given their isolated geography, limited land mass, narrow resource base, scarce access to fresh water, and expensive energy bills due to fossil fuel imports as baseload for their electricity systems. Small Islands in the Caribbean are over-reliant on a few industries, such as tourism and extractives, which makes them vulnerable to external shocks. Caribbean islands are disproportionately exposed to climate change impacts such as sea level rise, record high temperatures, extended periods of drought, and extreme weather events such as hurricanes and torrential rains.

The combination of vulnerabilities to external shocks from foreign markets or extreme weather events, limited resources, and strain on the natural environment makes it exceedingly difficult to achieve sustainable development. Frequently, investments in sustainability or social development are sidelined in favor of economic growth.

According to the UN Conference on Environment and Development, there are 58 small island developing states (SIDS). They represent less than 1 percent of the world's population (OECD, 2018) and occupy approximately 3 percent of the Earth's landmass. Despite their small size and population, SIDS are home to 20 percent of all plant and animal species globally (UN-OHRLLS, 2013). Islands are also surrounded by oceans that have not been fully explored or developed. The Caribbean Sea covers 2.75 million square kilometers.

This paper argues that the region's prosperity is inextricably linked to the health and good management of this natural resource. Thus, island nations must consider how new approaches to the blue circular economy and climate resilience can bridge the gap between traditional and innovative sectors that benefit from their abundant marine resources.

To promote sustainable development of islands, a paradigm shift is needed. It involves moving from a land-centric approach to an ocean-centric approach, focusing on ocean natural resources as a valuable sector for innovation, investment, employment, and growth.

Central to this new paradigm is the idea that islands should be managed as living organisms. The paradigm conceives of the island as a whole as the unit of measurement, rather than pursuing a sectoral approach. Public policy should focus on achieving the triple goal of sustainability: sustainable economic growth, environmental protection, and human equity. To accomplish this, the paper will argue that sectoral analysis should be complemented by systems thinking to better understand the complexity of sustainable development and that governments should establish a high-level institutional arrangement to

guarantee that the development model of islands is indeed focused on sustainability.

Preserving island ecosystems and their inhabitants and fostering economic growth will also require a paradigm shift with respect to how multilateral organizations, international financial institutions, and bilateral donors see Caribbean islands. Many Caribbean countries are not eligible to receive concessional financing because these institutions classify level of development largely according to per capita GDP. This paper will argue that vulnerability—not per capita income—should guide decisions on concessional financing and access to grants. Climate change is a global responsibility. Protecting and supporting the most vulnerable countries should also be a global responsibility.

Section 2, Small is Beautiful but Challenging, makes the case for specific initiatives and financing for small island nations that target their unique developmental challenges.

Section 3, Islands as the Unit of Measure: Using a Systems Thinking Approach, proposes a more progressive approach to dealing with island development that considers them to be living organisms with many complex, interconnected systems.

Section 4, Paradigm Shift from Small Island Developing States to Big Ocean Countries, suggests moving from a land-based approach to sustainable development to an ocean-based approach.

Section 5, Looking for New Approaches to Old Problems, proposes blue economy, circular economy, and climate resilience methodologies to solve common island development issues.

Section 6, Toward a Framework for Sustainable Islands, builds upon the previously mentioned methodologies to develop a new framework for sustainable island development.

Finally, ***Section 7, Money, Money, Money… Show Me the Money,*** recommends new and existing financial instruments that can be used to finance island development.

Small is beautiful but Challenging

2. Small is Beautiful but Challenging

Why a Focus on Islands?

Islands have some of the most diverse geographies, cultures, and ecosystems for which they are regarded as some of the most beautiful places the world has to offer. However, the attributes that add to islands' appeal, including their remoteness, spatial dispersion, proximity and economic ties to oceans, small landmass, and scant populations, are the same characteristics that make islands dependent on a few exports, including oil imports. This makes them vulnerable to economic shocks. Furthermore, climate change and the resulting sea level rise make them vulnerable to storm surge and flooding.

The vision of the Caribbean sustainable islands concept is to place island countries on a development path that harmonizes environmental with social and economic considerations and benefits, to ensure long-term economic growth and equity. This approach aims to encourage island nations to meet the resource and service needs of current and future generations without compromising the integrity of the socio-ecological systems that provide them. It also aims to create the conditions for resilience and interconnectedness that allow people to satisfy their needs within the limits of island systems and to regenerate their assets and functions without diminishing their inherent capacity.

Island territories and their populations face a series of challenges that limit their chances for sustainable development and make them highly vulnerable to climate change. They share a series of intrinsic characteristics, including their small size, limited access to freshwater resources, susceptibility to natural disasters while having limited capacity to respond to and recover from such events. Their economies are dependent on narrow resource bases and rely on a limited number of distant markets for international trade, without the means of influencing the terms of that trade. They rely on a few industries such as tourism and extractives, they depend on imported petroleum products. Diseconomies of scale, low levels of foreign direct investment, and limited means available to exploit their natural resources on a sustainable basis, make them sensitive to external financial and economic shocks.

Unsustainable development, including the effects of climate change, threatens the livelihood of people and the biological resources, marine and terrestrial, on which they depend. Due to the small size, isolation, and fragility of island ecosystems, biodiversity is seriously threatened. Given the limited development options on islands, planning for and implementing sustainable development options requires an integrated approach to resource management, which pays special attention to protecting the environment and people's livelihoods.

Islands and Sustainable Development

Small Island Developing States (SIDS) were recognized as a set of countries with special characteristics and needs in 1992 at the United Nations Conference on

Environment and Development, held in Rio de Janeiro, Brazil. Agenda 21 highlighted that small islands are ecologically fragile and vulnerable and face difficulties in planning and implementing sustainable development goals without the cooperation and assistance of donor countries and international financial institutions.

The United Nations coordinates global discussion on SIDS through Conferences. Three major conferences have been held so far, each producing documents that have helped shape the development agenda for small islands. In 1994, the First United Nations Global Conference on Small Island Developing States was held in Barbados, where a set of priority areas were discussed and summarized in the Barbados Plan of Action (BPOA). These priorities include climate change and sea level rise, natural and environmental disasters, coastal and marine resources, freshwater resources, management of waste, energy resources, biodiversity resources, tourism resources, transport and communication, science and technology, human resource development, national institutions and administrative capacity, regional institutions, and technical cooperation. The BPOA also defined the following crosscutting areas: capacity building, institutional development at the national, regional and international levels, cooperation in the transfer of environmentally sound technologies, trade and economic diversification, and finance (United Nations, 1994).

At the second conference, held in 2005 in Mauritius, new areas were incorporated into the Mauritius Strategy for Implementation of the BPOA. These are: graduation from least developed country status, trade, sustainable production and consumption, health, knowledge management, and culture.

The third International Conference on Small Island Developing States was held in Apia, Samoa in September 2014. It adopted the SIDS Accelerated Modalities of Action Pathway (Samoa Pathway), which sets out the most comprehensive set of priorities of the three SIDS conferences (United Nations, 2014).

The Rio +20 Outcome Document set the Sustainable Development Framework and the post-2015 sustainable development agenda. On January 1, 2016, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development officially came into force. Over the next ten years, countries will continue their efforts to end all forms of poverty, fight inequality, and tackle climate change while ensuring that no one is left behind.

Figure 1. Sustainable Development Goals.
Source: United Nations (2019).

The report of the Intergovernmental Committee of Experts on Sustainable Development Financing (ICESDF) emphasizes country ownership and an enhanced global partnership. The report underscores the importance of the international community in supporting the sustainable development efforts of small islands. The Inter-American Development Bank is committed to contributing to the economic, social, and environmental development of Caribbean islands and is developing a special initiative to better support the implementation of the actions needed to achieve sustainable development (United Nations, 2014).

This technical paper will adopt the following working definition of sustainable development:

"Meeting the resources and services needs of current and future generations without compromising the health of the ecosystems that provide them, and more specifically, as a condition of balance, resilience, and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by our actions diminishing biological diversity," (Morelli J. , 2011).

Figure 2. Framework of Sustainable Development.
Source: Freimann, Ham, & Josipa (2014).

For sustainable development to be achieved, it is crucial to harmonize three core elements: economic growth, social inclusion, and environmental protection. These elements are interconnected, and our efforts should contribute to building an inclusive, sustainable, and resilient future for people in the Caribbean. As such, any Caribbean initiative must support climate-proofing the region to help countries in the difficult transition from vulnerability to sustainable development.

Caribbean Development Paths and Current Challenges

The Caribbean region is comprised of a heterogeneous group of countries that have pursued different development paths in the post-colonial era. The development approach pursued by the region in the early post-independence period was a variant of the Arthur Lewis model of industrialization, which focused on absorbing surplus labor and improving export competitiveness.

Within this framework, Trinidad and Tobago achieved success in heavy industry (oil, gas and later petrochemicals) and Jamaica in light manufacturing, but many small economies were uncompetitive and continued to depend on agriculture up to the 1980s. Preferential access for the Caribbean's primary and agricultural products, such as sugar, was a critical factor in the region's ability to

sustain exports to the European Union market. After the loss of preferences, many of the affected countries moved into services, especially tourism and later offshore financial services. In addition, regional integration, which sought to improve export competitiveness of goods and services, was envisioned as a critical element of the region's development model.

The adopted approach worked for a while. Living standards improved along with educational outcomes, healthcare, and general social conditions. Enrollments rates at the secondary school level substantially increased in many countries, unemployment rates declined, and life expectancy improved.

However, in recent times, the socioeconomic environment has changed. After the global financial crisis of 2008, tourism-dependent countries experienced widening fiscal and trade imbalances and rising debt. Environmental shocks such as hurricanes, storms, and flooding, combined with a weak recovery in the advanced economies, caused Caribbean economic recovery to stall. The international trade environment, which was characterized by preferential access, has changed. Hydrocarbon-dependent countries now experience commodity price shocks more frequently.

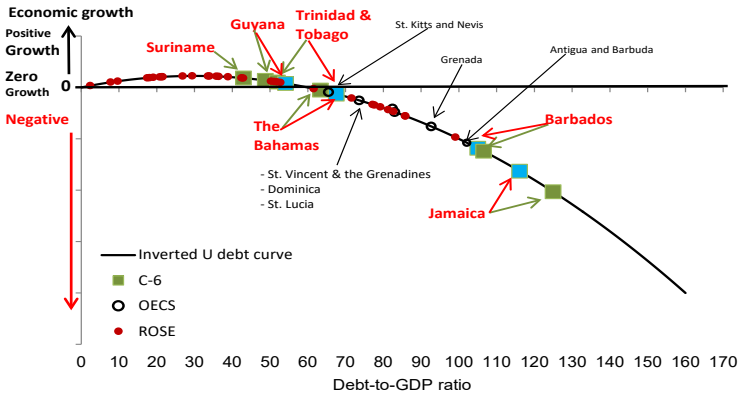
A sound macroeconomic environment is paramount for sustainable growth and development. External shocks through economic activity in advanced economies and commodity prices have a large effect on growth in the Caribbean (Inder, Karl Alexander, & Sierra, 2014)**.** Hence, after the great economic recession, growth sharply declined in both commodity- and tourism-dependent countries and has not returned to its pre-2008 level. If COVID-19 conditions persist over the medium to long term, then the current development model based on tourism, services, and extractive industries, such as oil, gas, and minerals will further hinder the region's ability to tackle the new development challenges that have emerged.

External shocks are expected to worsen the performance of tourism-dependent CARICOM countries. The Caribbean region's tourism industry is no stranger to adverse shocks. Two recent events that occurred before the COVID-19 pandemic are (i) the 9/11 terrorist attacks in the United States and (ii) the global financial crisis. In the aftermath of 9/11, the IMF estimated that tourism arrivals in the Eastern Caribbean declined by 1.5 percent, triggering a rise in unemployment and deterioration in the governments' fiscal accounts (Boote, et al., 2003). Further, the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) reported that the global financial crisis accounted for an 8 percent decline in international travel to the Caribbean (ECLAC Caribbean Subregion, 2010). Notably, some tourism-dependent countries, such as The Bahamas, Barbados, and Antigua and Barbuda, were negatively affected, recording declines of 10 percent and greater. These setbacks created fiscal imbalances in most Caribbean countries and rising debt-to-GDP ratios.

Two major shocks have affected commodity-dependent Caribbean countries in recent times. These countries can be further separated into those that export hydrocarbons and those that depend on other minerals such as gold. Hydrocarbon dependent countries—Trinidad and Tobago and Suriname—had to contend with two additional significant commodity price shocks in the period 2008-16. Economic growth declined in both countries and has not returned to pre-2008 levels. The outlook of these economies over the medium term remains grim given the instability of oil and commodity prices.

The region has earned the moniker of "high debt, low growth" due to expanding fiscal deficits, rising debt levels, and slowing productivity growth. With limited fiscal buffers, rising debt levels and slow growth can plunge some countries into a vicious unsustainable cycle of increasing debt and rising interest payments. Most Caribbean countries have already crossed over to the 'dark side' of the debt-growth ratio (Khadan, et al., 2016). This level of debt severely limits their capacity to invest in sustainable development.

Figure 3. Debt-to-GDP ratio and Economic Growth.
Source: Khadan, et al. (2016).P ratio and Economic Growth.
Source: Khadan, et al. (2016).



More frequent and amplified extreme weather events caused by climate change add to the dire debt situation in the Caribbean. Since 1999, major financial and life losses were recorded. More than 12,000 extreme weather events have caused losses of US$3.54 trillion (in PPP) (Eckstein, Künzel, Schäfer, & Winges, 2019). By 2100, financial losses accrued from damages are estimated to increase to US$54 trillion and US$69 trillion as a result of a rise in atmospheric temperature of 1.5ºC and 2ºC, respectively (Hoegh-Guldberg, et al., 2018).

The COVID-19 Pandemic will Deepen the Development Challenges

When discussing island sustainability, the complex situation created by the COVID-19 pandemic cannot be ignored. The economic and social cost of the

pandemic is expected to be devastating. Island economies that rely on tourism will face significant challenges. But the bad news does not stop there.

The direct domestic economic impact of the pandemic is very difficult to predict, and the extent and duration of the damage will depend on the success of the measures underway in each country to combat the spread. Face-to-face services sectors are experiencing a sharp decline, as businesses are ordered to close and consumers are required to stay at home. Both supply and demand have been severely curtailed. In tourism-dependent economies, this effect exacerbates the decline in tourism arrivals, while in commodity-dependent economies, it amplifies the decline in commodity prices and its impact on government revenues (Rosenblatt, Mooney, & Alejandra Zegarra, 2020).

