

EU- MSP Funded Project: Promoting Integrated and Participatory Ocean Governance in  
Guyana: the Eastern Gate to the Caribbean.

Ocean Repository (Coastal and Marine Environment and Resources)  
Data and Data Needs

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## **Coastal and Marine Data Repository**

### **Methodology**

The approach was organized into three phases. First, desk research along several modes of investigation was carried out and includes: analysis of planners' needs, An in-depth review of projects and initiatives with relevance to MSP data needs and review of data infrastructures with relevance to MSP data needs. The repository survey to gather information and data from both primary and secondary sources from various agencies, literature, workshop reports, and direct research done on the coastal and marine environment. The Coastal and Marine environment based on stakeholders feedbacks have, but are not limited to the following general usage: Fishing (Artisanal & Industrial), Transportation, Tourism, Recreation, Research, Religious Functions/ Activities, Oil Exploration, Mariculture, Submarine Cables (Communication), Protected Areas (Shell Beach), Conservation, Diving, Agriculture, Housing, Hunting (sea turtles), Sand & Shell Mining, Bee keeping, Infrastructure Development (squattling), Sea birds & nesting, Wildlife trapping, Farming, Commercial Building (WWF, MSP Workshop Report, 2017). Feedbacks also showed available information in the form: Local/ traditional Knowledge, Best Practices, Spatial Data, SBPA Data, Squatting Zone, Non-netting Zone, Biodiversity Data, Marine turtle Date, Transportation Routes, Underwater Culture Heritage Data, Fishery Department Data (Marine Stock Data), Vessel Lists, Coastal Site Maps, Tidal Information, Hydrographic Data (WWF, MSP Workshop Report, 2017). A Database of living resources were tabulated as an annex to this report. The methods also utilized a data category Terms and Definition, criteria, content types and subjects that are likely required for MSP process (Lightsom et al., 2015)

### **Data category Terms and Definition**

#### **Data criteria**

The information required will be in two categories: 1. data content type and 2. data content subject as described in the paragraphs below.

#### **Data content types**

For most subjects, marine planning and decision-making require three different types of data content:

- Distributions describe locations or patterns of a feature of interest across space and (or) time. These data can include point data, lines, polygons, and temporal data at any scale relevant to CMSP and can be produced by observation, interpolation, or modeling. Distributions can also include maps or statistics of climatology, the environmental values that are expected to be observed at the present time.
- Assessments are derived data that provide information about the values, impacts, drivers, connections, or functions of a feature in its present distribution.

- Predictions are data expressing projections or models of future distributions, values, or impacts, including forecasts of anticipated changes brought about by natural and human processes, as well as scenario-testing models that compare outcomes of different management actions. Individual data products often contain more than one set of data and might be described with more than one category of data content type ((Lightsom et al., 2015)

## Data content subjects

The data needed for the MSP process is dependent on the goals and objectives set, but may include the following general areas:

Source:  
(Lightsom et al., 2015):  
information required for MSP

<b>Hierarchy of Data Content Subjects</b>	
<b>Nonliving Resources</b> Energy Resources Oil Resources Natural Gas Resources Wind Tides Ocean Currents Geothermal Resources Ocean Thermal Resources Solar Radiation Material Resources Sand Resources Mineral Resources Physical/Chemical Features Physical Habitats and Geomorphology Bathymetry and Elevation Substrate Water Column Features Water-Quality Parameters	<b>Ocean Uses—Continued</b> Harvesting Living Resources Pelagic Fishing Fishing with Benthic Mobile Gear Fishing with Benthic Fixed Gear Kayak Fishing Dive Fishing Fishing from Shore Gathering from Shore Offshore Seaweed Harvest Hunting Energy Production Wind Energy Production Wave Energy Production Ocean Current Energy Production Tidal Current Energy Production Ocean Thermal Energy Conversion Offshore Oil and Gas Production Transportation Shipping Cruise Ships Military Vessels Other Commercial/Industrial Uses Mining and Mineral Extraction Offshore Aquaculture Coastal Aquaculture Seawater Intake Sewage Discharge Ocean Dumping Underwater Transmission Cables
<b>Living Resources</b> Habitat Ecological Functions and Services Biological Production Biodiversity Biological Occurrence Fishes Invertebrates Flora Mammals Birds Reptiles Invasive Species	<b>Governance</b> Marine Protected Areas (MPAs) De Facto MPAs Commercial Leases Jurisdictional Boundaries Tribally Governed Areas Regulatory Use Restrictions
<b>Ocean Uses</b> Recreational Nonextractive /Cultural Use Scuba/Snorkeling Swimming Surface Board Sports Paddling Sailing Motorized Boating Wildlife Viewing at Sea Tide Pooling Shore Use Cultural Use	<b>Infrastructure</b> Ports Cables, Pipelines, and Power Grids Buoys and Navigational Aids Structures

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## Introduction

Marine space depicts a complex environment of input, output, and feedback loops from a multitude of sources that, thus, requires thorough planning for its effective management. Marine spatial planning, thus, aims to provide a comprehensive and systematic approach to utilizing the marine space under examination so that sustainable development of the marine environment can be achieved. This requires the meticulous planning of human activities within marine space as it is the only part of the marine environment that can be controlled. Therefore, marine spatial planning is often regarded as an iterative process of public discourse, analysis, re-analysis, and implementation that seeks to meet specific goals and guidelines, which are initially set, for human activities. Furthermore, it includes the establishment of objectives, authorities, plans, and knowledge baselines, along with the sourcing of funds, stakeholder engagement, implementation, monitoring, evaluation, and repetition of this process (Ehler & Douvere, 2009).

In Guyana, there is a lack of knowledge and horizontal information transfer between stakeholders of its marine space. Thus, there is a need for marine spatial planning to be conducted to provide an overarching view of Guyana's marine space, allowing individual stakeholders to better plan their actions.

Marine spatial planning, however, ultimately depends on the knowledge of the marine space and how it operates. There is a need to describe the marine space in its totality because holistic knowledge of the resources that are present, planned and ongoing human activities, and environmental features will allow for an understanding of how to manage the resources within the marine space. Additionally, how these resources will change over time must be projected to accounted for the future state of the resources. As such, there must be a thorough and continual examination of Guyana, its coastal zone, marine environment, spatial policies, and socioeconomic environment to provide a baseline from which planning can be grounded.

## Guyana Coastal and Marine Resources

### *Geography*

Guyana (4° 51' 20.43" N, -58° 57' 10.84" W) lies on the Northern coast of South America, bordered by the countries Venezuela, Brazil, and Suriname, and the Northern Atlantic Ocean (Ministry of Agriculture, 2016). It stretches from the latitudes of 1 and 9, and longitudes of 56 and 62 (Ministry of Agriculture, 2016; UNDP, n.d.), thus being situated in the tropics and slightly above the equator.

Within the country, there are three distinct zones based on its geography and topography (FAO, 2015). These begin along the Northern coast that stretches inland up to

12 km at its widest, and lies well below sea level (Caricom Today, 2017; FAO, 2015). This is followed to the immediate South by a region of white sand known for its hilly topography. Covering the remaining area of the country are mountains, forests and savannahs that comprise the interior highlands (FAO, 2015).

Guyana is also a part of a large geological formation known as the Guiana Shield, which includes Suriname, French Guiana, Venezuela, and parts of Brazil and Colombia. The Guiana Shield is approximately two billion years old, and consists of various metamorphic rock types, such as sandstone that is common among within the tepuis of the Pakaraima and Kanuku mountain ranges. Furthermore, the Guiana shield is generally characterized by low mountains, hilly savannahs, and alluvial plains (Department of the Environment, 2019a). Additionally, Guyana, Suriname and French Guiana constitute the Guiana highlands, known for lowland tropical rainforest (Ministry of Agriculture, 2016).