Some Caribbean economies are among the most tourism-dependent in the world. Tourism accounts for 11- 19 percent of direct output (GDP) and 34-48 percent of total GDP in The Bahamas, Barbados, and Jamaica. Tourism flows are responsible for similarly large shares of direct and overall national employment, with all three countries ranking in the top 20 globally on both measures (Rosenblatt, Mooney, & Alejandra Zegarra, 2020).

The significance of tourism on those economies dependent on this sector is clear. The potential implications of the current crisis are, however, more difficult to determine. Annual tourism arrivals increased appreciably from 2000 through 2019 for The Bahamas, Barbados, and Jamaica—by 73%, 37%, and 91%, respectively.

Given the unprecedented shock to tourism driven by the COVID-19 outbreak, developing scenarios and simulations can provide some indications of potential implications. When simulating the possible impact on GDP of three shock magnitudes (i.e., a reduction of tourism activity by 25, 50, and 75 percent) over three time horizons beginning on April 1, 2020 (i.e., through end-June 2020, end-September 2020, and end-December 2020).

At the extreme, a high-impact scenario of a 75 percent reduction in tourism arrivals over the last three quarters of the year could reduce GDP relative to the pre-crisis baseline expectation by between 11 and 26 percent in The Bahamas, Barbados, and Jamaica. Countries that are less tourism dependent would also be less affected across our range of scenarios, although other channels not simulated here could also have large impacts (IDB, 2020).

In economies reliant on oil and gas production, the key factor is the commodity price decline. In Trinidad and Tobago, gas production outperforms oil production tenfold in equivalent barrels of oil. Based on the December 2019 production (3.4 billion cubic feet per day), 2020 gas production is estimated at 1.25 trillion cubic feet. For April to December 2020, gas production would amount to 933.3 billion cubic feet. Taking the IMF's 2020 gas price of 2.7 US$/mmbtu, the value of gas exports for April-December is estimated at US$2.51 billion.

However, assuming a gas price of US$1.8/mmbtu, the government's current working assumption, the value of gas exports would drop to US$1.67 billion, corresponding to a 33 percent drop in the value of gas exports. Assuming a gas price of US$1.6/mmbtu, the value of gas exports would drop by 40 percent. Natural gas and oil exports together add up to about 18 percent of GDP. The knock-on effects of lost income and potential decline in sector investments could have a large effect on economic growth this year (IDB, 2020).

Economists everywhere have expressed concern about a synchronized recession in large countries. There is a high probability of a synchronized recession among Caribbean countries. The ongoing shock is having an unprecedented economic impact on Caribbean countries. To protect public health, countries have undertaken strong measures to limit the spread of COVID-19 by implementing social distancing measures and restricting internal and international travel. In 2020, the ongoing shock will affect economic growth and other macroeconomic aggregates. Policies are being considered to support affected households and businesses, but current policy constraints will likely cause a trade-off between public health and economic health. Over the medium term, a multisector approach to putting the economy on a sustainable growth path will have to be carefully developed.

Island nations, which will suffer catastrophic economic consequences of COVID-19, also bear the burden of fossil fuel pollution, increased greenhouse gas emissions, sea level rise, and climate disasters. It is imperative to renew the efforts to build a more sustainable future and protect islands and their populations. The fight against COVID-19 and the global economic recovery should not be at the expense of vulnerable islands and the fragile global ecosystem. Addressing climate change does not have to slow down the economic recovery; on the contrary, this might be the time to increase investment in renewable energy, reduce fuel dependence, foster innovation and implement a climate-focused economic recovery that fosters the sustainability of Caribbean islands.

Caribbean Islands and Climate Change

Climate change alters the frequency, duration, and intensity of extreme weather events, further complicating the chances of sustainability of islands, given their intrinsic vulnerability. The effects of climate change are already evident: warming of the ocean surface has already been detected. This trend is expected to continue in the Caribbean region, reaching between 0.5°C and 1.5°C of warming. Compared to the 1971–2000 baseline, up to half of the year is projected to be under warm spell conditions in the Caribbean at 1.5°C, with a further increase of up to 70 days at 2°C (Taylor, et al., 2018).

Considering human-induced climate change, which causes global temperature increases, sea level rise, and more frequent extreme weather events, many island nations and regions are currently experiencing and will continue to face

serious problems with environmental sustainability, water quantity and quality, and exceptionally high costs associated with these issues. Economic sustainability is also a critical issue facing island economies, with many experiencing limited or no growth, particularly those that depend on tourism. Where will the necessary growth come from if the traditional drivers of growth such as tourism or agriculture are stagnant? Islands are surrounded by oceans, which are potential developmental spaces from which a new economy can emerge.

Although the negative impacts of climate change on islands' sustainability could be reduced through effective adaptation measures, there is a limit to how effective these measures can be. For this reason, small islands are insisting on a global cap on greenhouse gas emissions that would increase global average temperatures to 1.5˚C above pre-industrial levels. Global warming above1.5˚C would threaten the existence of some islands (Strauss & Kulp, 2018).

The ocean is an integral component of the global economy that provides vital services to the world's population directly and indirectly. It provides the world with vital materials like minerals and food, which are shipped internationally on ocean liners (Secretariat of UN Conference on Trade and Development, 2019). Oceans generate oxygen and absorb carbon dioxide. This maintains global temperatures and weather patterns, providing the world's population with non-market services. Additionally, oceans contribute to coastal protection, cultural services, and tourism (Costanza, et al., 2014). Market and non-market ocean-based industries are the seventh largest economy, earning an estimated US$2.5 trillion annually (Cabral, Gaines, Free, & Golbuu, 2019).

"Multiple studies published in peer-reviewed scientific journals show that 97 percent or more of actively publishing climate scientists agree: climate-warming trends over the past century are extremely likely due to human activities" (Cook, Oreskes, Doran, & Anderegg, 2016). Anthropogenic climate change and environmental pollution are apparent, as are their impacts on human and natural systems (IPCC, 2015). Among these changes are the immediate and gradual changes to the world's oceans, which in turn affect the global economy (Pörtner, et al., 2019). Islands already face numerous development challenges due to their scarce land mass, economic dependence on ocean industries, and reliance on imports, especially fossil fuels (Dornan, 2015), which make their economies vulnerable to changes in global trade (Lederman & Lesniak, 2017). Climate change impacts even under a low-emission pathway are expected to cause island and coastal communities' disproportionately higher risks throughout this century, which account for 28 percent of the global population (IPCC, 2019; Pörtner, et al., 2019).

Sea level rise, combined with human activities like coastal infrastructure development, is already affecting coastal areas. Toward the end of this century, sea level rise is expected to increase more rapidly under all emission scenarios, even those consistent with the Paris Agreement (Pörtner, et al., 2019). This is

expected to cause biodiversity damage and population relocation inland, which in turn could cause the degradation of saltwater marshes and mangroves, which humans destroy to create more space for infrastructure (Cabral, Gaines, Free, & Golbuu, 2019).

Climbing global temperatures cause sea levels to rise worldwide. Melting glaciers and collapsing ice sheets swell the oceans and increase ocean temperatures, causing thermal seawater expansion. While rising tides are a threat to all coastal places, the Caribbean Basin is unusually vulnerable due to the flat, low-lying topography, porous limestone bedrock, and tropical cyclones common to the area.

Global society must ultimately choose a carbon emissions pathway to follow over the coming years. This choice will have profound consequences for the Caribbean in the second half of the century. The differences between pathways could be amplified even further if recent research is correct in suggesting greater-than-expected instability in Antarctica. In such a case, low emissions scenarios could prevent the Caribbean from experiencing an additional one meter of sea level rise by 2100 (Strauss & Kulp, 2018).

In nearly all cases, floods reaching 0.5 meters above contemporary high tide levels appear likely to become common throughout the Caribbean within the next several decades to half century. Floods reaching 1 meter above today's high tide lines may become the new routine later in the century, especially in the event of rapid Antarctic ice loss (Strauss & Kulp, 2018).

Long-term sea level rise set in motion by near-term carbon emissions threatens major coastal cities across the world. Science-based imagery reveals the stakes for the Caribbean. The first image in each pair below shows projections of post-2100 sea level rise that could be locked in following 4°C (7.2°F) of warming from carbon pollution. This pathway corresponds roughly to business as usual. The second image in each pair shows projections based on 2°C (3.6°F) of warming, corresponding to the upper limit target named in the 2015 Paris Climate Agreement. Figure 4 and 5 show the estimated flooding of Kingston, Jamaica and a realistic picture of the impact(Strauss & Kulp, 2018).

Figure 4. Potential flooding impact on downtown Kingston, Jamaica.
Source: Strauss & Kulp (2018).

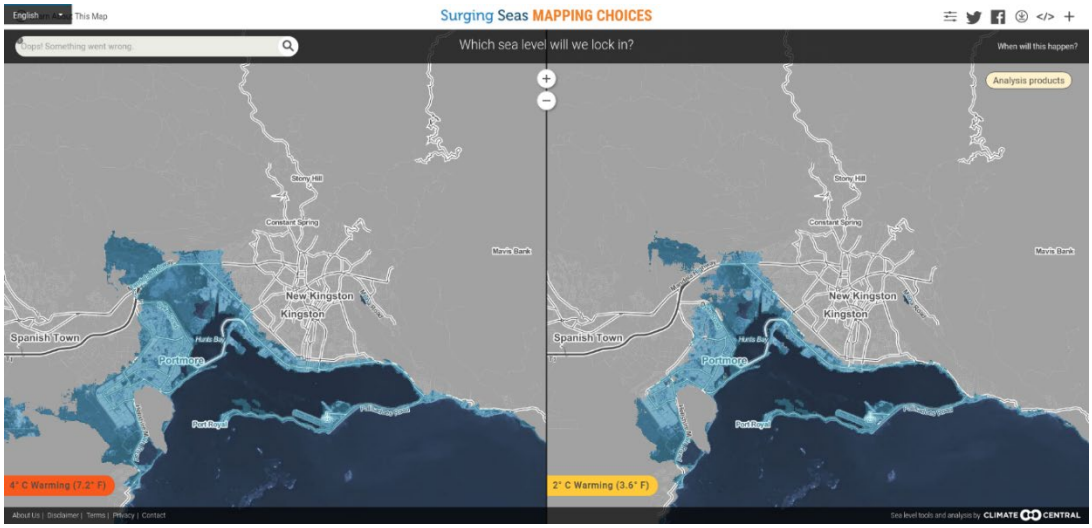


Figure 5. Visualization of potential flooding impact in downtown Kingston, Jamaica.
Source: Strauss & Kulp (2018).

Ocean warming is changing the distribution of ocean animals, including plankton, marine mammals, and fisheries of high economic importance. In some cases, species are relocating to new areas, which increases demand on coral reefs, seagrasses, and local species (Albins, 2013). Warming can also alter ocean nutrient cycles and cause stratification (Pörtner, et al., 2019).

Change in ocean chemistry is directly linked to increased occurrences of algae blooms and the alteration of marine habitats (Griffith & Gobler, 2020). Ocean chemistry includes deoxygenation, eutrophication, and acidification that can be attributed to ocean warming and storage of atmospheric CO_2. Algae blooms have adverse impacts on coastal habitats, fisheries, and tourism, all of which negatively affect island economies (Cabral, Gaines, Free, & Golbuu, 2019). Rising concentrations of atmospheric CO_2 also cause ocean acidification, which threatens marine biodiversity by causing coral death and therefore altering entire marine habitats (Doo, Edmunds, & Carpenter, 2019).

The Caribbean region is among the most vulnerable to natural disasters (Rasmussen, 2004)**. Caribbean islands are located within the hurricane belt, making them highly vulnerable to the effects of storms and flooding.** In recent years, the frequency and intensity of hurricanes in the Caribbean have been increasing, a trend that is expected to continue with rising global temperatures and changing weather patterns. Worryingly, the Caribbean region is becoming more exposed to the potential damages from tropical storms just when economic activity in coastal areas seems to be increasing (McGranahan, Balk, & Anderson, 2007).

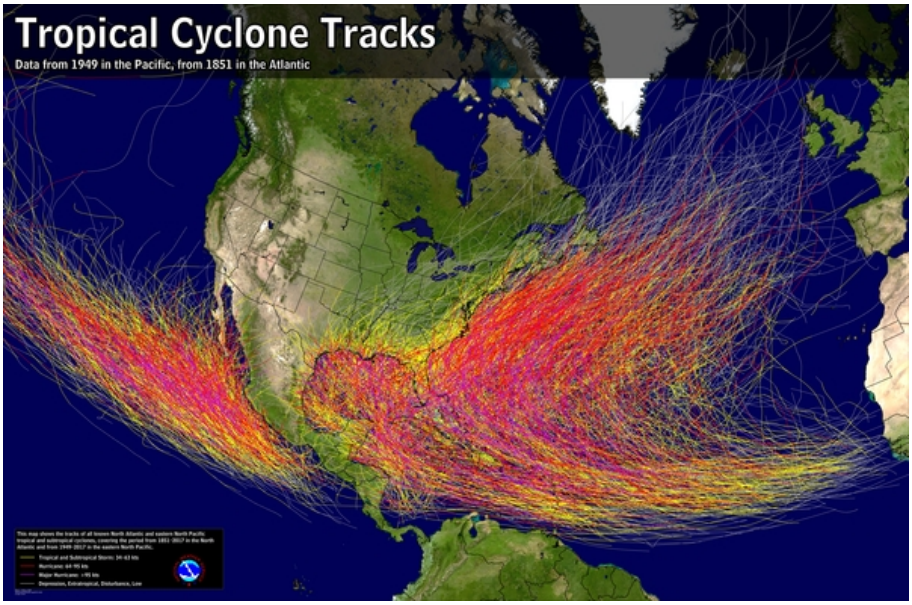
Extreme weather events are associated with climate change and are directly linked to tropical cyclones. These include heat waves, torrential rains, and high winds. Torrential rains cause erosion, which affects infrastructure and degrades beaches, negatively affecting tourism (Toubes, Gössling, Hall, & Scott, 2017). Climate change has caused heat waves to become more common and last longer and to have negative impacts on coral reefs, seagrasses and kelp forests (Pörtner, et al., 2019). Wave height increased average wind speed, and precipitation are associated with tropical storms. Extreme weather events are expected to increase in intensity and occurrence throughout this century (Pörtner, et al., 2019). Tropical cyclones are associated with storm surge, which will be exacerbated by sea level rise and be capable of causing infrastructure and habitat damage to coastal areas (Vitousek, et al., 2017).

Since 1960, the Caribbean has reported more than 300 storms, 132 floods, and other natural disasters. Together they have resulted in 251,802 deaths and an estimate loss of US$44.6 billion. The OECS region is particularly prone to natural disasters. For example, Hurricane Ivan caused losses of over 300 percent of Grenada's annual GDP, while the heavy rains due to a tropical trough system in St. Vincent and the Grenadines in 2013 caused damage amounting to nearly 15 percent of GDP. On September 1, 2019, Hurricane Dorian hit The Bahamas. The Category 5 hurricane, with wind gusts peaking at 185 mph, became the

most powerful hurricane ever to hit the archipelago, leaving catastrophic damages on Abaco and Grand Bahama. An estimated 70,000 people were left homeless, 200 dead and an estimated $3.4 billion dollars in damages.

The effects of climate change, in the absence of adaptation, could cost the region up to 5 percent of GDP in 2025, increasing to almost 22 percent of GDP by 2100 (Bueno, Herzfeld, Stanton, & Ackerman, 2008). Figure 6, a map from the National Hurricane Center, depicts tropical storms that have hit the Caribbean since 1851.

Figure 6. Tropical cyclone tracks.
Source: National Hurricane Center (2020).



Disasters caused by tropical cyclones pose a major threat to the region. Fifteen Caribbean islands are in the top 25 positions for having the most tropical cyclone disasters per square kilometer, and another seven islands rank in the top 50 (IMF, 2016).

Changes in tropical cyclone and hurricane tracks have also been observed in recent times. Historically, Trinidad and Tobago has rarely been affected by tropical cyclones and storms. Few pass within 20 nautical miles of Trinidad and Tobago, and even fewer make landfall (Trinidad & Tobago Weather Center, 2020). But according to an IDB study on the economics of climate adaptation, cyclone tracks have been observed to be shifting south and are having more of an effect on areas which have generally been safeguarded from the impacts of these extreme weather events. Sea level rise caused by climate change "increases the effects of the tropical cyclones and hurricanes magnifies the coastal flooding generated by storm surge and waves," (IDB, Factor CO2, IH Cantabria, the University of the West Indies, 2014)(Alleng, 2014). More frequent storms passing over Trinidad and Tobago in combination with the impacts of climate change could result in US$36.9 million in damages compared to US$19.6

million in mean damage of today's vulnerability scenario (Inter-American Development Bank, Factor CO2, IH Cantabria, the University of the West Indies, 2014).

In 2017, the punishing Hurricanes Irma and Maria provided sharp reminders of this vulnerability. Extreme events like these are already catastrophic to lives and infrastructure in the low elevation coastal zone and will become even more so as sea level rise continues to increase the height of storm surges.

Hurricane Irma, a Category 5 hurricane with record-breaking wind speed in the Atlantic, impacted several Caribbean islands, including Anguilla, Antigua and Barbuda, The Bahamas, British Virgin Islands, Cuba, Saint Martin, Sint Maarten, Turks and Caicos, and the U.S. Virgin Islands, that were in its path after making landfall on September 5, 2017 (Pan American Health Organization, 2017).

Two weeks later, Hurricane Maria, another Category 5 hurricane, brought further devastation to the Caribbean islands, adding Dominica, Guadeloupe, Martinique, and Puerto Rico to the list of heavily impacted islands. According to an initial assessment of infrastructure damage, Antigua and Barbuda, Saint Martin, and Sint Maarten had an average of above 85 percent of total destruction from Hurricane Irma, whereas Anguilla and the Bahamas were less affected with a destruction of buildings and infrastructure averaging 30 percent (Pan American Health Organization, 2017).

The country most affected by Hurricane Maria was Dominica, with over 90 percent of the island infrastructure destroyed, which resulted in critically damaged water, electricity, and communication services. The country's mortality rate is currently at 37 deaths per 100,000, followed by Saint Martin, with a rate of 28, and Anguilla, with 27 per 100,000, respectively. The highest total mortality count has been in Puerto Rico, with 45 deaths, followed by Dominica with 27 and Saint Martin and Cuba, both with a total of 10 deaths.

Tropical cyclones in the Caribbean cause damage every year, with damages averaging 1.6 percent of GDP. However, recent IMF studies show that the damages could be under reported, making the real impact 1.6 to 3.6 times larger. Climate change will only exacerbate these costs in the future, and if no significant efforts to limit CO_2 emissions worldwide are carried out, even in the most conservative scenarios, damages could increase by at least 11 percent (IMF, 2016).

The Caribbean must prepare to cover the current and future cost of storms. More efforts are needed to make infrastructure more resilient to sustain the expected future damages resulting from global warming. Adaptation measures, "such as improved early warning systems, better building codes and zoning laws, accompanied by stricter enforcement will also help reduce future damages, even in the absence of climate change" (IMF, 2016).

Island as the Unit of Measure: Using a Systems Thinking Approach

3. Island as the Unit of Measure: Using a Systems Thinking Approach

Applying Systems Thinking to Help Islands Move toward Sustainable Development

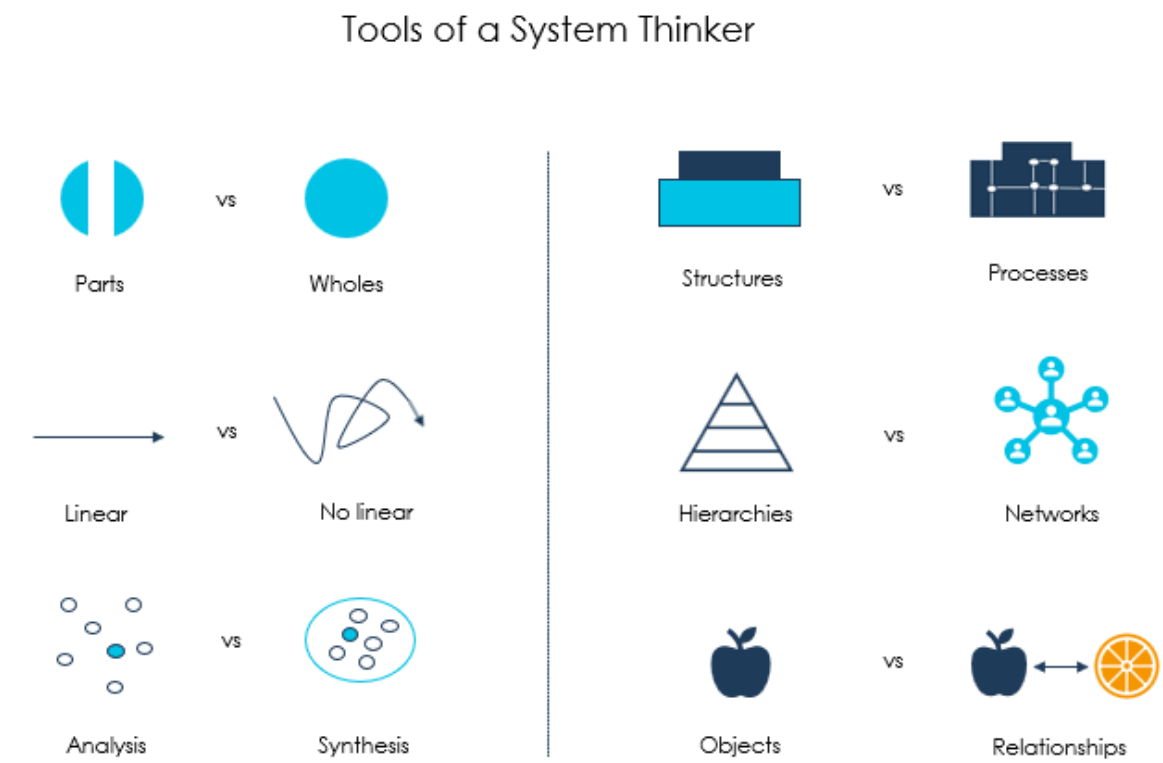
"Traditional fragmented and mechanistic science is unable to cope with issues about sustainability, as these are often related to complex, self-organizing systems… System Dynamics, which operates in a whole-system fashion, is put forward as a powerful methodology to deal with issues of sustainability" (Hjorth & Bagheri, 2006)**.** Systems dynamics, one branch of systems thinking, is a thinking model and simulation methodology developed specifically to support the study of dynamic behavior in complex systems. Widely used around the world and across industries, this framework uses data and technology to model the relationships between all the parts of a system and illuminates how those relationships influence the behavior of the system. Islands are a system.

Systems thinking is the process of understanding how things influence one another within a whole. Many examples can be seen in nature, including ecosystems, in which various elements such as air, water, plants, and animals work together to survive. In organizations, public or private, systems consist of people, structures, and processes that work together to make an organization effective (Sanneh, 2018).

Systems thinking focuses on cyclical rather than linear cause and effect. Systems thinking is not one thing but a set of habits or practices within a framework that is based on the belief that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation (Senge, 2006).

A systems approach can be defined as an attempt to understand the world as a series of interconnected systems or subsystems, each with its own collective parts working together to maintain the proper functioning of the system. An underlying element of this concept is inter-dependency of the parts, regardless of the size of the system. These parts—social, economic and environment pillars—are the basis for sustainability. They equally support its goals and should not be mutually exclusive.

Figure 7. From Linear to Systems Thinking.
Source: Acaroglu (2017).



"Meeting sustainability objectives will certainly require an increased understanding of the interactions between nature and society. Issues about sustainability are not merely complicated, they involve subsystems at a variety of scale levels and there is no single privileged point of view for their measurement and analysis. Such problems can neither be captured nor solved by sciences that assume that the relevant systems are simple. If something really is complex, it cannot be described by means of a simple theory, and a major problem seems to be that our technologies have become more powerful than our theories" (Hjorth & Bagheri, 2006).

A core element that underscores sustainability is climate resilience, which can be defined as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change" (IPCC, 2015)**.** This ability to respond to disturbances will be limited by human and institutional capacity as well as financial and resources capacity. But there is also a spatial dimension to this absorptive ability, which will influence sustainability efforts. This spatial dimension is dictated by the biophysical setting and determines whether there is space or adequate space that allows the system to absorb the disturbance. It is for this reason that some coastal biological systems, such as mangrove systems, will not survive. Coastal squeeze describes the situation

where sea level rise causes landward migration that is restricted by topography or human development (Ellison, 2015).

The Millennium Ecosystem Assessment analyzes "island systems" as a land category, regardless of whether they are states or territories within larger states (MEA, 2005)**.** Similarly, in its reports the IPCC refers to small islands in general, regardless of whether they are states or part of larger states (Barker, 2007; Kaito, et al., 2014).

Unsustainable development threatens the livelihood of humans and the biological resources (marine and terrestrial) on which they depend. Given limited development options for islands, planning and implementing sustainable development interventions require an integrated approach in the management of resources, paying special attention to protecting the environment and people's livelihoods (MEA, 2005; UNEP-WCMC and IUCN, 2014).

A systems approach to sustainable development is fundamental given the threat of climate change to Caribbean islands. Some of the expected effects of climate change on the Caribbean as identified by UNEP include: (i) deteriorating coastal conditions; (ii) floods, storm surge, erosion, and other coastal hazards; (iii) reduction in freshwater resources (iv) economic losses from reduced agricultural yields; (v) bleaching and acidification of the ocean; (vi) damage to forests caused by extreme events; (vii) reduction of general water resource availability; (viii) inundation of coastal settlements and arable land on the coast; and (ix) reduction in tourism (UNEP, 2014).

Thus, when analyzing the interactions between humans and nature, systems dynamics provides essential system properties to better understand the complexity of sustainable development: bounded rationality, limited certainty, limited predictability, indeterminate causality, and evolutionary change (Hjorth & Bagheri, 2006).

Islands ought to be managed as living organisms which requires a different type of thinking, where the island itself is the unit of measurement as opposed to pursuing only a sector approach. Public policy ought to be focused on achieving the triple goal of sustainability: sustainable economic growth, environmental protection, and human equity.

Key Areas to be Considered When Thinking about Caribbean Islands

A. Freshwater

Many islands are already experiencing shortages in freshwater availability due to anthropogenic pressures, the natural fragility of water resources, and the scarcity of economic resources, which prevents the development and implementation of comprehensive plans to solve the problems in water

distribution systems in the Caribbean (UNEP, 2014)(IDB, 2011). Rainfall records for the Caribbean region, show a consistent reduction in rainfall. Average Caribbean rainfall records from 1900 to 2000 show a consistent 0.18 mm yr–1 reduction in rainfall, a trend that is projected to continue (IPCC, 2014). Regional climate models show a trend of increasing temperatures that will lead to greater evapotranspiration stress, which in turn increases the occurrence of heat waves. It also causes reduced precipitation at the regional Caribbean level, which could have detrimental effects on the availability of water resources for human consumption, economic activities, and biodiversity if adequate measures are not taken promptly (Oglesby, et al., 2016; Stock, 2014)

Given the limited geographic space of island territory, the catchment areas are also limited, which restrains the amount of the precipitation that enters surface and underground water flows. Moreover, the altered hydrological cycles and precipitation variance and saltwater intrusion negatively affect the availability of freshwater (FAO, 2007; Field, et al., 2014; Secretariat of the United Nations Framework Convention on Climate Change, 2007). Freshwater scarcity is becoming frequent in Caribbean island territories as it is in most islands (UNEP, 2014) and is aggravated by an existing deficit of adequate storage facilities and delivery systems (UN-OHRLLS, 2011; Field, et al., 2014).

Islands have had a negative impact on water resources in terms of water quality and quantity as well as flow regimes. Without adequate freshwater resources, small islands will have to depend on desalinated or imported water. Water supplies in island territories are often threatened by pollution, particularly from poorly treated sewage, inadequately managed solid waste, and chemical-dependent agriculture (Duraiappah, et al., 2005; UN-OHRLLS, 2011; UNEP, 2014a & 2014b).

B. Agriculture

In general, increased intensity and frequency of cyclones, drought and flooding, changing rainfall patterns affecting hydrological cycles, and precipitation variance have implications for future food availability (FAO, 2007); Secretariat of the United Nations Framework Convention on Climate Change, 2007; Nurse, et al., 2014). In the case of islands, climate change threatens food crops, especially coastal-concentrated agricultural land and infrastructure (United Nations, 1994; UN-OHRLLS, 2011). Climate change will adversely affect subsistence and commercial agriculture on small islands: sea level rise, inundation, seawater intrusion into freshwater lenses, soil salinization, and decline in water supplies are likely to adversely impact coastal agriculture (IPCC, 2014; United Nations, 1994; Watson, Zinyowera, & Moss, 1997; UNFCCC 2007; UNEP 2014b).

The projected impacts of climate change on islands' sustainability include: economic losses from reduced agricultural yields due to a shorter growing season because of weather events or drought (United Nations, 1994). Unlike in continental areas like the Ecuadorian Andes, or the United States, where the movement of local crops and crop varieties constitutes a feasible, locally-based

adaptive response to changes in growing conditions induced by climate change (Skarbø & VanderMolen, 2016; Weise, 2013), crop migration on islands is a difficult task given the scarcity of available arable lands in their already limited geographic space.