Additionally, throughout Guyana, there are three main rivers that run varying lengths until meeting and emptying into the Atlantic Ocean, characteristically depositing sediment onto the coast (Commonwealth, 2018). These rivers are known as the Berbice, Demerara, and Essequibo, and they are fed into by several tributaries, with the Essequibo river having the most and the Berbice river having only one. Additionally, there are a number of smaller rivers within Guyana that feed directly into the Atlantic Ocean, namely the Abary, Mahaica, Mahaicony, Moruka, Pomeroon, Waini rivers, which have several or no tributaries (FAO, 2015; Spillman, Jernigan, & Scott, 1998).

### *Climate*

Being in the neotropics, Guyana experiences high humidity, precipitation, and temperatures consistently year-round. Guyana also falls within the Intertropical Convergence Zone (ITCZ) twice a year causing high precipitation, which influences the country's seasonality. Since the ITCZ moves Northward from May to July, it causes a break from July to August in the Northeast Tradewinds that usually affect Guyana's coast (FAO, 2015; Department of the Environment, 2019a). As such, during the months of September to May when the Northeast Tradewinds are not obstructed, they blow over the coast of Guyana (Lowe, 1962) and create a moderating effect on the temperature (Department of the Environment, 2019a). Additionally, Guyana is affected by the El Niño Southern Oscillation (ENSO) that is characterized by the warming of ocean's surface (El Niño) followed by average temperatures and rain (Neutral) and then by the cooling of the ocean's surface (La Niña), which cause a decrease, leveling out, and an increase in rainfall over Guyana, respectively (Department of the Environment, 2019a; L'Heureux, 2014; Ministry of Agriculture, 2016).

These phenomena do not affect the entirety of Guyana the same, thus climate varies slightly across Guyana. The interior highlands experiences much lower air temperatures (as low as 16 °C) than along the coast (up to 34 °C), along with greater fluctuations in daily temperature due to being away from the mediating effect from the Northeast Tradewinds. Humidity is also lower (60 %), compared to the coast (70 %). Precipitation, amounting to 2387 mm/year or 513,100 million m<sup>3</sup>/year (Spillman,

Jernigan, & Scott, 1998), varies more widely, being greater in the forested parts of the interior highlands (2500 mm) , but lower within the savannah regions and towards the Southeast of the country because the ITCZ passes over the Southern areas of Guyana once in its yearly movement while it passes over the Northern areas twice (1500 mm; FAO, 2015; Sustainable Management of Natural Resources).

Guyana is generally known to have two dry seasons and two wet seasons per year (Ministry of Agriculture, 2016). The seasonality follows the pattern of a wet season from November to January, a dry season from February to March, a second wet season from May to July, and a second dry season from September to October. However, this varies in the Rupununi savannahs region, where there is no wet season from November to January since the ITCZ does not pass over that region of Guyana during that time of year, and instead a wet season from April to September and a dry season from October to March (Department of the Environment, 2019a; FAO, 2015; Spillman, Jernigan, & Scott, 1998).

The overall climate of Guyana, however, is predicted to shift over coming years, following trends noticed over recent years. It has been noted that precipitation along Guyana's coast has increased by 4.8 mm/month per decade, along with temperature increases of 0.3 °C per decade (Ministry of Agriculture, 2016). Thus, it is expected that the wet seasons will become more intense, while but precipitation will be scarce during dry seasons, which may lead to overall water deficits for the country (Department of the Environment, 2019a).

### ***Natural Regions***

Within Guyana, there are four natural regions that are widely recognized, and they are the low coastal plain, hilly sand and clay region, forested highland region, and interior savannahs (Environmental Protection Agency, 2006). These vary, however, with descriptions by external agencies that may categorize natural regions into three to five groups (Department of the Environment, 2019a; FAO, 2015).

The low coastal plain is a belt along the Northern coast of Guyana in contact with the Atlantic Ocean, and which is 5 to 12 km wide (Environmental Protection Agency, 2006; FAO, 2015; Ministry of Agriculture, 2016). It is characterized by its rich alluvial soil and numerous sea defense structures due to the region being below sea-level. Furthermore, the region is known for its focus on agriculture on the rich soils (Spillman, Jernigan, & Scott, 1998).

Immediately South, the hilly sand and clay region is composed of intermediate savannahs, hardwood forests, and is known for its gently sloping hills, white and brown sand, and bauxite reserves (Environmental Protection Agency, 2006). It contains several rivers running through it, along with streams that are present only at certain times of year (Spillman, Jernigan, & Scott, 1998).

The forested highland region, which comprises approximately two-thirds of Guyana's landmass, is mainly covered by neotropical rainforest and mountains, such as the Pakaraima mountain range and Mount Roraima (Environmental Protection Agency,

2006; Ministry of Agriculture, 2016). Most of the region is virtually inaccessible, and contains steep hills and gorges, with fast-flowing rivers and waterfalls (Spillman, Jernigan, & Scott, 1998).

To the Southwest, bordered by the forested highland region and Brazil, the interior savannahs account for 11 % of the country's land area (Ministry of Agriculture, 2016). It is characterized by sparse trees, hills, low-flowing streams, and open grasslands. Generally, this region conducts cattle ranching due to the suitable climate (Spillman, Jernigan, & Scott, 1998).

### ***Boundaries***

Guyana is bounded to the West along the Schomburgk line partially by the Cuyuni and Amacuro rivers, separating it from Venezuela; to the East by the Corentyne river, separating it from Suriname; to the South by the Takatu river, separating it from Brazil (Environmental Protection Agency, 2006; Spillman, Jernigan, & Scott, 1998); and to the North by the Atlantic Ocean, although the continental shelf extends to approximately 80 miles (Lowe, 1962). To the West, the Pakaraima mountain range also serves as a partial boundary between Guyana and Venezuela, and Guyana and Brazil. Meanwhile, to the South, the Acarai mountain range also serves as a border between Guyana and Brazil.

### **Coastal Regions**

Six administrative regions lie along the coast of the Guyana, fully or partially, and are thus in contact with the Atlantic Ocean to varying degrees (FAO, 2015). These regions are Barima-Waini (Region 1), Pomeroon-Supenaam (Region 2), Essequibo Islands-West Demerara (Region 3), Demerara-Mahaica (Region 4), Mahaica-Berbice (Region 5), and East Berbice-Corentyne (Region 6), which are generally named based on the rivers the border them (UNDP, n.d.).

Barima-Waini (Region 1) falls within both the low coastal plain and forested highland region, and it is generally populated by Amerindians. It is known for its beaches, such as Shell Beach, and its main activities include logging and gold and diamond mining (Ministry of Communities, 2016).

Similarly, Pomeroon-Supenaam (Region 2) falls within both the low coastal plain and forested highland regions, along with a fraction of the hilly sand and clay region, and it is also mainly populated by Amerindians. The region generally engages in rice farming due to its large conservancy, but there is small scale coconut farming, cattle farming, and logging (Ministry of Communities, 2016).

Region 2, Essequibo Islands-West Demerara (Region 3) is composed of low coastal plain, forested highland, and the hilly sand and clay regions, and, by its name, includes islands found in the mouth of the Essequibo River. As this region also contains a large conservancy, rice farming is the main economic activity. However, sugarcane farming, coconut farming, and cattle farming are also conducted (Ministry of Communities, 2016).

In contrast, Demerara-Mahaica (Region 4) contains only the low coastal plain and hilly sand and clay regions. Although sugarcane farming is popular in this region, it is better characterized as the primary port and commercial center of the country, because the capital city can be found within this region (Ministry of Communities, 2016).