Scientific evidence shows that climate change is creating conditions for enhanced invasiveness of certain native and exotic species in island ecosystems, while at the same time limiting the ability of other species to adapt to changes in their habitats (IPCC 2007; Duraiappah et al., 2005; UNEP 2014a). This applies to vegetal and animal species potentially becoming weeds and pests, with economic impacts on agriculture.

C. Fisheries

The fisheries sector is a major foreign exchange earner on islands and is vital to sustain the livelihoods of island populations. Per capita annual consumption of fish in the Caribbean is approximately 15 kilograms, which is approximately three times that of the United States. Nevertheless, resources are at risk for being depleted after having been overexploited for extended periods of time (Duraiappah, et al., 2005).

In addition, there is a tendency for island populations to be highly concentrated in narrow coastal areas, as observed in the Caribbean where more than 50 percent of the population lives within 1.5 kilometers of the shoreline (IPCC, 2014; UN-OHRLLS, 2011). This places pressure on coastal resources to maintain livelihoods in terms of income and food security. Under these circumstances, maintaining sustainability in the use of coastal and marine resources poses a challenge (UN-OHRLLS, 2011; UNEP 2014b). This in turn impacts the ability to sustainably manage a *blue ocean economy,* where the maintenance of the health of surrounding oceans is impacted.

D. Tourism

Tourism is one of the most important economic activities for islands, but due to the large seasonal influx of tourists, it places stresses on local infrastructure and resources (UNEP 2014b). Energy and water demand for tourism is high, mainly during the peak seasons when air conditioning and water demands are high. Tourism also produces important amounts of waste, which presents a big problem in a space-constrained ecosystem such as an island (Krajačić, da Graça Carvalho, & Duić, 2008). Tourism development without proper planning, management standards, and guidelines poses a threat to the environmental health of islands and therefore the island's appeal as a tourist destination (Duraiappah, et al., 2005; UN-OHRLLS, 2011)

Climate change affects the occurrence and intensity of El Niño-Southern Oscillation (ENSO) events, which increases sea surface temperature, sea level, damage from tropical cyclones, and alterations in the ocean's physical and

chemical conditions. These impacts are likely to affect marine ecosystems by accelerating beach erosion and degradation and bleaching of coral reefs, which sustain island fisheries and tourism. The effects of climate change on tourism are likely to be both direct and indirect, and largely negative (UN 1994; IPCC, 2007; Nurse, et al., 2014).

Sea level rise, accelerated beach erosion, degradation of coral reefs (including by coral bleaching), and the loss of cultural heritage on the coasts through inundation will likely reduce the attractiveness of small island states to tourists. Increases in the frequency or intensity of hurricanes and cyclones will also severely affect the tourism industry (UNFCCC 2007a). It is estimated that up to 38 percent of the total current beach areas on Caribbean islands could be lost with a 0.5-meter rise in sea level, with lower and narrower beaches being the most vulnerable. This also has the potential to reduce turtle nesting habitats by one-third (IPCC, 2014). Up to 60 percent of tourist beach resorts would be lost with sea level rise of 1 meter, which would decrease destination appeal (Nurse, et al., 2014). Water shortages and the increased danger of vector-borne diseases may also steer tourists away from small islands (UNFCCC 2007).

E. Energy

With the exception of Trinidad and Tobago, energy costs in Caribbean countries are relatively high. The cost of fuel (gasoline and diesel) is higher than the global average. Moreover, electricity prices are some of the highest in the world and fluctuate greatly along with global oil prices (IDB, 2013). The main reason for the high cost of electricity is that most Caribbean countries use diesel and heavy fuel oil for electricity generation (IDB, 2013). Energy production faces challenges in terms of security, quality, and reliability (Krajačić, da Graça Carvalho, & Duić, 2008) (Duraiappah, et al., 2005) ; UNEP 2014a, 2014b).

The effect of high energy prices lowers firms' competitiveness, reduces household disposable income, and has a big impact on countries' external accounts. Hence, the region must move toward creating a new energy portfolio consisting of a mix of renewable energy sources, bioenergy, and fossil fuels.

As most island systems are isolated grids where there are no connections to mainland systems, their vulnerability to the impacts of climate change is high as their infrastructure is at high risk to climate change impacts, and there are few redundancies or back-up systems.

F. Transportation

More than 50 percent of the population lives within 1.5 kilometers of the shore in Caribbean islands. This is where most of the islands' critical infrastructure, such as airports, roads, hospitals, and urban centers, is located. Sea level rise will exacerbate flooding, erosion, and other coastal hazards, which threatens vital

infrastructure and thus compromises the socio-economic well-being of island communities and states (UN 1994; IPCC 2007). Replacing or adjusting these assets will be a challenge to island territories given cost and physical limitations.

Connectivity and accessibility are considered key issues for islands because of small size and isolation (Karampela, Kizos, & Spilanis, 2014). The small size of island economies negatively influences their connectivity with the international transportation system, adding to their already constrained integration into international markets, their ability to create economies of scale, the high cost of doing business, and their low economic resilience to external shocks (United Nations, 1994; IMF, 2013; Nurse, et al., 2014; UNEP 2014a). In relation to maritime transport, relevant challenges are affecting, among others, shipping services, transport costs, port infrastructure and equipment, and markets size and operations (Duraiappah et al., 2005; The Secretariat of the United Nations Conference on Trade and Development, 2019).

G. Waste

Population growth is putting pressure on waste disposal systems, which creates a tremendous problem in a space constrained ecosystem such as an island (Krajačić, da Graça Carvalho, & Duić, 2008) (UNFCCC 2007;Duić et al., 2008; UNEP 2014a). In addition, in tropical regions, climatic conditions tend to be conducive to the transmission of diseases such as malaria, dengue, filariasis, schistosomiasis, and food and waterborne diseases. The incidence of these diseases is high on islands because of poor public health practices, inadequate infrastructure, changing climatic conditions, and poor waste management practices. (IPCC, 2014) For these reasons, there is a need to minimize waste in quantitative and qualitative terms within the Caribbean (Riquelme, Méndez, & Smith , 2016).

H. Health

Health and health care services on small islands have been a concern for a number of years (Hotchkiss, 1994). Some of the issues are "communication difficulties leading to insularity; small populations not reaching the critical mass needed to make the provision of specialists or expensive facilities viable; and a susceptibility to epidemics of infectious diseases in more isolated communities among other things" (ibid, 1994). Islands are more susceptible to epidemics because of their size. There are indications that many small islands experience high burdens from climate-sensitive health impacts including morbidity and mortality due to extreme weather events in combination with the increased rate of certain vector, food and waterborne diseases (Ebi, Lewis, & Corvalan, 2006; WHO, 2003; Ebi et al., 2006). These impacts are expected to increase with climate change, and it is suggested that small islands are the canaries in the coal mine regarding climate change and health (Hanna & McIver, 2014).

I. Migration

There is a growing discussion of climate-induced relocation as a result of the impacts of climate change, including the possibility that entire populations of low lying islands will need to be relocated if the sea level rises one meter (Raleigh, Jordan, & Salehyan, 2008; ADB, 2012). Although climate migration will not be limited to island states, its impact will be more acute in low-lying islands where no viable protection mechanism exists faced with the real threat of complete loss of land of these territories (IPCC, 2015). Increased conflict can be expected due to the mass movement of people away from vulnerable areas (GEF, 2009).

The pursuit of sustainability in the context of small islands will have to be a highly integrated process involving all sectors to achieve a measure of self-reliance, given their characteristics. This pursuit will have to be done within the framework of the Sustainable Development Goals, to which countries have already committed.

From Seeing the Parts to Seeing the Whole

Sustainable development of islands requires the calibration of three kinds of non-linear systems: environmental, social, and economic. These systems include laws, regulations, taxation, policies, elections, health, education, employment, crime, violence, and markets with biology, hydrology, geology, wildlife, climatology, and land-use. These systems work on different time scales and by different processes as parts of a whole in a single island biosphere. Systems thinking and systems tools can help countries better deal with the complexities of interacting non-linear systems. Today, countries live in designed systems which have been established over time without a coherent logic of sustainable development. Thus, it should not be surprising that the pieces of the puzzle do not make a whole. If nations established the systems by which they are governed and provisioned today, they can most certainly redesign them. The application of systems analysis is no panacea, but it will provide a framework to understand complex problems and unintended consequences.

Island models as a system of ecological, social, and economic inputs and outputs are useful tools to place seemingly disparate and confusing data into its larger context to improve decision making across sectors, departments, and agencies. When confronted with the overwhelming amount of existing data and sectoral knowledge, systems analysis can help governments organize information to distinguish the ecological and social signals from the noise and avoid data/information paralysis. As complex systems, islands provide a confusing array of inputs and outputs: fossil fuels, agriculture production, fishing, food imports, materials, fresh water, and tourists as part of the inputs, and carbon dioxide, wastewater, waste management, pollutants, violence, crime, unemployment, high debt, and ecological degradation as outputs.

The data necessary to understand resource flows and the larger ecological, social, and economic context of an island can also be used to educate the citizenry to understand the relationships between their behavior and the environmental and economic prospects. The use of internet and public information channels could share data to change public attitudes. Systems analysis would also improve planning and forecasting, including decisions about zoning, land-use, location, and type of infrastructure, building codes, food supply, taxation, and emergency preparedness, with a sustainable development framework in mind.

Systems thinking can lead to greater realism and preventative public policies for the simple reason that most systems are nonlinear and therefore inherently unpredictable. It would also give citizens the necessary information to show that everyone shares responsibility for problems generated by a system. Systems thinking and dynamics provide higher-level precision and analytical power inherent in sophisticated computer modeling. Systems dynamics may be a powerful tool to clarify the consequences of policy decisions and actions and identify better options because of increased foresight.

An example of systems thinking is presented in: A Systems Dynamics Approach for Urban Water Reclamation-Reuse Planning: A Case Study from the Great Lakes Region, Center for Green Chemistry & Green Engineering at Yale (Yale University, 2017). The project involved the creation of a systems dynamics computer model of the water and sanitation system in the Great Lakes region, extending the system to include water reuse and determining if water reuse is cost effective under different scenarios.

Figure 8. Example of Systems Dynamics Modeling. Source: Yale University (2017).

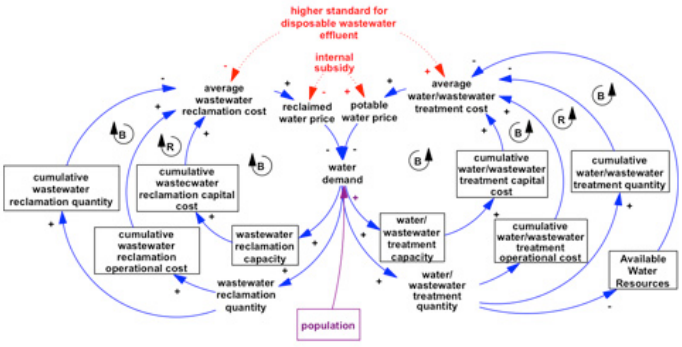


Figure 8 depicts the systems dynamics used to analyze water reclamation and reuse. "Appropriate water reclamation and reuse practices are critical due to increasing water scarcity, concerns about the effect of wastewater discharges on receiving water, and availability of high-performing and cost-effective water reuse technologies. However, incorporation of water reuse schemes into water/wastewater infrastructure systems is a complex decision-making process,

involving various economical, technological, and environmental criteria. System dynamics allows modeling of complex systems and provides information about the feedback behavior of the system," (Yale University, 2017).

Paradigm Shift from Small Island Developing States to Big Ocean Countries

4. Paradigm Shift from Small Island Developing States to Big Ocean Countries

Moving from Land-based to Ocean-based Territories when Conceiving Islands

Oceans cover more 72 percent of the earth's surface, which provides food, jobs, and recreation to a large share of the world's population. Oceans are also a significant driver of global GDP where 80 percent of global trade, 32 percent of hydrocarbon extraction for energy, and tourism in 200 countries depend on it. Recent studies estimate that the ocean economy contributes US$1.5 trillion annually (OECD, 2016). Marine services, including shipping and tourism, generate around US$880 billion, marine resources generate US$377 billion, and marine manufacturing generates US$107 billion per year, all of which provide more than 350 million jobs (OECD, 2016).

A recent World Bank report "estimates for the first time the gross revenues generated by the ocean economy in the Caribbean as a baseline for future policy, which are estimated at US$407 billion (as of 2012), equivalent to some 14-27 percent of the estimated value of the global ocean economy (though the Caribbean Sea covers less than 1 percent of the area of the global ocean). The composition of this economy is dominated by the estimated value of the volume of cargo shipped through the Caribbean Sea, together with tourism and oil and gas in the region's island states and territories" (OECD/The World Bank, 2016).

The Caribbean Sea covers 2.75 million square kilometers, less than 1 percent of the world's ocean area, but it directly supports the economies of 37 coastal and small island countries and territories. The region's prosperity is inextricably linked to the health and good management of this natural resource. A more developed ocean economy may help diversify Caribbean economies, contributing significantly to economic growth and employment in the future (OECD/The World Bank, 2016).

The concept of Small Island Developing States is based on the small size of their land mass and their conditions and vulnerabilities, but Caribbean countries, and islands, have jurisdiction over substantial ocean areas that far exceed their land area. "The Bahamas exclusive economic zone, for example, is estimated to be 242,970 square miles compared to its land area of 5,383 square miles, whereas Saint Vincent and the Grenadines' is estimated to be about 13,900 square miles, over 90 times its land area. In the case of Saint Kitts and Nevis, the ocean space is almost 7,900 square miles, with its land area being only 100 square miles" (OECD, 2016).

To capitalize and protect the bounty offered by the Caribbean Sea, a paradigm shift is needed to include the marine territory as a fundamental part of

sustainability and economic growth programs, moving from the *small island* concept to a more accurate concept of *big ocean countries*. Figure 9 shows a map describing islands as terrestrial mass territories plus their ocean jurisdictions, while. Figure 10 shows a map of Caribbean countries as ocean territories that include their limited land mass.

Figure 9. Land-Based Map of the Caribbean with Marine Jurisdictions. Source: University of Caen Normandy (2020).