Mahaica-Berbice (Region 5), similarly, contains the low coastal plain and hilly sand and clay regions, but there is a greater focus on farming. With several creeks, dams, and conservancies, rice farming is predominant, but individuals also conduct sugarcane farming, coconut farming, cattle farming, and crafting, which is done mainly by Amerindians (Ministry of Communities, 2016).

East Berbice-Corentyne (Region 6) contains portions low coastal plain, hilly sand and clay, and forested highland regions. As such, economic activities range from rice farming, to sugarcane farming, to cattle farming, and to logging (Ministry of Communities, 2016).

### ***Socioeconomic***

Over time, Guyana's GDP has fluctuated greatly due to external influences. In 2012, GDP totaled US \$2,851 million/year, which translates to US \$3,586 per capita/year, all the while Guyana recorded a 12% unemployment rate, leading to high emigration. Additionally, only 47 % of the population were noted to be economically active, most of which were males (63 %), and for those involved in agriculture, it was mostly men (92%) who were economically active. Thus, there was a loss of 52 % of human development in Guyana, with a score of 0.524 on the gender inequality index in 2012 (FAO, 2015). However, accounting for life expectancy, expected and mean years of schooling, and gross national income per capita, Guyana was noted as a country with medium human development, slowly increasing toward high human development, with a score of 0.638 on the human development index in 2012 (FAO, 2015).

### ***Population***

Guyana has a population of 747,884 individuals as of the 2012 census, leading to a population density of 3.5 individuals/km<sup>2</sup>. The regions along the coast, however, contains a combined population of 653,750 individuals (87.4 %), leading to a much higher population density of 8.9 individuals/km<sup>2</sup>. This becomes further inflated when examining Region 4 that hosts a population of 313,429 individuals (41.9 %), resulting in a population density of 140.4 individuals/km<sup>2</sup>. Regardless, the coastal regions are, on average, decreasing in population by approximately 0.2 % per annum, so population density is declining (Bureau of Statistics, 2014).

By region, populations vary widely, along with their corresponding population densities. Regions 1, 2, and 5 recorded the lowest populations of 26,941, 46,810, and 49,723 individuals, respectively. Meanwhile, regions 3, 4, and 6 recorded the highest populations of 107,416, 313,429, and 109,431, respectively. However, regions 1, 2, and 6 incurred the lowest population densities of 1.30, 7.60, and 3.00, respectively,

while regions 3, 4, and 5 incurred the highest population densities 28.6, 140.4, and 11.9, respectively (Bureau of Statistics, 2014).

### ***Area/Size***

The entire country covers an area of 353,210 km<sup>2</sup>, of which 214,970 km<sup>2</sup> is terrestrial and 138,240 km<sup>2</sup> is marine (Department of the Environment, 2019a; FAO, 2015). Of the landmass, 165,000 to 185,000 km<sup>2</sup> (87 %) is made up of forest and woodlands, while 12,000 km<sup>2</sup> is dedicated to being pasture land, and 5,000 km<sup>2</sup> is being used for agriculture (Department of the Environment, 2019a; FAO, 2015).

The regions that make up the coast vary in size as follows: Region 1 - 20,339 km<sup>2</sup>; Region 2 - 6,195 km<sup>2</sup>; Region 3 - 3,755 km<sup>2</sup>; Region 4 - 2,232 km<sup>2</sup>; Region 5 - 4,190 km<sup>2</sup>; Region 6 - 36,234 km<sup>2</sup> (Bureau of Statistics, 2014). This totals to 72,945 km<sup>2</sup> of landmass; however, the entirety of these regions does not fall along the coast.

### **Coastal zone and marine environment**

The coastal zone can be defined in several ways, but it is generally known as the interface between the land and the water. The extent of the seaward boundary may be to the end of territorial limits or simply where the continental shelf reaches a depth of 200 m, but this is ultimately defined by legislation. Generally, however, it has been accepted as the region where land-based activities affect the marine environment. Similarly, the landward boundary of the coastal zone has been accepted to only include areas directly connected to the sea and the use of its resources, and this varies from place to place (European Environment Agency, 2016).

On the other hand, the marine environment refers to the interconnected habitats, activities, and social systems within territorial waters or the exclusive economic zone (Atkins, Burdon, Elliott, & Gregory, 2011). Additionally, by law in the USA, it has been defined to include navigable waters and its land and resources within and below it, fisheries the seabed and subsoil, and recreational, economic and scenic values of the waters.

### ***Guyana's coastal zone***

Guyana's coastal zone is a mudflat created by expansive deposition by the Proto-Berbice river in the Mesozoic era, which has since become a combination of inter-tidal mudflats, mangrove forests, beaches, lagoons, and swamps. These habitats along the coast provide various ecosystem services, such as acting as nesting and foraging grounds for some migratory species (Department of the Environment, 2019a). Also, at various intervals man-made structures, such as groins, dikes, and seawalls, can be found along the coast to protect against inundation, flooding, and erosion, and allow accretion of the coast over time (Commonwealth, 2018; Department of the Environment, 2019a).

The coastal zone stretches up to the limit of the inshore waters at about 22 km, where the marine environment begins (Department of the Environment, 2019a). This area is known for its highly turbid and brown coloured water, due to the discharge of sediments from the surrounding rivers, and lies over a seafloor of soft mud, which can be easily disturbed by winds (Lowe, 1962).

### ***Guyana's marine environment***

Guyana's marine environment is stratified based on the distance away from the coastline. It begins at 22 km from the coastline, in a region known for its green coloured water, where brown inshore water mixes with the blue ocean water, creating a transition zone. This area generally lies over a seafloor of mud and sand, and is highly productive, with high concentrations of plankton and high fish diversity, due to being nutrient rich. Further offshore, the green coloured water gives way to blue water that lies over a seafloor of mainly sand. To the edge of the continental shelf, the blue water becomes darker in colour significant of the deep ocean, and this lies above a seafloor of calcareous rock and old coral blocks (Lowe, 1962).

### ***Administrative boundaries***

Guyana's coastal zone stretches for 370 to 480 km in length (Caricom Today, 2017; Environmental Protection Agency, 2000; FAO, 2015; Lowe, 1962; Maison, 2007), across a width of 26 to 77 km, and covering 16,800 km<sup>2</sup> (Environmental Protection Agency, 2000). It lies 1 to 3 m below sea-level, based on tides (Commonwealth, 2018; Department of the Environment, 2019a; Environmental Protection Agency, 2000; Lowe, 1962), and this may become lower by as much as 51 cm by 2071, due to rising sea levels from climate change (Department of the Environment, 2019a). Towards the Atlantic Ocean, the continental shelf gradually declines to 90 m at 120 km, then quickly approaches a depth of 180 m when it extends to approximately 130 km, after which it gives way to deep ocean (Lowe, 1962), but has an average width of 112.6 km and covers 48,665 km<sup>2</sup> (Maison, 2007). The marine environment, however, begins at 22 km and ends at the exclusive economic zone (Department of the Environment, 2019a), which stretches to 322 km (Environmental Protection Agency, 2006), and covers 138,240 km<sup>2</sup> (Maison, 2007).

Along the coastal zone, the climate is relatively stable, like what is experienced through most of Guyana. There is high humidity (70 %), precipitation (2500 mm), and temperature (24 to 32 °C), and influence from the Northeast tradewinds, ENSO, and the ITCZ (twice per year). Thus, the coastal zone experiences two rainy seasons and two dry seasons per year, following the pattern of a wet season from November to January, a dry season from February to March, a second wet season from May to July, and a second dry season from September to October (FAO, 2015).