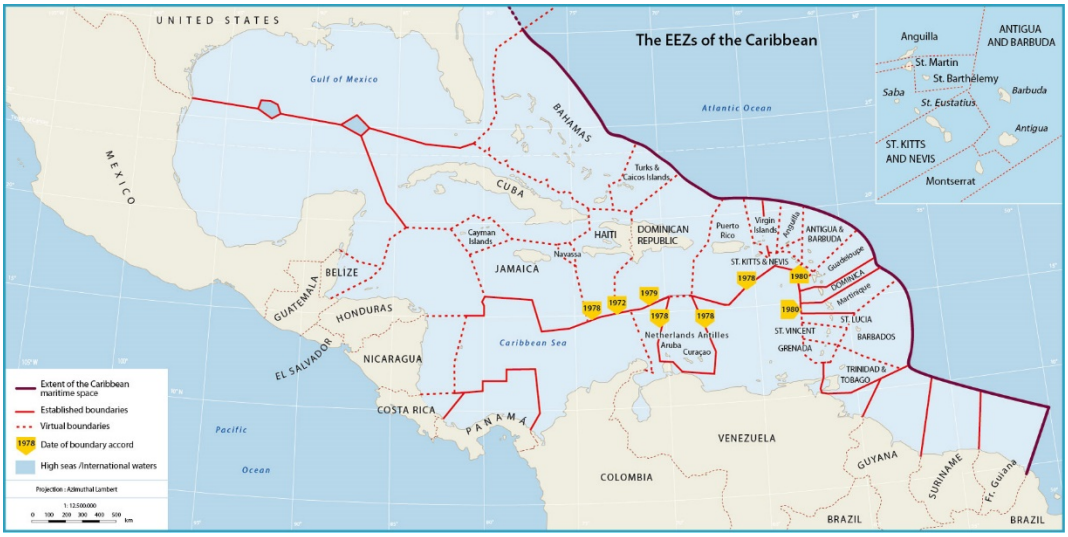
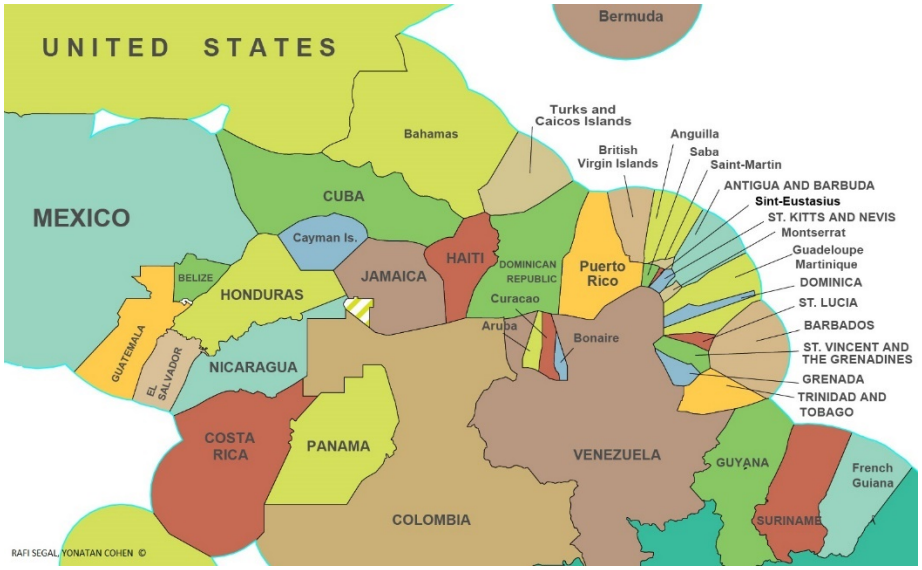


Figure 10. Territorial-Based Map of the Caribbean including the Ocean. Source: Segal & Cohen (2013).



The proposed paradigm shift allows for a more accurate understanding of the natural capital of Caribbean islands, highlighting the potential for growth that lies in the ocean economy. As a result, countries should focus on the need to simultaneously invest in both natural and produced capital, and open up new opportunities in areas such as aquaculture, marine renewable energy, tourism, and marine biotechnology.

The natural capital base of oceans is comprised of natural resources and ecological systems that must be protected. "The natural ocean capital consists of three components: renewable stocks or living resources that are harvested for use such as fisheries, non-renewable stocks or non-living resources harvested for use such as minerals from the seabed, and ecosystems and ecosystem processes that represent the interaction between the living and non-living environment as a functioning unit (e.g. coral reef ecosystems, mangrove ecosystems, etc.)" (OECD/The World Bank, 2016).

Recent studies show that the natural capital of the Caribbean Sea is being depleted, principally due to poorly planned and regulated coastal development, pollution, introduction of invasive species, anthropogenic drivers like overfishing, the increasing intensity of hurricanes and other extreme weather events, and climate change as an underlying driver of many of these impacts. If these issues are not addressed, the Caribbean will not fully reap the benefits of its ocean wealth.

"It is estimated that 35 percent of fish stocks in the wider Caribbean region are overexploited, which has implications not only for the economic sustainability of these resources but also for coastal communities that rely on fisheries as a livelihood and source of food. The pollutants constituting the greatest threat to coastal and marine ecosystems and to public health in the wider Caribbean region include, oil hydrocarbons, sediments, nutrients, pesticides, litter and marine debris, and toxic wastes. Sewage, however, is one of the most significant pollutants affecting the region" (OECD, 2016).

The consequences of not protecting marine natural capital are dire, including loss of livelihoods and economic opportunities. If these issues are not addressed, the consequences will be reduced protection of coastlines to storm surges, loss of flora and fauna that depend on natural coastal habitats, loss of recreational opportunities, food stock reduction with enormous losses to fishers, and the erosion of beaches, leading to the reduction of income for hoteliers and businesses.

Looking for New Approaches to Old Problems

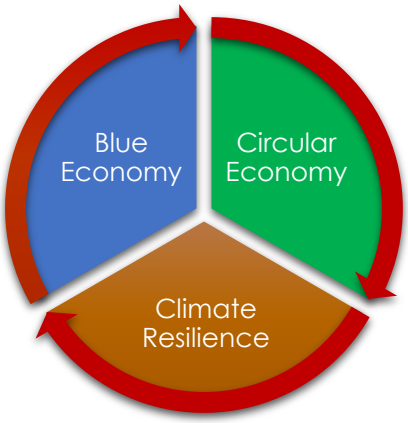
5. Looking for New Approaches to Old Problems

Blue Economy, Circular Economy, and Climate Resilience: The BCR Approach

Sustainable development has long been an aspiration for many islands where access to basic services like clean water, sanitation, energy, food, and housing as well as connectivity infrastructure for mobile networks, financial services, and road networks have been labeled priority investment areas (The New Climate Economy, 2016). Due to high debt, escalating climate change, and the uncertain impact of the COVID-19 pandemic, sustainable development on islands is facing increased obstacles. At this juncture, it is imperative that Caribbean islands have access to the necessary technical and financial support to face these challenges and embark on a more sustainable development path.

To move such an agenda forward, it is essential to identify new approaches, with the tools necessary for private and public sector stakeholders to assess island progress and to prescribe innovative approaches to bolster sustainable development. In the case of islands, the pursuit of an innovative framework to foster sustainable development would be inadequate without the determined inclusion of the ocean ecosystem. The concept of blue economy cannot be discussed without incorporating circular economy and climate resilience, which are driving concepts behind the blue economy. These concepts, when converged, target some of the biggest issues that islands face and complement existing approaches to economic growth, environmental sustainability, climate change mitigation and adaptation, social inclusion, diversity, equity, and good governance. As such, sustainable islands would benefit from a blue economy, circular economy, and resilience approach (BCR) as project priorities.

Figure 11. The BCR approach to old problems: blue economy, circular economy, and climate resilience.
Source: Developed by the authors



What is the Blue Economy? The concept of the blue economy is based on the sustainable use of ocean resources to spur economic growth and improve

livelihoods and jobs while protecting the health of ocean ecosystems. It means that "economic activities will be balanced to promote a sustainable, healthy ocean that can benefit not only the people directly using it but indirectly the entire population of the world. If economic activities are managed in this way, the ocean holds the potential to make a much greater contribution to poverty reduction and shared prosperity. The effort will also increase the resilience of low-elevation communities that face the threats of sea level rise and other impacts of climate change" (Vierros & De Fontaubert, 2017).

> **"This ocean focus has the potential to help the islands of the Caribbean Basin overcome many of their inherent limitations, by means of intensifying, diversifying and expanding coastal and offshore economic activities.** Investments in marine zoning, restoration of coastal vegetation and coral reefs, protection of marine and coastal areas or grey infrastructure for coastal protection, are all examples of climate change risk management activities under a blue economy framework," (OECD, 2016).

> **"A sustainable island economy will create renewable solar, wind, wave, tidal, thermal and biological energies that meet blue economy design criteria.** It will develop innovative approaches to create opportunities for local aquaculture businesses, artisanal fishing and locally managing fishing activities to maintain optimal levels for fish and other marine organisms' stock regeneration. A sustainable island economy will also promote sustainable tourism. A fundamental aspect of the framework is to develop basic infrastructure when needed which includes developing clean water and sanitation systems and recovering waste as a valuable material through composting and reincorporating waste into the value chain and for reducing the impacts of waste on marine and coastal environment. A key component to the framework is also to promote inter-island communication and coordination," (OECD, 2016).

A blue economy model is capable of improving the lives of island and coastal communities by increasing their independence and transforming their economies into more competitive players in global markets. Blue economy solutions improve on sectors that islands already know well, like fisheries, aquaculture, and tourism, while developing new, innovative solutions to target areas which typically have not been solved through ocean technology, like renewable energy and biotechnology (Greenhill, Day, J., & Stanley, 2016).

1. Restore and Regenerate Ocean Ecosystems

Island states should seek to do more than just sustainably manage ocean resources. The potential exists to restore and regenerate ocean ecosystems. This benefits island economies, environment, and society by creating a more resilient society. These activities could be completed in coordination with organizations that conduct ocean exploration, such

as (NOAA)'s Office of Ocean Exploration and Research (National Oceanic and Atmospheric Administration, 2018) and Nekton Deep Ocean Research Institute (NEKTON, 2018), which conduct research on underwater species and resources. According to NOAA (U.S. National Ocean Service, 2018), more than 80 percent of the world's oceans have not been explored. This leaves ample room for new discoveries that lead to new, blue innovation.

Island ecosystems and natural capital have numerous benefits for islands that go beyond protecting natural ecosystems. Restoration services can have major impacts on island economies that rely on their natural habitats as a source of food and materials, protection against environmental threats, and for its nonmarket benefits, which bolster cultural services and consequently tourism. Coral reefs are suffering damage from climate change due to acidification and increased ocean temperatures. Coral conservation efforts are being carried out to save reefs and help protect marine habitats. By protecting coral habitats, these islands are in turn protecting fishing and tourist industries that rely on marine health. Restoration to protect and rehabilitate endangered native species and coastal blue carbon habitats can be achieved through a blue approach to integrated coastal management.

2. Aquaculture and Sustainable Fishing

Demand for fish and fishery products is expected to increase worldwide in the coming years, and it is expected that nearly half of the production will come from aquaculture. To meet the growing demand, aquaculture will need to double its existing production by 2050. Aquaculture is a global multi-billion-dollar industry but, except for Jamaica and Belize, the Caribbean region is a minor player. To capitalize on this opportunity, the Caribbean aquaculture sector will require significant investment to develop the sector sustainably. (http://aquaculturedirectory.co.uk/aquaculture-gateway-blue-economy-caribbean/#sthash.sp4EVImX.dpuf)

The development of sea aquaculture would increase food production and security, generate employment, diversify production, reduce the demand for food imports, and increase foreign exchange earnings. Developing this sector also creates the opportunity to develop sustainable techniques that could be marketed as a model to other coastal and island regions to be scaled up or down.

Protecting local marine resources is one of the most urgent needs in promoting food security and sustainable development. In islands, sustainable fisheries and aquaculture may play an important role in food security, poverty alleviation. and livelihoods while respecting ecosystems

and creating local jobs. If well designed, circular models can foster new innovative approaches to create opportunities for local business, artisanal fishing in communities, manage fishing activities to an optimal level, and restore fish stocks. A successful example of this is observed in Belize, which is using a managed access program to secure fishing area for local fishers to promote their sustainable, traditional practice (Maaz, 2018).

3. Renewable Energy, Including Marine-based Renewable Energy

Islands must change their energy matrices by prioritizing investments in renewable energy such as: solar, wind, wave, tidal, thermal, and biological sources. Renewable energy and energy efficiency, combined with electrification of end-uses, make up 94 percent of the emission reductions worldwide. The share of renewable energy in total primary energy supply would rise from 14 percent in 2015 to 63 percent in 2050. The share of renewable energy in the power sector would increase from 25 percent in 2015 to 85 percent in 2050. Marine-based renewable energy sources could significantly contribute to the increase in renewable energy. Marine-based renewable energy also carries significant potential for green job creation (Gielen, Boshell, Saygin, & Bazilian, 2019).

With global interest in renewable energy increasing, the development of ocean-based energy will grow in the coming years and decades. By developing marine renewable energy, the Caribbean could reduce its dependence on imported fossil fuels as a baseload for electricity and increase its energy security. "Marine renewable energy technology options include offshore wind, wave, tidal stream, thermal energy conversion and salinity gradient, and the feasibility varies according to each technology as they range in development status globally. Considering the multiple benefits of MRE [marine renewable energy], in terms of energy security, environmental protection and socio-economic benefits, it is a win-win solution in terms of sustainable development and the blue economy" (Greenhill, Day, J., & Stanley, 2016).

4. Biotechnology and Research and Development

Island economies rely on the exploitation of living and non-living resources as well as trade related activities, which must be carried out sustainably and adopting innovative technologies through research and development and innovation (R&D+i). R&D+i on ocean resources can boost new food supply sources and preventive therapeutics, novel drugs, and health and personal care products. Ocean exploration can be used to develop innovations that add value to new and existing ocean resources.

While marine–based biotechnology globally is at an early stage of development, the biotechnological potential of marine organisms is

enormous. Macro-algae, microalgae, bacteria, and other living organisms have the capacity to deliver solutions to major socioeconomic and political drivers, including the following:

Marine biotechnology also has broad commercial potential in industrial products and processes and in the life sciences industry as a novel source of enzymes and polymers. These opportunities remain to be explored and fully developed in the Caribbean region, building on good practices and utilizing the support of development partners, including regional organizations and international development partners (Day & Stanley, 2014).

5. Ocean-related Tourism and Leisure

Against a global background of rising incomes, ageing populations, growing leisure time, and increasing accessibility of cruise tourism to socioeconomic groups beyond just the wealthy, the long-term prospects for ocean cruise tourism appear healthy. According to the Caribbean Tourism Organization, the region recorded nearly 24 million cruise passenger were recorded for the region in 2014, an increase of 8 percent from 2010 levels (Caribbean Tourism Organization, 2014). There are, however, abundant opportunities for further expansion of the well-established cruise industry that would strengthen this component of blue economic development.

In a post COVID-19 reality, there might be an appetite not only for new, safe, and exotic destinations, but also new tourism related to ocean life. "Underwater hotels and sea-floor/floating resorts already exist in such places as Florida, China, and Fiji, with more in the planning stage. Deep sea tourist expeditions are another such activity with significant potential" (OECD, 2012).

6. Biological and Technological Waste Recovered as a Resource

Waste poses a unique problem on islands where physical space is limited. Innovative ways of treating material and water waste must be developed to avoid contaminating waterways and polluting limited land area. Innovative waste management models will enhance the waste recovery value chain and help create jobs. Many activities, such as sustainable fisheries and aquaculture, eco-tourism, and others, rely on a structured recycling and composting industrial streams sector to cope with the products and packaging that reach island shores. Technological and biological materials may prevent further pollution of the oceans, help conserve natural resources, and avoid costs to operate landfills or exporting waste out of the island. Above all, waste recycling and composting activities in developing countries enrolls lots of informal small enterprises or individuals to earn an income. Regulating this informal sector into associations and cooperatives and including them into the circular economy can be the basis for improving the circular economy streams in islands nations and territories.

What is the Circular Economy? A circular economy is a system that is restorative and regenerative by intention and design. It replaces traditional end-of-life models with restoration, repair, reuse, and refurbish; promotes the shift toward the use of renewable energy; eliminates the use of toxic chemicals, which impair reuse and return to the biosphere; and aims for the elimination of waste through the superior design of materials, products, systems, and business models (Ellen MacArthur Foundation, 2013). The following are five circular economy priority areas to be incorporated into a new approach for islands:

1. **Eliminate the concept of waste**. The goal for islands should not only be to reduce waste and promote recycling, but to reduce waste generation to zero. This can be accomplished by using, collecting, and reusing materials safely in perpetuity while valuing both clean potable water and the oceans, using clean and renewable energy throughout for the economic, environmental, and social benefit of all.

2. **Understand material flows**. Materials that are imported, exist, and flow through islands need to be intentionally designed to cycle safely in either a biological or a technical cycle. This requires a detailed understanding of all materials flowing onto, throughout, and off islands. It also covers a comprehensive analysis to determine where resources are used and where they are disposed of after their use cycle has ended.

3. **Assess human and environmental health effects of materials**. Material flow data need to be combined with a comprehensive assessment of the human and environmental health effects of those materials in the context of their use on islands so that safe flows can be assured in perpetuity.

4. **Design and manage materials, energy, and waste to convert them from liabilities to assets**. Armed with information, islands can begin to determine if the materials, energy, and water imported for their day-to-day operations are adequately specified, designed, and managed so as to be assets for perpetual use and reuse.

5. **Establish specifications for goods to be imported**. In an ideal future scenario, all imported goods can be specified and selected intentionally such that inputs to the island are assets that can be used, collected after use, and managed (material reutilization management not waste management) for safe and sustainable value-added cycling. To do this, specifications for imported goods must include key requirements to operate safely on islands.

What is Climate Resilience? Climate resilience is the ability to prepare for, recover from, and adapt to the harmful effects of climate change, including ocean warming and acidification, sea level rise, more frequent and severe weather events, extended periods of drought, torrential rain, and extreme temperatures (Center for Climate and Energy Solutions, 2019).

Disasters create macroeconomic instability and take countries away from their development path, sometimes setting a country back 10 years in GDP per capita, such as in the case of Dominica after Hurricane Maria. Failure to manage and build resilience to climate risk poses a serious threat to development, leaving Caribbean countries trapped in the vicious cycle of high debt and low growth.

"High exposure to climate risks magnifies the structural obstacles that constrain the region's long-term economic prospects, such as limited fiscal space, brain drain, violent crime, financial sector weaknesses, and high cost of doing business. Massive reconstruction costs take away scarce resources from social spending, with each disaster taxing countries along the development path," (Navarro-Martin, 2019).

For sustainable island growth, climate resilience must be addressed in coordination with the blue economy and the circular economy. The following two points should be carefully considered when developing an integrative approach to climate resilience on islands:

1. **Structural Protection**

   Structural protection to reduce disaster risks, such as through resilient infrastructure, adequate land-use, zoning rules and building codes, and early warning systems are fundamental in the Caribbean. Upfront costs of resilient infrastructure are estimated to be around 25 percent higher than regular infrastructure. However, this approach pays off, as resilient structures help limit damage and the need for ex-post assistance over time, and countries gain from improved growth and fiscal positions (UNEP, 2014).

2. **Financial Resilience**

   "Financial resilience to mitigate disaster costs also implies upfront costs. Resilient structures mitigate destruction and losses from natural disasters, but do not eliminate them. To ensure liquidity for relief and reconstruction while protecting public finances, acquiring self- or market insurance is essential. But weak fiscal positions of most Caribbean states and competing demands on public resources limit governments' ability and willingness to set aside rainy-day funds. Insurance coverage is also low for both public and private sectors, with average insurance gap at 66 percent. Innovative risk-sharing tools such as catastrophe bonds have not been issued by Caribbean sovereigns, reflecting their complexity, high setup costs, and capacity/regulatory constraints. Governments rely mainly on the regional insurance pool, the Caribbean Catastrophe Risk Insurance Facility, which provides quick payouts to meet immediate cash-flow needs. But payouts have been limited compared to actual damages. Lower insurance primes and carefully-designed mandatory insurance for the private sector with targeted subsidies can help raise insurance penetration," (Navarro-Martin, 2019).

Is Focusing on the Blue Economy a Solution?

The 2012 Rio+20 conference first raised the notion of a blue economy and the need to stimulate blue growth, particularly for island nations and developing countries with significant coastlines or maritime areas. Transitioning to a blue economy in the Caribbean requires a policy framework that considers the ocean a unique development space, shaped by its ecology. Currently, ocean governance in the Caribbean is fragmented which hinders how it can support integrated policies that promote the blue economy. Over 30 regional and sub-regional organizations are engaged to some degree in this matter along with a collection of multilateral environmental agreements, political agreements, non-binding agreements, programs, projects, and national laws, all working at different levels and spatial scales. Across the region and at the national level, this framework often takes a sector-specific approach to the ocean economy, rendering it unable to respond to the cumulative and synergistic impacts and pressures from human activities in this shared space, (Roberts & Ali, 2016). For an effective transition to the blue economy, organizations, agreements, and policy throughout the region must be aligned.

The challenge is where to start to alter the existing course and shift to a blue economy while strengthening social, economic, and environmental linkages. The move toward a paradigm of *big ocean countries* focusing on the blue economy should set the region on a new development path. It will not be easy. It will require fundamental changes in the way the ocean is managed at the national, regional and global levels to create a more harmonized and integrated approach. Substantial investments and R&D+i will be needed, and changes in regulations and policy will be essential to foster such change. The blue economy paradigm will enable islands to achieve sustainable development.

Toward a Framework for Sustainable Islands

6. Toward a Framework for Sustainable Islands

Although sustainable development is a common phrase used in publications about the environment, economics, and human development, a review of the multidisciplinary literature on sustainable development conducted by Yosef Jabareen concludes that there is no comprehensive theoretical framework for understanding sustainable development or general agreement on how to translate the concept into practice (Jabareen, 2015; Berke & Conroy, 2000). Wolfgang Sachs argues that the concept of sustainable development has widespread appeal because it builds a bridge between the fields of ecological sustainability and economic development (Sachs, 1993). Furthermore, Geisinger argues that most definitions acknowledge the tension between the goals of economic growth, environmental protection, and social well-being but give preference to the goal of economic development (Geisinger, 1999).

With the adverse effects of climate change, all countries should rethink the tendency to prioritize economic growth in public policy, a short-term goal, to the detriment of the long-term goals of preserving the natural capital stock and human development. Given that islands are closed ecosystems, public policy on islands should pursue economic growth strategies that protect the environment and their small populations.

The key principle of sustainable development should be the integration of environmental, social, and economic concerns into all aspects of decision making. To do so, governments must eliminate the fragmentation of these three critical areas. Environmental, social, and economic concerns ought to be integrated throughout the decision-making processes to ensure that national strategies, policies, and programs effectively move toward the type of development that is truly sustainable (Rachel Emas, 2015).

Sustainable Islands Framework: Five Conceptual Streams

A sustainable islands framework must encompass at least five conceptual streams: (i) the preservation of land and marine natural capital stock; (ii) the promotion of social equity; (iii) the stimulation of sustainable economic growth, including economic diversification efforts; (iv) the implementation of eco-form urban planning; and (v) the adoption of practices of integrative management.

(i) The preservation of land and marine natural capital stock

Natural capital stock can be defined as ''the stock of all environmental and natural resource assets, from oil in the ground to the quality of soil and groundwater, from the stock of fish in the ocean to the capacity of the globe to recycle and absorb carbon,'' (Pearce and Turner, 1990).

Natural capital stock includes three interrelated areas: non-renewable resources, such as oil and mineral resources; the finite capacity of the natural system to produce renewable resources such as water supplies, marine life, and food crops; and the capacity of natural systems to absorb the emissions and pollutants avoiding the transfer of heavy costs to future generations (Roseland, 2000).

(ii) Promotion of social equity

The promotion of social equity requires deliberate policies and programs to foster environmental, social and economic justice. A "truly sustainable society is one in which wider questions of social needs, equity, welfare, and economic opportunity are integrally related to environmental limits imposed by supporting ecosystems," (Agyeman, Bullard, & Evans, 2002).

(iii) Stimulation of sustainable economic growth, including diversification efforts

Governments of island nations need to create the right conditions and institutional frameworks to encourage investment, innovation, and economic growth while avoiding policy capture, corruption, and crowding in private sector investment. Island economies must develop their ocean resources, open markets to trade, promote basic infrastructure investments, promote technology adoption, and modernize ports and airports to maintain active supply chains and to connect with the globalized world.

Their regulatory regimes must encourage competition, protect property rights, and maintain fair and equitable labor laws to empower marginalized groups, such as the impoverished, women, and indigenous peoples, to engage in the formal economy. This means ensuring that they have access to land and resources, security of tenure, and the capacity to use their assets productively and sustainably.

(iv) Implementation of eco-form urban planning and construction

The eco-form concept implies designing habitats with desirable environmental goals. Thus, the design of cities, neighborhoods, and buildings should include energy conservation, reduction of air pollution and energy efficiency mechanisms. Planners have a critical responsibility to promote and supervise the implementation of more holistic plans to help communities move toward sustainable development (Berke & Conroy, 2000).

(v) Adoption of integrative management practices

Integrative management advocates for a holistic view of social development, economic growth, and environmental protection concerns in planning and management. As such, national strategies, public policies, planning and management should provide the necessary legal and regulatory framework, as well as the necessary incentives to ensure that public officials, decision makers, and civil society share responsibility for protecting their livelihoods and their natural capital stock.

Figure 12. Sustainable Islands Framework. Source: Developed by authors.

To implement sustainable development policies, the challenges is how to shift from prioritizing economic growth first, followed by social equity and if there are additional resources, protection of the natural capital stock. In the case of islands, environmental health is a pre-condition of social and economic success. Furthermore, poverty and environmental degradation are interconnecting factors. Islands should not be faced with a choice between "environment" or "development"; rather, they should find ways to integrate these to achieve sustainable development (Dodds, 2000).

Sustainable development on islands will be difficult to achieve from the policy standpoint if separate ministries manage environmental policy, economic development policy, and social development policy. The institutional arrangement should facilitate integrative decision making, taking the systemic problems into consideration. Governments may pursue analytical work and policy recommendations with a sectoral focus, but the overarching development strategy must be debated and agreed using a holistic approach. Goals and indicators to achieve the SDGs and the NDC should be periodically reviewed and updated by an institutional arrangement that has sufficient political leverage to adapt and change course as needed.

Money, Money, Money…Show Me the Money

7. Money, Money, Money…Show Me the Money

Shifting island economies toward a sustainable islands model will help islands combat climate change while promoting the development of island communities and businesses. This transition requires financing and expertise to allow governments to address environmental, economic, and social policy. In addition, individuals and businesses will need access to finance to develop the blue economy, the circular economy, and climate resilience solutions that target their island's issues and unlock the ocean's potential that is unique to their island environment. Blue finance, which targets initiatives that exploit the ocean for its economic potential while supporting coastal and marine habitats, will be needed to open up new opportunities (Thiele, et al., 2020).

Small Islands Need Access to Finance Based on Vulnerabilities, Not Income

Caribbean small island countries need substantial investment to pursue economic transformation, climate change adaptation and mitigation, and expansion of their economic and social infrastructure. However, recent estimates show that these island countries allocate less than 4 percent of fiscal expenditures to capital investment, significantly below what is needed. In addition, debt service obligations have been beyond the fiscal capacity of some Caribbean countries, resulting in IMF programs, debt renegotiations, and restructuring to reduce the level of debt and interest payments. (Campton Bourne)

Small islands are not likely to be able to adapt to climate change and become more resilient just through the actions of their governments. High levels of global financial commitments will be needed to progress toward sustainable development. Small islands' climate change adaptation needs are among the highest in the world when measured as a proportion of GDP. The capital investments required to finance climate change adaptation and mitigation are immense and likely to be beyond the capacities of many small island governments (Hurley, Financing for Development and Small Island Developing States: A Snapshot and Ways Forward, 2015).

In recent years, Caribbean island countries have seen a considerable reduction in trade preferences and access to foreign assistance. Official development assistance (ODA) from traditional bilateral donors, namely the United Kingdom, the United States, Canada, and Japan, has decreased over time as aid preferences have shifted toward low-income countries and countries in post-conflict situations. Multilateral ODA from EU institutions were large in 2007-2010 but decreased substantially as per capita income became a major influence in aid policy (Bourne).

Many Caribbean countries are not eligible to receive concessional financing from multilateral institutions or grants from bilateral donors because these institutions classify countries' level of development largely according to their per capita GDP. Most multilateral organizations and bilateral donors follow this practice because they argue that higher-income countries are able to mobilize domestic resources and leverage private financing for development projects. However, it has been shown that despite similar income per capita levels, there is great variation in countries' capacity to mobilize domestic resources and access external financing. Many island countries have restricted capacities to mobilize domestic resources given their limited tax revenues, high public expenditure, and high government consumption as a percent of GDP. In the same vein, their low levels of exports of goods and services, low foreign direct investment, and average levels international reserves as a percent of GDP hinder small countries' ability to leverage external financing (Sagasti, 2013).

Per capita GNI is a bad indicator of development and should not be used when better reliable measures are available. To date, there are no standard criteria for what constitutes a developing country. According to the OECD, "the term 'developing country' has generally been taken to mean a country eligible for official development assistance (ODA)" following the IBRD's classification scheme, which is predominantly influenced by per capita GNI—an anachronistic metric when it comes to measuring development (Inder, Karl Alexander, & Sierra, 2014). At a minimum, the per capita income criterion should be complemented with that of economic vulnerability in the case of small islands.