Throughout the coastal zone, soil is rich in nutrients and tends to take the form of silty and clayey loams. The deposition of silt from local rivers, and the Orinoco and Amazon rivers, assisted in the formation of these soil profiles, which exhibit poor

drainage capacity. Furthermore, anthrosols, gleysols, fluvisols, and histosols can be found along the coast. For instance, swamp regions along the coast tend to create histosols, known as pegasse, from layers of clay, organic matter, and peat that are acidic and infertile (Department of the Environment, 2019a)

### ***Physical, chemical and biological characteristics***

The coastal zone and marine environment exhibit various types of characteristics based on location. This begins at the onshore region of the coastal zone, followed by inshore waters, and several zones of offshore waters. The changes that accompany the zones tend to involve seafloor strata, biodiversity, and activities that are generally conducted.

As water moves down from rivers and out to the ocean, it is clear brown, since it has not come into contact with silt from the coast (Lowe, 1962). This area usually coincides with the region protected by seawalls and other defenses, meaning the land is likely flat, low-lying, and consisting of rich soil. Thus, this area may have aquaculture ponds, agricultural lands, or settlement, and human-associated biodiversity would mostly be present. However, since this is low-lying land that is productive for human activities onshore, there are threats from flooding and sea-level rise. On the other hand, these human activities may also be disrupting natural biodiversity of the area (Department of the Environment, 2019a).

On the other side of man-made sea defenses, the environment is composed of flat, low-lying beaches and mudflats. At this point, water from rivers become muddy brown as they encounter tides and waves that stir up and suspend silt in the water. Generally, this zone stretches as far as 16 km out to sea, but benthic biodiversity tends to be low because of the silt. Regardless, along the mudflats, three species mangroves tend to occupy the immediate space: the black mangrove (*Avicennia germinans*), red mangrove (*Rhizophora mangle*), and white mangrove (*Laguncularia racemosa*). They act as coastal defense, buffering waves from the man-made defenses behind the mangroves, as carbon sinks, as nurseries for young fishes, and as sanctuaries for wildlife, and they help with trapping sediment and building up the coastline. Furthermore, the mangroves can be utilized for tanning, fuel for brick making, apiculture, and as poles. However, excessive destruction of the mangrove forests tends to happen, and this leads to erosion, losses in fisheries, and potential loss of livelihoods for individuals living near to man-made sea defenses (Caricom Today, 2017; Department of the Environment, 2019a; Environmental Protection Agency, 2006; Lowe, 1962)

Waters shift more to a muddy green colour further out as the muddy brown water begins to mix with salt and nutrient rich water and transition to the eventually clear green water filled with plankton. This zone generally occurs over a seafloor that is a mix of mud and sand that can be stirred up with strong enough winds. Additionally, it contains relatively high biodiversity as the water is allowing for higher productivity than prior zones (Lowe, 1962).

As the seafloor begins to change to more of a sandy consistency, the water becomes clear green, from the salts and nutrients brought out from the rivers to enrich the wa-

ter and cause plankton to thrive. This zone tends to contain high biodiversity due to the productivity accompanied by nutrient and salt rich waters. As such, industrial fishing is often conducted in this region. However, this can lead to overfishing and decline of fish stocks and biodiversity (Lowe, 1962).

Beyond this area, the water starts transitioning to blue characteristic of the open ocean, creating a blue-green colour. This area occurs over a mainly sand seafloor but does not have the same level of nutrients and salts as the previous zone for plankton to thrive as intensely. As such biodiversity is beginning to decrease as fewer, but larger fish species are being encountered (Lowe, 1962).

At the edge of the continental shelf, the colour of the water becomes completely blue and clear (Lowe, 1962). As such, these areas tend to have greater benthic biodiversity as light can penetrate further down to the seafloor, which is composed of calcareous rock and old coral blocks. This zone allows for fishing by hook for large fish species, and without proper optimization, this does not negatively impact fish stocks or biodiversity (Department of the Environment, 2019a; Lowe, 1962).

### *Human activities*

Having the most concentrated population, the coastal zone of Guyana experiences a great amount of human activities. Most of these activities take the form of extractive resource use, such as fishing and oil production. However, there is a growing interest in non-extractive activities, such as, renewable energy production, tourism, and aquaculture. Current human activities along the coast include the following.

### *Coastal defense*

Being below sea-level, the coast requires adequate defense from the intrusion of salt water from the Atlantic Ocean to protect the vast array of human activities occurring there. Most of the sea defenses still used currently were originally built by the Dutch, and include seawalls, canals, kokers, groins, and sluices. Over time, these defenses were built taller and stronger, and included pumping stations, gabion baskets, and dikes/embankments. These structures need to be regularly repaired and maintained to ensure their effectiveness, because they tend to wear quickly from coastal processes (Spillman, Jernigan, & Scott, 1998).

Before waves reach these hard structures, however, mangroves serve as means of coastal protection. They assist in breaking waves, thus reducing the force with which the waves impact the hard structures built behind them. Additionally, they help to trap sediment, which builds up the coast (NAREI, 2015).

To ensure mangrove forests remain healthy and continue acting as a buffer, the Guyana Forestry Commission, along with other agencies, developed the National Mangrove Management Action Plan in 2001. Since then, several mangrove restoration efforts have been conducted to replant and reduce the destruction of mangrove forests along the coast (Environmental Protection Agency, 2007).

## Aquaculture

Started in Onverwagt with species found in brackish water (Lowe, 1962), aquaculture in Guyana has since diversified and occurs in three methods along the coast. These are based on the location and type of water used in the operations, thus leading to freshwater, brackish, and marine aquaculture. Since aquaculture is generally conducted to fill the gaps of the fishing industry, freshwater aquaculture produced GUY \$150,691,242 over 93 ha and brackish water aquaculture produced GUY \$159,128,337 over 425 ha in 2014. There are, however, no values for marine aquaculture since it is rarely practiced (Ministry of Agriculture, 2016).

Freshwater aquaculture generally occurs on small scale in ponds at varying points from to the coastline, some of which do not lie along the coast, and uses inland waters with salt content of less than 0.1 ppt. Of these, the operations that are conducted along the coast occur in Demerara-Mahaica (Region 4), Mahaica-Berbice (Region 5), and East Berbice-Corentyne (Region 6). The species that are farmed usually include Jamaican red tilapia (*Oreochromis sp.*), Nile tilapia (*Oreochromis nilotica*), freshwater pacu (*Colossoma macropomum*), and hassar (*Hoplosternum littorale*), which are usually exported. Thus, this aquaculture generally involves the feeding the farmed fish with a specific feed, along with providing plankton by fertilizing the pond and allowing the plankton to grow. However, care is taken to avoid overfeeding or overfertilizing because they cause algae to grow, which kill the fishes by removing dissolved oxygen from the water. Ponds also need to be monitored and protected since natural predators, such as hawks, kingfishers, caiman, and kiskadees can kill the fishes. Additionally, during the dry periods of the year, saltwater intrusion makes it difficult to source water, because water cannot be alternatively sourced from drainage canals due to waste contaminating the water supply (Ministry of Agriculture, 2016).