Natural disasters and climate change severely affect the growth trajectory of small islands, putting previous economic and social gains at risk and limiting their ability to achieve sustainable development. Caribbean islands are in some of the most disaster-prone regions in the world. When disaster strikes, governments must divert scarce public resources from essential social and economic development investments to disaster-related needs, compromising the pace and scope of future growth (OECD/The World Bank, 2016).

Building resilience is essential to achieve sustainable development in the Caribbean, but available financing for this purpose is limited and difficult to access. The responsibility, expertise, and funding for climate and disaster-resilient development is scattered across a complex global architecture of funds and providers. Even though several private sector financing mechanisms have been put in place globally, they are not equally and easily accessible to Caribbean countries. Hence the relevance and importance of opening multilateral and bilateral assistance and concessional funding to all small island countries (OECD/The World Bank, 2016).

In 2016, the Caribbean Development Bank (CDB) proposed a Multidimensional Vulnerability Index (MVI) tailored to the reality of the Caribbean. The index combines what are perceived to be the root causes of vulnerability into an

aggregate composite index. It provides a static view of the vulnerability of a country at a point in time relative to other Caribbean small states. It quantifies the extent of the country's exposure to exogenous shocks and is updated using data for 2016 and 2017. The MVI updated and revised the CDB's previous Vulnerability Index, broadening the coverage of the vulnerability analysis to include social vulnerability and a climate change component that not only considers historic natural-hazard events but also predicts how the environment is likely to cope with future events. The MVI contemplates the following vulnerabilities: (i) the extent of trade openness with other countries, (ii) dependence on a few major exports and trading partners, (iii) dependence on the imports of energy and related products, (iv) social challenges such as crime, and (v) exposure to natural hazards and climate change.

The MVI shows that although many Caribbean countries are classified as middle-income countries, "economic security of these countries is highly vulnerable due to small size, economic and social structures, the high annual probability of many individuals being affected by natural disasters and, to a lesser extent, individuals losing their lives as a result of natural disasters. The individual country vulnerability scores for 2016 and 2017 (the change from year to year), show that when an event occurs vulnerability can change significantly from one period to the next, highlighting the economic insecurity of the Region" (Ram, Cotton, Frederick, & Elliott, 2019). Using such an indicator to measure vulnerability to complement income per capita would be more appropriate when evaluating access to grants and concessional financing.

Toward a More Collaborative Approach to Financing Sustainable Islands

At a high-level conference organized by the IMF, the World Bank, and the IDB in November 2018, participants called for greater emphasis on investing in ex-ante resilience to natural disasters, supported by the international community. They expressed strong support for building alliances among key stakeholders, with greater collaboration across Caribbean states and the international community. There was also a strong call to revise the OECD classification criteria for small states highly vulnerable to natural disasters to allow access to low-cost financing for resilience building. Such collaboration should generate synergies and expand the resource and knowledge pool to address the key obstacles that undermine risk management and resilience-building. (IMF, 2019).

"Building a climate-resilient Caribbean is a shared goal and calls for a collaborative approach among stakeholders. Countries would be at the center of such an effort. Countries could design disaster-resilience strategies with support from international financial institutions (IFIs), multilateral development banks, donors, and climate funds, increase efforts to restore fiscal sustainability to create room for resilience-building, while incorporating upfront costs and long-term

benefits of resilience investments in macro-fiscal frameworks. Countries could also identify financing needs to be supported by the international community beyond the needed fiscal adjustment." (IMF, 2019).

The international community could help the region's policymakers to develop the capacity to manage risk. IFIs could support countries in assessing risks and designing resilience strategies. Technical assistance could deepen insurance and financial markets to improve access and reduce insurance costs, help countries assess net benefits of innovative risk-sharing tools, and design affordable risk-transfer mechanisms, safety nets, and diversification strategies to better absorb economic and social impacts of climate shocks. Donors could support resilience strategies with credible macroeconomic frameworks backed by IFIs. They could contribute to capacity development and strengthened risk-sharing pools, including to broaden their capital base and lower insurance premiums. Low-cost financing is critical to support these efforts where fiscal challenges are present. Climate funds could simplify their requirements, using IFIs' endorsement of policies and resilience-building efforts. (IMF, 2019).

For the proposed collaboration to flourish and really help the Caribbean invest ex-ante in resilient infrastructure and embark on a strategy of sustainable development, multilateral and bilateral organizations must consider the extreme vulnerability of these beautiful islands. Climate change is a global responsibility, and it should also be a global responsibility to protect and support the most vulnerable countries.

Conclusions

8. Conclusions

Caribbean islands are beautiful natural wonders, surrounded by sandy beaches, coral reefs, and a vast ocean, ready to be explored and capitalized. However, the combination of vulnerabilities to external shocks, from foreign markets or extreme weather events, make these countries extremely vulnerable regardless of their level of income. Furthermore, with limited fiscal buffers, rising debt levels and slow-growth Caribbean islands must concentrate of fiscal balances, leaving critical environmental, social, and economic investments on hold.

Caribbean islands have already identified priority actions in their NDCs, which include macroeconomic stability, youth development, entrepreneurship, innovation, human capital development, mainstreaming diversity, diversification of energy resources, access to better ICT, and the reduction of environmental vulnerabilities. The SDG framework addresses most of these priorities. But for these islands to achieve sustainable development, identifying problem areas and setting goals is not enough.

The post-15 development agenda and the COP-23 focus on the ocean pathway are opportunities for Caribbean countries, but only if they are treated as a priority region for assistance.

Islands are different than mainland countries, not only because of their small size and economic and climate vulnerabilities, but because they are encapsulated living organisms. National governments, civil society, and the international community should leverage the technology and resources available in the twenty-first century to rethink approaches to the sustainability of islands. The principles of the blue and circular economies, when added to resiliency, open up new opportunities for, employment, growth, education, diversification, and protection of island environments. A global commitment is needed to make concessional resources available to these countries to help them invest in resilient infrastructure, protect their marine resources, and diversify their sources of income.

Sustainable development will only be achieved with a paradigm shift. A transformative reform is needed to conceptualize and analyze islands as interconnected systems, shifting from prioritizing economic growth to a more comprehensive view of environmental protection as the cornerstone of survival and social equity as fundamental to foster social development and economic growth. It is time to develop sustainable development models tailored to the needs of Islands.

References

Acaroglu, L. (2017). Tools for Systems Thinkers: Getting into Systems Dynamics… and Bathtubs. Medium.

ADB. (2012). Addressing Climate Change and Migration in Asia and the Pacific. Manila: Asian Development Bank.

Agard, J., Alston, K., Solaun, K., Larrea, I., Garcia, C., Cerezo, F., . . . Farreny, R. (2019). Defining the Elements of Blue and Circular Growth for Island Sustainability and Generation of Project Ideas. Washington, DC: Inter-American Development Bank.

Agyeman, J., Bullard, R., & Evans, B. (2002). Exploring the Nexus: Bringing Together Sustainability, Environmental Justice and Equity. Retrieved from Space and Polity: https://doi.org/10.1080/13562570220137907

Albins, M. A. (2013). Effects of Invasive Pacific Red Lionfish Pterois volitans versus a Native Predator on Bahamian Coral-Reef Fish Communities. Retrieved from Biological Invasions: https://doi.org/10.1007/s10530-012-0266-1

Alleng, G., Miguel Aparicio, L., Khadan, J., Mills, A., Jorge Saavedra, J., & Valero, S. (2016). *Caribbean Sustainable Islands Initiative (CarSII): IDB Initiative to Increase the Sustainability of Islands.* Washington, D.C.: IDB Publication.

Barker, T. (2007). Climate Change 2007 : An Assessment of the Intergovernmental Panel on Climate Change. Retrieved from In Change: https://doi.org/10.1256/004316502320517344

Berke, P., & Conroy, M. (2000). Are We Planning for Sustainable Development? Retrieved from Journal of the American Planning Association: https://doi.org/10.1080/01944360008976081

Boote, A. R., Turner-Huggins, T., Njoroge, P., Randall, R., Samuel, W., Velculescu, D., . . . Bassari, A. (2003). Eastern Caribbean Currency Union: Selected Issues. (pp. 1-130). Washington DC: International Monetary Fund.

Bueno, R., Herzfeld, C., Stanton, E., & Ackerman, F. (2008). *The caribbean and climate change: The costs of inaction.* Environment.

Cabral, R., Gaines, S., Free, C. M., & Golbuu, Y. (2019). *The Expected Impacts of Climate Change on the Ocean Economy.* Washington, D.C.: High Level Panel for a Sustainable Ocean Economy.

Caribbean Tourism Organization. (2014). *Caribbean Tourism Review.* Caribbean Tourism Organization.

Center for Climate and Energy Solutions. (2019). *What is Climate Resilience and Why it Matters.* Center for Climate and Energy Solutions.

Chen, C., Noble, I., Hellmann, J., Coffee, J., Murillo, M., & Chawla, N. (2015). *University of Notre Dame Global Adaptation Index: Country Index Technical Report.* Notre Dame, Indiana: Notre Dame Global Adaptation Initiative.

Comparing Graphs. (2014, May 12). Retrieved from mathgoodies.com: http://www.mathgoodies.com

Cook, J., Oreskes, N., Doran, P., & Anderegg, W. (2016). *Consensus on consensus: A synthesis of consensus estimates on human-caused global warming.* Retrieved from Environmental Research Letters: http://doi.org/10.108/1748-9326/11/4/048002

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S. J., Kubiszewski, I., . . . Turner, R. K. (2014, April 1). *Changes in the global value of ecosystem services.* Retrieved from Global Environmental Change: https://community-wealth.org/sites/clone.community-wealth.org/files/downloads/article-costanza-et-al.pdf

Day, J., & Stanley, M. (2014). *Early briefing report on the feasibility of marine/blue biotechnology.* The Commonwealth Secretariat.

Directorate General for Maritime Affairs and Fisheries of the European Commission. (2019). *The EU Blue Economy Report 2019.* Brussels: The European Union Publications.

Dodds, H. S. (2000). *Pathways and paradigms for sustaining human communities. In: Lawrence R. J. Sustaining human settlement: A challenge for the new millennium.* Great Britain: Urban International Press.

Doo, S. S., Edmunds, P. J., & Carpenter, R. C. (2019, August 19). *Ocean acidification effects on in situ coral reef metabolism.* Retrieved from Scientific Reports: https://doi.org/10.1038/s41598-019-48407-7

Dornan, M. (2015). *Renewable Energy Development in Small Island Developing States of the Pacific.* Canberra: Development Policy Centre, Crawford School of Public Policy, The Australian National University.

Duraiappah, A., Naeem, S., Agardy, T., Ash, N., Cooper, H., Díaz, S., . . . Jaarsve, V. (2005). *Ecosystems and human well-being: Synthesis.* Millennium Ecosystem Assessment. In World Resources Institute. doi:https://doi.org/10.1196/annals.1439.003

Ebi, K., Lewis, N., & Corvalan, C. (2006). *Climate variability and change and their potential health effects in small island states: Information for adaptation planning in the health sector.* Environmental Health Perspectives. doi:https://doi.org/10.1289

Eckstein, D., Künzel, V., Schäfer, L., & Winges, M. (2019). *Global Climate Risk Index 2020.* Bonn: Germanwatch.

Ellen MacArthur Foundation. (2013). *Towards the Circular Economy.* Journal of Industrial Ecology. doi:http://doi.org/10.1162/108819806775545321

Ellison, J. C. (2015). *Vulnerability assessment of mangroves to climate change and sea-level rise impacts.* Wetlands Ecology and Management. doi:https://doi.org/10.1007/s11273-014-9397-8

European Commission. (2015). *Closing the loop - An EU action plan for the Circular Economy.* Brussels: The European Commission Publication.

FAO. (2007). *Adaptation to climate change in agriculture, forestry and fisheries : perspective and framework.* Interdepartmental Working Group on Climate Change.

Field, C., Barros, V., Dokken, D., Mach, K., Mastrandrea, M., Bilir, T., . . . White, L. (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects.* IPCC. doi:https://doi.org/10.1017/CBO9781107415324.004

Freimann, A., Ham, M., & Josipa, M. (2014). *Measuring Objective Well-Being and Sustainable Development Managment.* Journal of Knowledge Management.

GEF. (2009). *A new climate for Peace Taking Action on climate and Fragility Risks.* Germany: G7.

Geisinger, A. (1999). *Sustainable Development and the Domination of Nature: Spreading the Seed of the Western Ideology of Nature.* BC Envtl Aff L Rev 43.

Gielen, D., Boshell, F., Saygin, D., & Bazilian, M. (2019). *The role of renewable energy in the global energy transformation.* Energy Strategy Reviews. doi:https://doi.org/10.1016/j.esr.2019.01.006

Greenhill, L., Day, J., J., & Stanley, M. (2016). *Blue biotechnology: Commonwealth Blue Economy Series.* Commonwealth Secretariat. doi:https://doi.org/doi.org/10.14217/25191349

Griffith, A., & Gobler, C. (2020). *Harmful algal blooms: A climate change co-stressor in marine and freshwater ecosystems.* Harmful Algae. doi:https://doi.org/10.1016/j.hal.2019.03.008

Hanna, L., & McIver, L. (2014). Small Island States - Canaries in the Coalmine of Climate Change and Health. In *Climate Change and Human Health* (pp. 181-191). CABI.

Harut, D. (2019). Sustainable Finance: The Blue Economy. (pp. 1-12). Barbados: The Standard Chartered.

Herron, H., Roy, S., Bohn, B., Courtney, C., & Hoagland-Grey, H. (2015). *Addressing Climate Change within Disaster Risk Management.* Washington D.C.: Inter-American Development Bank.

Hjorth, P., & Bagheri, A. (2006). *Navigating towards sustainable development: A system dynamics approach.* Futures. doi:https://doi.org/10.1016/j.futures.2005.04.005

Hoegh-Guldberg, O., Caldeira, K., Chopin, T., Gaines, S., Haugan, P. a., Howard, J., . . . Tyedmers, P. (2019). *The Ocean as a Solution for Climate Change: Five Opportunities for Action.* Washington, D.C.: World Resources Institute.

Hoegh-Guldberg, O., Ebi, K., Engelbrecht, F., Guiot, J., Hijioka, Y., Mehrotra, S., . . . Zhou, G. (2018). *Chapter 3: Impacts of 1.5°C global warming on natural and human systems.* IPCC.

Hotchkiss, J. (1994). *Health care on small islands: a review of the literature.* World Health Organization.

Hurley, G. (2015). *Financing for Development and Small Island Developing States: A Snapshot and Ways Forward.* UNDP & UN-OHRLLS.