Brackish water aquaculture, on the other hand, is a low input system utilizing the coastal saltwater of varying salt content, along with the species found in these waters. It is generally accompanied by small stocks of fish that are not provided supplementary feed. Initially, this type of aquaculture involved species such as Atlantic tarpon (*Tarpon atlanticus*), ladyfish (*Elops saurus*), mullet (*Mugil liza*, *M. curema* and *M. incilis*), kakinette (*Pseudauchenipterus nodosus*), highwaterman (*Hypophthalmus edentates*), pargee (*Lobotes surinamensis*), large cownose ray (*Rhinoptera sp.*), and foureyes (*Anableps microlepis* and *A. anableps*) in its operations (Lowe, 1962). However, it now focuses on brackish water shrimp (*Litopenaeus schmitti* and *Penaeus subtilis*, mullet (*Mugil cephalus*), querriman (*Mugil liza*), and bashaw (*Micropogonias furnieri*) in their young phases, but a number of other species make their way into the ponds since the method of letting water free-flow from the high tide overtopping of shores and river banks until ponds are full does not discriminate between which organisms move along with the water (Ministry of Agriculture, 2016).

Any aquaculture operation is dependent on water supply, and droughts and floods have both negatively affected operations. Flooding tends to allow species to move out of ponds into nearby streams and trenches and disrupt the natural ecosystem. For instance, during the 2005 flood in Demerara-Mahaica (Region 4) and Ma-

haica-Berbice (Region 5), ponds were flooded and allowed fishes to freely move, coming into contact with predators, like snakes and caiman, and similar species that could have produced feral species. Droughts on the other hand tend to cause salt intrusion from the ocean, affecting the availability of freshwater that can be supplied to the ponds. Prolonged droughts can lead to reduced production as fishes are forced to grow in sub-optimal saltwater conditions, along with a lack of plankton available for feeding since they also die in these conditions. In these cases, farmed fish may cost more in production than wild-caught fish, thus leaving the market favoured towards cheaper wild-caught fish than farmed fish (Ministry of Agriculture, 2016).

Aquaculture is regulated by the Environmental Protection Agency because they determine areas along the coast where operations can be conducted, but there are still issues incurred within the industry. Along the Northeastern coast, in East Berbice-Corentyne (Region 6), non-fed aquaculture has caused the destruction of coastal defenses for the sake of pond irrigation and fish capture. Unfortunately, there is no current solution for this issue because relevant authorities cannot provide better solutions to ensure successful breeding programs, and the practice has not been banned, possibly due to its considerable revenue generation. Additionally, the effects of this practice, and general pond construction on local ecosystems is unknown, so no action has been taken. However, sustainable options, such as aquaponics and a hassar breeding project displayed at the Satyadeow Sawh Aquaculture Station are available for others to adopt (Ministry of Agriculture, 2016).

### *Fishing*

The fisheries industry stands as one of the most productive and expansive coastal industries in Guyana, spanning 138,240 km<sup>2</sup> and generating GUY \$14,692,615,448 of revenue in 2015, despite space for improvement within the industry (Ministry of Agriculture, 2016). Its abundant fish stocks include over 213 species from 72 families (Lowe, 1962), although not all species are usually harvested. Nevertheless, the fisheries industry can be sub-divided, based on the type of equipment used, into the artisanal (marine and inland), semi-industrial and industrial fisheries.

The artisanal fishery involves fishing on a small scale within the brown waters closer to the coast (Lowe, 1962). Catches tend to be larger and more diverse between June and August because river discharge from the Orinoco river, Amazon river and local rivers tends to attract fish closer to land in what becomes nutrient-rich water, unlike the rest of the year when the Northeast Tradewinds blow and stir up mud, causing fish to move further offshore the stronger the winds (Lowe, 1962). Yet, regardless of the time of year, the artisanal fishery tends to use polyethylene and nylon gillnets, cadell lines that may be demersal or mid-water in shallow water and estuaries, Chinese seines across river mouths, and pin seines along tidal mudflats in its operations (Lowe, 1962). As such, tides often determine when and where operations can be done, since these methods heavily depend on the tides to be most effective. Nevertheless, the equipment and location allow for mainly finfish to be caught within the artisanal fishery, although gillnets are known to accidentally trap sea turtles (Ministry of Agriculture, 2016). Specific species caught in artisanal fisheries tend to include inshore

species of tilapia (*Tilapia spp.*), tambaqui (*Colossoma macropomum*), hassar (*Hoplosternum spp.*), and lukanani (*Cichla spp.*), and 80% of this catch is exported (Caricom Today, 2017; Department of the Environment, 2019a).

The semi-industrial fishery, however, conducts its operations furthest offshore in the blue waters of the open ocean, over the hard, benthic surface of coral blocks and sand. In these operations, hooks, lines, and traps are generally used to target red snapper (*Lutjanus purpureus*, *L. campechanus* and *L. aya*), vermillion snapper (*Rhomboplites aurorubens*), gill backer (*Sciades spp.*), giant grouper (*Epinephelus lanceolatus*), and lukanani (*Cichla spp.*) (Department of the Environment, 2019a; Lowe, 1962; Ministry of Agriculture, 2016). While this fishery can also target tuna species in this region, this has not been sought after (Department of the Environment, 2019a).

The industrial fishery focuses on large scale operations within the green water zone offshore, where coastal and oceanic waters meet and produce a highly nutrient rich area. However, operations may also be conducted further onshore. This fishery mainly uses trawlers for its operations, along with by-catch reduction devices to avoid catching fishes because it is currently under assessment by the Marine Stewardship Council of whether it is fishing sustainably, to obtain an eco-label (Caricom Today, 2017; Commonwealth, 2018; Ministry of Agriculture, 2016). This is because it focuses on the catch of seabob shrimp (*Xiphopenaeus kroyeri*) and penaeid shrimp (*Farfantepenaeus brasiliensis*, *F. subtilis* and *F. notialis*), and not fish (Department of the Environment, 2019a; Ministry of Agriculture, 2016), despite the high diversity of fish and marine invertebrate species found within this area of coastal waters as recorded by Lowe (1962).

The diversity of the fisheries industry, the magnitude of the accompanying fleet of vessels, and the use of inappropriate gear, however, poses a threat to the fish stocks. Fishes are being removed at rates higher than their recruitment rate (Environmental Protection Agency, 2006), leading to fewer and younger fish being landed, and fewer being left to reproduce and bolster the populations (Ministry of Agriculture, 2016), as evidenced by a decrease in catch by 6.5 % in 2013 (Department of the Environment, 2019a).

To combat this issue, there is need to establish limits and policies within the industry, along with innovative ideas. Thus, constant stakeholder engagement and decentralization of governance is being employed to deal with this issue, and guidelines are being set, for instance fish stocks always being kept above 40 %. A closed season of seven (7) weeks once a year has also been enforced within the seabob fishery to allow the stock to replenish itself. To enforce this, patrols are conducted within the exclusive economic zone (EEZ). Additionally, local knowledge on the behaviour of fishes and anecdotal information on the changes in fishing conditions is being used to inform management strategies. In some other cases, species have become a focus in aquaculture to supplement and/or replace their harvesting from fish stocks (Ministry of Agriculture, 2016).

Also, the fisheries industry tends to encounter marine mammals and reptiles in their operations, especially the industrial fisheries, and these encounters usually result in

the mortality of the animals. These animals include, but are not limited to, the sperm whale (*Physeter macrocephalus*), leatherback turtle (*Dermochelys coriacea*), Olive Ridley sea turtle (*Lepidochelys olivacea*), loggerhead sea turtle (*Caretta caretta*), and green sea turtle (*Chelonia mydas*). Also, while it is assumed that seabirds would be encountered, there is no recording of seabirds as by-catch (Ministry of Agriculture, 2016).

To avoid this, the industrial fisheries tend to follow stringent regulations to ensure that only the desired species are caught, by-catch is reduced to a minimum, and stakeholders adopt these strategies, unlike the artisanal and semi-industrial fisheries that are more difficult to regulate. As such, most vessels used in the industrial fisheries are equipped with by-catch reduction devices and turtle-exclusion devices, and the fisheries department conducts regular inspections of fishing equipment to ensure it meets the required standards (Ministry of Agriculture, 2016).

### *Installations and Infrastructure*

Along the coast of Guyana, infrastructure and installations are primarily onshore, although there are plans to establish offshore infrastructure. Existing infrastructure requires protection, and future infrastructure needs to be more resistant and resilient to reduce risks associated with failure of the infrastructure or installation (Commonwealth, 2018).

Due to the coast being below sea level, drainage infrastructure needs to be up to standard and well maintained. When there are changes in sea level or after heavy rain, these structures need to function as intended, otherwise it will lead to a cascade of problems. Furthermore, existing infrastructure needs to be updated or replaced to anticipate changes in the environment in the future. For instance, with the clear increase in sea level over time, infrastructure associated with draining excess water out from communities needs to be updated so that when sea levels do rise, the infrastructure is already in place to deal with the change (Department of the Environment, 2019b).

### *Marine transport routes and Traffic flows*

Guyana has several seaports along the coast that ships usually use to conduct business. These tend to be located at towns, such as Georgetown, New Amsterdam, and Bartica, but others may not, such as a port located along the Essequibo river, and one at Skeldon. Additionally, there are ports found at Port Kaituma and Linden further inland. Furthermore, bridges across the major rivers are usually built to allow the movement of marine traffic further inland.

Most of the marine traffic stems from cargo shipping and trawlers but have recently diversified to include oil exploration and extraction vessels. The trawlers number to 87 vessels that work within the expanse of the exclusive economic zone, each of which operate for about 4 to 7 days at a time (Southall, Addison, & Keus, 2019). Cargo shipping is actively done by several companies, including Muneshwers Ltd, Guyana Na-

tional Shipping Corp, Guyana National Industrial Co, Demerara Shipping Co Ltd, and John Fernandes Ltd, but this leads to a variable number of vessels traversing the marine environment. Meanwhile, the oil exploration and extraction vessels generally stay within the Stabroek block, and while they are few, some vessels are recruited into this area over the course of operations, such as the Guyana Hero (Esso Exploration and Production Guyana Limited, 2018).

### *Military*

Guyana's military has normal presence along the coast, granted the headquarters are located a few kilometers from the coastline. The coast guard is the branch of the military associated with monitoring the coastal and marine environment, and it is mandated to patrol coastal waters, up to the exclusive economic zone, and enforce laws in areas within Guyana's jurisdictions. The coast guard is expected to conduct coastal and exclusive economic zone surveillance, fisheries, hydrocarbon and harbour patrols, anti-smuggling and anti-narcotic operations, search and rescue operations, riverine small boat operations, marine pollution monitoring, troop transport, civil defense operations, marine traffic management, marine GDF training, as well as maintain safety at sea, maintain port security, maintain the integrity of the exclusive economic zone, and advise defense headquarters on maritime affairs (Caricom Today, 2017; Pike, 2017). These activities are conducted using fast-patrol boats and offshore patrol craft, including seven Metal Shark 38ft DEFIANT boats, along with helicopters and smaller patrol craft (Pike, 2017).

### *Nature and Species Conservation sites and Protected Areas*

While the country contains five legally recognized protected areas, over 18,000 km<sup>2</sup> of land (8.3 % of the country's landmass), only one of these is located along the coast. This is the Shell Beach Protected Area, which occupies 1,230.55 km<sup>2</sup> of land (0.57 % of Guyana's landmass) and stretches over 120 km of coastline (Department of the Environment, 2019a; Protected Areas Trust, n.d.). The Shell Beach protected area was established in 2011 as a means of protecting flagship species, such as the Scarlet Ibis (*Eudocimus ruber*), sea turtles (*Caretta caretta*, *Lepidochelys olivacea*, *Eretmochelys imbricata*, *Chelonia mydas*, and *Dermochelys coriacea*), and dolphins (*Sotalia spp.*), that forage and nest there, along with the natural mangrove habitat (Department of the Environment, 2019a; Environmental Protection Agency, 2006), but the area is also known to host Caribbean flamingos (*Phoenicopterus ruber*), West Indian manatees (*Trichechus manatus*), jaguars (*Panthera onca*), and 59 species of fish (Protected Areas Trust, n.d.). Furthermore, monitoring and recovery of the sea turtle populations is an ongoing project within the Shell Beach protected area, which is led by the Guyana Marine Conservation Society and the Environmental Protection Agency (Environmental Protection Agency, 2006; Ministry of Agriculture, 2016). This project also seeks to ensure local communities can still use the resources on Shell Beach despite its protected area status, and educates the communities on the work of Shell Beach (Ministry of Agriculture, 2016).

Among the urban parks classified as protected areas, the National Park lies within a few kilometers of the coastline. The park is known for its ponds that have populations of West Indian manatees (*Trichechus manatus*). The park also attracts about 1000 persons daily, and houses the head office of the Protected Areas Commission that is in charge of the protected areas network of the country (Protected Areas Commission, 2016).

Throughout almost 480 km of coast, mangrove forests are being managed, protected, and restored (Caricom Today, 2017) due to their importance in coastal defense and biodiversity conservation by the Mangrove Restoration Project. The ecosystem supported by mangroves serves as a nursery for commercial species of fish, shrimp, and marine invertebrate, along with being a hotspot for bird species (Department of the Environment, 2019a). However, the mangrove forests are not fully protected excepted within the Shell Beach protected area.

Regardless, the coastal zone contains several areas that qualify as natural wetlands. These areas need to be conserved for the services they provide and the biodiversity they hold, and they can be identified as RAMSAR sites, allowing for their conservation. However, Guyana has not signed on to the RAMSAR convention, so these wetlands are still at risk (Department of the Environment, 2019a).

#### *Raw material extraction areas*

Guyana is known for its abundance of natural resources, within each of its natural environments. Many of these resources have been mostly left intact, but there is a greater push to find and extract new resources, along with streamlining the extraction of resources already in use.

The mangrove forests along the coast experience several extractive uses, some of which are sustainable. Generally, the trees are used for firewood, poles, and heart of palm extraction. However, the environment itself is utilized to help trap wildlife, such as birds, snakes, and monkeys and other mammals, for the wildlife trade (Environmental Protection Agency, 2006; Environmental Protection Agency, 2007). While these uses have prompted the National Mangrove Management Action Plan to be created, more sustainable activities have been attempted along Shell Beach. This involved the harvesting of crabwood oil by Waini communities in a sustainable manner (Environmental Protection Agency, 2006).

Also, groundwater is heavily extracted from the coastal aquifers for domestic use. Although high precipitation along the coast tends to refill these aquifers, over-extraction coupled with climate change and sea-level rise may cause the groundwater to be subject to saltwater intrusion (Department of the Environment, 2019a; Spillman, Jernigan, & Scott, 1998).

Most recently, oil and gas reserves were discovered within Guyana's marine environment in the Guyana-Suriname basin (Department of the Environment, 2019a). This has prompted the establishment of drilling and extraction operations within the Stabroek block, which is 26,800 km<sup>2</sup> in size and 183 km offshore and parallel to the Northeast-

ern coast of Guyana. However, at current, only 76.6 km<sup>2</sup> is being utilized for extraction (Esso Exploration and Production Guyana Limited, 2018). Regardless, this has sparked concern for its threats to coastal and marine habitats (Department of the Environment, 2019a)

### *Renewable energy*

Renewable energy is a recent concept to the country of Guyana, with a few attempts at it, such as the Amaila Falls project. Since then, however, new opportunities and ideas have arisen. The country has committed to shifting to almost 100 % renewable energy by 2025, and there has been implementation of solar energy systems by providing photovoltaic grids to government buildings, streetlights, and hinterland communities, but no large-scale grids. Specific to the coast, the Guyana Energy Authority has been working towards establishing wind energy and hydropower systems (Environmental Protection Agency, 2006). Furthermore, there are several opportunities that have been highlighted for future sources of renewable energy, include small to large-scale hydropower plants at 67 potential sites, biofuel from agricultural byproducts and waste, and bioethanol (Guyana Office for Investment, 2019).