Hurley, G. (2015). *Financing for Development and Small Island Developing States: A Snapshot and Ways Forward.* New York: The United Nations Office of the High Representative for Least Developed Countries, Landlocked Developing Countries and Small Island Developing States.

IDB, Factor CO2, IH Cantabria, the University of the West Indies. (2014). *Understanding the Economics of Climate Adaptation, Trinidado & Tobago.* IDB.

IMF. (2013). *Caribbean Small States: Challenges of High Debt and Low Growth.* IMF.

IMF. (2016). *Gone with the Wind: Estimating Hurricane and Climate Change Costs in the Caribbean.* IMF Working Papers. doi:https://doi.org/10.5089/9781475544763.001

Inder, R. J., Karl Alexander, M., & Sierra, R. (2014). *Is There a Caribbean Sclerosis? Stagnating Economic Growth in the Caribbean.* IDB.

Inter-American Development Bank. (2016). *Annex I: List of Excluded Activities for NSG Operations.* Retrieved from IIC Exclusion List: www.docs.iic.org

Inter-American Development Bank. (2019, March 4). *IDB announces selected proposals of its Blue Tech Challenge in the Caribbean*. Retrieved from https://www.iadb.org/en/news/idb-announces-selected-proposals-its-blue-tech-challenge-caribbean

IPCC. (2014). *Climate Change 2014 Mitigation of Climate Change.* Intergovernmental Panel on Climate Change. doi:https://doi.org/10.1017/cbo9781107415416

IPCC. (2015). *Climate Change 2014: Synthesis Report.* Geneva, Switzerland: The Intergovernmental Panel on Climate Change.

IPCC. (2019). *Global warming of 1.5°C.* Intergovernmental Panel on Climate Change. doi:https://doi.org/10.1002/9780470996621.ch50

Jabareen, Y. (2015). *The Risk City: Cities Countering Climate Change: Emerging Planning Theories and Practices around the World.* Dordrecht: Springer Netherlands.

Kaito, C., Ito, A., Kimura, S., Saito, Kimura, Y., Saito, Y., & Nakada, T. (2014). *Fifth Assessment Report (AR5).* IPCC. doi:https://doi.org/10.1016/S0022-0248(00)00575-3

Karampela, S., Kizos, T., & Spilanis, I. (2014). *Accessibility of islands: Towards a new geography based on transportation modes and choices.* Island Studies Journal.

Khadan, J., Ruprah, I. J., Walthe, K., Wenner, M. D., Clarke, D., Schmid, J., . . . Bienman, S. (2016). *Caribbean Region Quarterly Bulletin: Volume 5, Issue 2: June 2016.* IDB.

Krajačić, G., da Graça Carvalho, M., & Duić, N. (2008). *RenewIslands methodology for sustainable energy and resource planning for islands.* Retrieved from In Renewable and Sustainable Energy Reviews: https://doi.org/10.1016/j.rser.2006.10.015

Lederman, D., & Lesniak, J. T. (2017). *Open and Nimble: Finding Stable Growth in Small Economies.* World: The World Bank.

Lial, H. M. (2008). *Developmental Mathematics - Basic Mathematics and Algebra 2nd edition.* Pearson - Addison Wesley.

Maaz, J. R. (2018). *WCS Belize*. Retrieved from Initiatives Managed Access Program: https://belize.wcs.org/Initiatives/Managed-Access-Program.aspx

McDonough, W., & Braungart, M. (2002). *Cradle to Cradle: Remaking the Way We Make Things.* United States: North Point Press.

McGranahan, G., Balk, D., & Anderson, B. (2007). *The rising tide: Assessing the risks of climate change and human settlements in low elevation coastal zones.* Environment and Urbanization. doi:https://doi.org/10.1177/0956247807076960

MEA. (2005). *Ecosystems and Human Well-Being. Synthesis.* World Health.

Morelli, J. (2011). *Environmental Sustainability: A Definition for Environmental Professionals.* Journal of Environmental Sustainability. doi:https://doi.org/10.14448/jes.01.0002

Morelli, J. (2011). *Environmental Sustainability: A Definition for Environmental Professionals.* Journal of Environmental Sustainability.

National Oceanic and Atmospheric Administration. (2018). *Office of Oceanic and Atmospheric Research*. Retrieved from http://explore.noaa.gov/

Navarro-Martin, M. (2019). *Seychelles: Introducing the World's First Sovereign Blue Bond.* Washington D.C.: The World Bank.

NEKTON. (2018). *NEKTON Mission, Deep Ocean Exploration*. Retrieved from https://nektonmission.org/

NU. CEPAL. Sede Subregional para el Caribe. (2010). *The tourism sector and the global economic crisis: development implications for the Caribbean.* Economic Commission for Latin America and the Caribbean.

Nurse, L., McLean, R., Agard, J., Briguaglio, L., Duvat-Magnan, V., Pelesikati, N., . . . Webb, A. (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B. Regional Aspects. United Kingdom and New York: Cambridge Univeristy Press.

OECD (Organisation for Economic Co-operation and Development). (2016). *The Ocean Economy in 2030.* Paris: OECD Publishing.

--------. (2018). *Making Development Co-operation Work for Small Island Developing States.* Paris: OECD Publishing.

--------. (2013, June 10). Debt Conversion. Retrieved from Statistics Portal: https://stats.oecd.org/glossary/detail.asp?ID=552

OECD/The World Bank. (2016). *Climate and Disaster Resilience Financing in Small Island Developing States.* Paris: OECD Publishing.

Office of Disaster Preparedness and Management. (2013). *Hurricanes and Tropical Storms*. Retrieved from http://www.odpm.gov.tt/node/21

Oglesby, R., Rowe, C., Grunwaldt, A., Ferreira, I., Ruiz, F., Campbell, J., . . . Perez, J. (2016). *A High-Resolution Modeling Strategy to Assess Impacts of Climate Change for Mesoamerica and the Caribbean.* American Journal of Climate Change. doi:https://doi.org/10.4236/ajcc.2016.52019

Pan American Health Organization. (2017). *Hurricanes Irma and Maria, Situation Report No. 8.* Pan American Health Organization.

Pauli, G. (2009). *The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs.* Paradigm Publications.

Perkinson, A., Lopez, L., & Chavez, S. (2018). *Blue, Circular Economy Project Opportunities to Enable Implementation of NDC/SDG Objectives in Caribbean Islands, Waste Management Sector Technical Note.*

Pörtner, H.-O., Roberts, D., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., . . . Weyer, N. (2019). *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.* IPCC.

Raes, J., Brekelmans, H., Hieminga, G., van Dun, J., Bani, M., Cracau, A., . . . Naber, G. (2018). *Circular Economy Finance Guidelines.* Amsterdam: ABN AMRO.

Raleigh, C., Jordan, L., & Salehyan, I. (2008). *Assessing the Impact of Climate Change on Migration and Conflict.* World.

Ram, J., Cotton, J. J., Frederick, R., & Elliott, W. (2019). *Measuring Vulnerability: A Multidimensional Vulnerability Index for the Caribbean.* Caribbean Development Bank.

Rasmussen, T. N. (2004). *Macroeconomic Implications of Natural Disasters in the Caribbean.* International Monetary Fund.

Riquelme, R., Méndez, P., & Smith , I. (2016). *Solid Waste Management in the Caribbean: Proceedings from the Caribbean Solid Waste Conference.* IDB.

Roberts, J., & Ali, A. (2016). *The Blue Economy in Small States.* Small States Digest.

Roseland, M. (2000). *Sustainable community development: Integrating environmental, economic, and social objectives.* Progress in Planning. doi:https://doi.org/10.1016/S0305-9006(00)00003-9

Rosenblatt, D., Mooney, H., & Alejandra Zegarra, M. (2020). *Caribbean economies in the time of the coronavirus Caribbean Economies in the time of Coronavirus.* IDB.

Sachs, W. (1993). *Global Ecology and the Shadow of 'development'.* London: Zed Books.

Sagasti, F. (2013). *From 'Graduation' to 'Gradation' in International Development Finance*. Retrieved from https://franciscosagasti.com/portfolio_page/from-graduation-to-gradation-in-international-development-finance/

Sanneh, E. S. (2018). *Systems thinking for sustainable development: Climate change and the environment.* Systems Thinking for Sustainable Development: Climate Change and the Environment. doi:https://doi.org/10.1007/978-3-319-70585-9

Secretariat of the United Nations Framework Convention on Climate Change. (2007). *Vulnerability and Adaptation to Climate Change to Small Island Developing States.* UNFCCC.

Secretariat of UN Conference on Trade and Development. (2019). *Trade and Development Report: Financing a Global Green New Deal.* New York: United Nations Publications. Retrieved from UNCTAD Trade and Environment.

Secreteriat of the United Nations Framework Convention on Climate Change. (2007). *Report on the expert meeting on adaptation for small island developing States.* UNFCCC.

Segal, R., & Cohen, Y. (2013, October 7). *Open Democracy*. Retrieved from Territorial map of the world: https://www.opendemocracy.net/en/territorial-map-of-world/

Senge, P. M. (2006). *The Fifth Discipline: The Art and Practice of the Learning Organization.* Performance Instruction.

Skarbø, K., & VanderMolen, K. (2016). *Maize migration: key crop expands to higher altitudes under climate change in the Andes.* Climate and Development. doi:https://doi.org/10.1080/17565529.2015.1034234

Stock, P. (2014). *Island Innovations- UNDP and GEF: Leveraging the Environment for the Sustainable Development of Small Island Developing States.* UNDP.

Strauss, B., & Kulp, S. (2018). *Sea-Level Rise Threats in the Caribbean: Data, tools, and analysis for a more resilient future.* Princeton, New Jersey: IDB.

Taylor, M. A., Clarke, L. A., Centella, A., Bezanilla, A., Stephenson, T. S., Jones, J. J., . . . Charlery, J. (2018). *Future Caribbean Climates in a World of Rising Temperatures: The 1.5 vs 2.0 Dilemma.* J. Climate.

The Brundtland Commission. (1987). Report of the World Commission on Environment and Development: Our Common Future. New York, NY United Nations General Assembly.

The New Climate Economy. (2016). *The Sustainable Infrastructure Imperative.* The New Climate Economy Report.

Thiele, T., Alleng, G., Biermann, A., Corwin, E., Crooks, S., Fieldhouse, P., . . . Zeitlberger, J. (2020). Blue Infrastructure Finance: A new approach, integrating Nature-based Solutions for coastal resilience. Gland, Switzerland: IUCN.

Third International Conference on Financing for Development. (2015). Outcome document of the Third International Conference on Financing for Development: Addis Ababa Action Agenda. Addis Ababa: United Nations.

Toubes, D. R., Gössling, S., Hall, C. M., & Scott, D. (2017, November 6). Vulnerability of Coastal Beach Tourism to Flooding: A Case Study of Galicia, Spain. Retrieved from Sustainable Territorial Management: https://doi.org/10.3390/environments4040083

Trinidad & Tobago Weather Center. (2020, May 16). Tropical Cyclone History In T&T. Retrieved from https://ttweathercenter.com/tropical-cyclone-history-in-tt/

U.S. National Ocean Service. (2018, November 7). How much of the ocean have we explored? Retrieved from https://oceanservice.noaa.gov/facts/exploration.html

UNEP (United Nations Environment Programme). (2014). Emerging Issues for Small Island Developing States. Results of the UNEP/UN DESA Foresight Process. Nairobi: UNEP.

--------. (2014). GEO Small Island Developing States Outlook. Nairobi: UNEP.

--------. (2014). UNEP Year Book 2014: Emerging Issues in Our Global Environment. Emerging Issues. Divison of Technology. Nairobi: UNEP.

UNEP-WCMC, & IUCN. (2014). Protected Planet Report 2014: Tracking progress towards global targets for protected areas. Cambridge: UNEP World Conservation Monitoring Centre.

United Nations. (1994, May). BPOA (1994) - Barbados Programme of Action. Retrieved from Sustainble Development Goals Knowledge Platform: https://sustainabledevelopment.un.org/conferences/bpoa1994

United Nations. (2014). Resolution adopted by the General Assembly on 14 November 2014. SIDS Accelerated Modalities of Action (SAMOA) Pathway (pp. 1-30). United Nations.

University of Caen Normandy, C. U. (2020). Maritime Spaces. Retrieved from Atlas Caribbean: https://atlas-caraibe.certic.unicaen.fr/en/page-123.html

UN-OHRLLS. (2011). Small Island Developing States: Small Islands Big(ger) Stakes. United Nations.

--------. (2013). Small Island Developing States in Numbers. New York: United Nations.

Vierros, M., & De Fontaubert, C. (2017, January 1). The Potential of the Blue Economy: Increasing Long-Term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Costal Least Developed Countries. Retrieved from http://documents.worldbank.org/curated/en/523151496389684076/The-potential-of-the-blue-economy-increasing-long-term-benefits-of-the-sustainable-use-of-marine-resources-for-small-island-developing-states-and-coastal-least-developed-countries

Vitousek, S., Barnard, P. L., Fletcher, C. H., Frazer, N., Erikson, L., & Storlazzi, C. D. (2017, May 18). Doubling of Coastal Flooding Frequency within Decades due to Sea-Level Rise. Retrieved from Scientific Reports: https://doi.org/10.1038/s41598-017-01362-7

Watson, R., Zinyowera, M., & Moss, R. (1997). The Regional Impacts of Climate Change: An Assessment of Vulnerability. Cambridge: Cambridge University Press.

Weary, R. (2019). Financing Blue Economy Investment via a Debt Conversion. (pp. 1-13). Barbados: NatureVest.

Weise, E. (2013, September 17). Some crops migrate north with warmer temperatures. Retrieved from USA Today: https://eu.usatoday.com/story/news/nation/2013/09/17/climate-change-agriculture-crops/2784561/

World Bank Group. (2020). GDP per Capita (current US$). Retrieved from World Bank Open Data: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

WHO (World Health Organization). (2003). Synthesis Workshop on Climate Variability, Climate Change and Health in Small Island States. Maldives: WHO.

WHO (World Health Organization). (2017). *Small Island Developing States Health and WHO Country Presence Profile.* Geneva: Department of Country Cooperation and Collaboration with the United Nations System.

World Wildlife Fund Baltic Ecoregion Programme. (2018). Principles for a Sustainable Blue Economy. Washington, DC: WWF Publication.

Yale University. (2017). PAST RESEARCH: MUSES Project - A Systems Dynamics Approach for Urban Water Reclamation-Reuse Planning: A Case Study from the Great Lakes Region. Retrieved from Center for Green Chemistry & Green Engineering at Yale: https://greenchemistry.yale.edu/past-research-muses-project-systems-dynamics-approach-urban-water-reclamation-reuse-planning-case