### *Scientific research*

Along the coast, numerous studies have been conducted on various aspects of Guyana's coastal zone. Generally, research is conducted as part of government department projects, external organization projects, or by the University of Guyana. However, funding for these research tends to be a major limiting factor, except those funded by external organizations, that restricts the volume of quality research that can be conducted at any given time.

Biodiversity assessments are a common and much needed form of research along the coast, especially with increasing use of coastal resources. However, most of these provide general information, but some produce detailed data, like the sea turtle research that occurs in the Shell Beach protected area and produces species data (Environmental Protection Agency, 2006). Furthermore, with the production of oil offshore Guyana, some biodiversity assessments have been conducted by Exxon Mobil, prior to production. The assessments include coastal wildlife, seabirds, marine mammals, and marine reptiles to determine baseline and possible effect operations would have on these species (Esso Exploration and Production Guyana Limited, 2018).

Of similar importance, mapping of the coastal environment is pertinent to the development and marine spatial planning of the coast. This will allow for ships to better navigate Guyana's coastal waters and improve accessibility of the port. As such, there is a need to create a National Hydrographic Committee to conduct seabed mapping research and disseminate the information to the relevant departments. This, for instance, is important to protect the seabed while oil exploration is being conducted (Commonwealth, 2018). There are some available hydrographic data with MARAD that

were done over the years that may need to be integrated to give a broader picture of the coastal and marine environments.

Furthermore, with the trends of climate change noted over the past few decades along Guyana's coast, there is a further need to research climate change and its effects along Guyana's coast. This will accommodate timely and suitable adaptation to changes, which can be done by human intervention (Commonwealth, 2018)

**Lowe Mc Connell (1950s-60s)** did significant amount of work on fisheries in the Northern coast of Guyana, describing and characterising the geomorphology of the area and habitats and documented various species of invertebrates including coral reefs, sharks and fishes and their biology and ecology.

### *Submarine cables and Pipeline routes*

At present, submarine cables and pipelines are mostly under consideration, and awaiting approval except for those presently installed by Guyana Power and Light Company (GPL). Exxon Mobil, for instance, has requested permission to lay fiber-optic cables from their offshore facilities, specifically the Liza Destiny, to Georgetown to provide real-time updates between locations (Kaieteur News, 2019). More recently, a different fiber-optic cable has been laid by E-Networks, from Guyana to Barbados, in an effort to provide high-speed internet access to Guyanese (Kaieteur News, 2020).

Subsea pipelines in the form of umbilicals, risers, and flowlines, however, are abundant within the Stabroek block of oil exploration offshore. These connect wells and ships together as needed to transport oil, gas, and water (Esso Exploration and Production Guyana Limited, 2018).

### *Tourism and Recreation*

Although Guyana earns a substantial amount of income from its tourism industry (GUY \$380,000,000,000 in 2014), especially eco-tourism, little focus is placed on tourism along the coast. Most tourism along the coast would take the form of tours within Georgetown, a few birding trips along the Abary and Mahaica Rivers, recreation activities on the Mariot beach, Hope beach, N0. 65-66 beach and lakes on the Essequibo coast, hence, there is space for future development in coastal and marine tourism in Guyana. However, the Shell Beach protected area is a site for scientific, research or educational tourism along the coast. Furthermore, similar areas can be developed for the purpose of recreational tourism, with the numerous beaches located along the stretch of coast. Nevertheless, mangrove forests are another major site of tourism along the coast for its bird communities (Guyana Forestry Commission, 2010)

Currently, Guyana is not a docking location for cruise ships because there is no data on the seabed to allow for proper navigation. As such, seabed mapping, along with dredging can be useful to Guyana to access cruise ship tourism (Commonwealth, 2018).

### *Underwater cultural heritage*

Although Guyana's marine environment is largely unexplored, the country is committed to preserving its underwater cultural heritage, having ratified the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage in 2014, and drafting several policies thereafter. There is potential for the utilization of Guyana's underwater cultural heritage for education and tourism in the future, but first requires identification of these underwater cultural heritage locations and objects, such as shipwrecks and artifacts (Daggers, 2015). Within the Stabroek block offshore, Fugro Marine Geoservices recorded several potential instances of underwater cultural heritage, all of which were dismissed as geological features and man-made debris (Esso Exploration and Production Guyana Limited, 2018). Additionally, there has been documentation of some underwater cultural heritage, such as petroglyphs, but these were not found offshore Guyana. Regardless, when identified, sites of underwater cultural heritage will add to scientific research, tourism, and development (Daggers, 2015).

Along the coastal zone, however, several archaeological sites are present. These include quarries, seashell deposits, pottery sites, shell mounds along with Hindu prayer flag locations, and burial and cremation sites (Esso Exploration and Production Guyana Limited, 2018). The remnants of Fort Zeelandia, Fort Nassau and KyK-Over-All are also present along the coast that forms part of our historical heritage.

### *Spatial policy*

The Guyana Lands and Surveys Commission was created in 2012 for the purpose of creating policies concern spatial planning and use of space within Guyana. Within a year, in 2013, the commission publish the National Land Use Plan, an extensive review and mapping of Guyana's resources. Along the coast, it ensures land is effectively used between competing purposes, such as housing and agriculture. For instance, it proposes the use of planned nuclear settlements to develop sparsely populated areas in an attempt to move populations away from already densely populated areas, so more land is used for agriculture rather than housing in the densely populated areas. It includes the repurposing of land, such as the highlighting of abandoned rice fields for aquaculture purposes, and the delineation of land for protected areas (Guyana Lands and Surveys Commission, 2013) The Environmental Protection Agency also possesses control to select areas for protection, including marine and aquatic areas (Daggers, 2015).

Offshore, there is a general lack of spatial data and policy, and thus requires trained staff to conduct ocean modelling to inform policy (Commonwealth, 2018). However, the Shell Beach protected area includes a region offshore that is closed to any activities to allow for the effective management of sea turtle species (Ministry of Agriculture, 2016).

### ***Socio-economic data (Human population, economic indicator, social indicator)***

From estimates by the World Bank (n.d.), Guyana's population is approximately 780,000 individuals, 90 % of which live on the 16,800 km<sup>2</sup> of coastland (Commonwealth, 2018). The country's GDP stands at US \$3.8 billion, but with an inflation rate of 5.4 % and 12 % higher imports to exports. This has been accompanied by an unemployment rate of 13.8 %, primary school completion of 93 %, fertility rate of 2.5 births per woman, and a life expectancy of 70 years (World Bank, n.d.). Most of the livelihood associated with the coast and marine areas are strictly associated with fisheries for many of the local communities from Regions 1-6.

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## **Nonliving resources**

### **Water-Quality Parameters**

“Water-Quality Parameters” includes measures of the ranges and distributions of the chemical, physical, and biological constituents of waters, including temperature, salinity, pH, dissolved oxygen, turbidity, total suspended solids, chlorophyll, nutrients, bacteria, and toxicants.<sup>(9)</sup> There are two institutions that are primarily responsible with the mandated to manage and regulate the water resource of Guyana. These are Guyana Water Inc. (GWI) and Hydrometeorological Service. The Ministry of Agriculture hydrometeorological Service has the responsibility to provide meteorological, hydrological, and oceanographic data and services in support of Guyana's national needs and international obligations. However, data are not readily available through open access but can be obtain upon request.

### ***Distribution***

There is a map showing locations where water quality parameters were sampled by Environmental Service Limited (ESL). <sup>(7)</sup> Map is also available showing ecosystem services. <sup>(8)</sup>

### ***Assessment***

Environmental Services Limited (ESL) through their assessment on the water quality of Guyana provided data for the following in-situ parameters, temperature, salinity and specific conductivity, dissolve oxygen, turbidity, water chemistry, Total Dissolved Solids(TDS), Total Suspended Solids (TSS), Total Organic Carbon( TOC), Chemical Oxygen Demand(COD), saturated hydrocarbons and ammonia <sup>(7)</sup>. Assessment of the ecosystem services provided by water resources are recorded in report by Environmental Resources Management (ERM) and Environmental Management Consultants

(EMC) for Liza Phase 1 Development Project Esso Exploration and Production Guyana Limited (ERM & EMC, 2018).

### **Prediction**

Predicted impacts on marine water quality are recorded as well as modeling of oil spills and other waste generated from activities during drilling and operational production of oil and how it will affect water quality is available <sup>(1)</sup>.

### **Bathymetry and Elevation**

Topographic or Bathymetric map is available for the Guyana basin (Yang et al., 2011) and Stabroek Block area offshore Guyana (EPA, 2020).

### **Energy resources**

#### **Oil resources**

“Oil Resources” refers to deposits of valuable liquid hydrocarbons or fossil fuels <sup>(9)</sup>.

#### **Distribution**

Geologic map is available with location and volume of deposition of oil <sup>(10)</sup>.

All data pertaining to the oil resources are held by the minister responsible for Natural resources. Some of these data are confidential and are only accessible by through special request.

Data pertaining to the importation and consumption of petroleum based products such as quantity, value of quantity, percentage of GDP, consumption rate, percentage utilization by sector with the main consumer being the Guyana Power and Light INC. Location of oil development is available <sup>(1)</sup>.

#### **Assessments**

Assessment of oil resource specifically environmental impacts and its interaction with other users are documented <sup>(1)</sup>. Assessments evaluate locations, methods, and profitability of oil extraction and transportation; environmental impacts; and interactions with other uses.

### **Natural Gas Resources**

#### **Wind**

The Guyana Energy Agency (GEA) is the institution with the mandate for managing and supplying the country’s energy needs. Its mandate can be found at (<https://gea.gov.gy/about-us-2/>). While a breakdown of total power consumption is available by sector there is no specific data for how much wind contributes to this total but rather with a combination of other energy sources <sup>(12)</sup>.

**Distributions** - A wind map is available with some special locations where wind speed and direction were measured while there are others locations where measurement was done but not updated on map <sup>(4)</sup>. In addition there is also another map providing wind data on this website (<https://www.weather-forecast.com/maps/Guyana> ) <sup>(5)</sup>.

## Assessments

### Prediction

Modelling of wind potential is available at (<https://gea.gov.gy/wp-content/uploads/2019/07/Annex-B-Green-Economy-Modelling-Study.pdf>).

## Ocean currents

**Distribution**-Descriptive and geographic map data of ocean current is available at EPA, Hydromet and MARAD and include maximum and minimum speed occurrence of current during the year. Ocean tidal data are also available with the Hydromet Office and can be easily access via website or formal request to the agency.

**Assessments**-Assessment of ocean current data is available for extraction of oil resource (EPA, 2020). However, assessment profitability for using ocean currents to generate energy is not available neither the effects of currents on biological resources.

### Prediction

Data is lacking on projection of future current, energy potential, effects and risks.

## Transportation

Shipping Association of Guyana- “The Shipping Association of Guyana is a private organization that represents its members terminal owners, shipping agents and ship owners, and, in general the shipping industry in Guyana.” <sup>(20)</sup> Data about shipping lines, ports, terminals and agents is available through open access from their website.

## Other commercial/Industrial uses

### Mining and mineral extraction

The Guyana Geology and Mines Commission (GGMC) has the overall responsibility for mining and mineral extraction. Its mission is “ To provide effective stewardship of our mineral resources by ensuring increased opportunities for mineral resources development (exploration, documentation and extraction) and promote and support increased investment on in the mining and mining related sectors.” <sup>(21)</sup> Data is not available through open access via their website but maybe available upon request.

Shell mining is not done commercially but removal of some quantity is being done. However, data for the amount removed is not available.

## Coastal Aquaculture

The Ministry of Agriculture, Fisheries Department, Aquaculture Unit is the agency that has the mandate to manage and regulate all aquaculture activities in the country. Data is available for the number of fish farmers and size of fish farm and type of aquaculture species farmed. However this data is not available through open access but can be obtained upon request. Assessment and prediction data is also not available.

## Sewage Discharge

GWI is the agency with the responsibility for sewage discharge. There are three sewage systems which serve the Georgetown area and the University of Guyana.

**Assessment and prediction data is not available**

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## Living Resources

“Living Resources” is a top-level category that includes aspects of coastal and marine biota that are of particular importance to ecology or to human uses. These can include particular species, groups of biota, associations of biota with physical features, biological function, and biological connectivity (Lightsom et al 2015).

In Guyana a number of institutions are responsible for management and regulation of living resources. As such data and information about living resources are held by these institutions. There are however, a few overlapping responsibilities when it comes to collection of data. These institutions are, Fisheries Department, Ministry of Agriculture, World Wildlife Fund, Environmental Protection Agency, University of Guyana, Center for the Study of Biological Diversity. Coastal habitats of living resources are described in (Guyana National Land Use Plan, 2013). A lot of data and information pertaining to living resources are documented through Environmental Impact Assessments (EIA) that is available through EPA.

## Habitat

### Distribution

General Habitat types like mangroves, beaches, salt to brackish lagoons, brackish herbaceous swamps, swamp woods, and swamp forests are listed and description of some of these habitats like mangroves, beaches and mudflats are described. A spatial map is available with geographic locations of benthic community along with imagery of these habitats (Environmental Resource Management, 2018). Description of habitats types for birds along part of the coast (Region 1-4) are documented with spatial and imagery information along with species richness and abundance. Spatial and aerial imagery of the distribution of mangroves habitats are captured and spatial map for the Shell beach and a distribution map of mudflats is presented <sup>(1)</sup>. Description of ma-

rine habitats, particularly fish zones, from nearshore extending to offshore can be found at (Lowe-McConnell, 1962) and are classified by zones. Sediment samples collected from Stabroek Block offshore Guyana was analyzed for a number of parameters for which data is available (EPA, 2020). Spatial distribution of benthic habitats types is also available (EPA, 2020).

### **Assessment**

Assessment of the coastal habitats by the classification of critical habitats and the vulnerability and susceptibility of these habitats to disturbance from primarily oil exploration and production is available as well as ecological services these habitats provide (EPA, 2020).

### **Prediction**

Projection of future disturbances and impacts to habitats as well as likely changes as a result of exploration and production of oil is available (EPA, 2020).

### **Missing data**

Scenario-testing habitats loss/gain models and prediction of related ecological or economic effects under different management strategies is absent.

## **Ecological Functions and Services**

“Ecological Functions and Services” includes data describing or measuring an ecological or ecosystem process, property, or benefit to humans that is associated with habitat or biota (Lightsom et al 2015).

### **Distribution**

Graphical representation of the distribution of ecosystems categories are visually shown for regions 1-4. In addition there is also distribution of ecosystem service types by region. Aerial imagery of identified locations of critical and high priority ecosystem services for regions 1-4 is available <sup>(8)</sup>.

### **Assessments**

Assessment of ecosystem services is classified based on replaceability of service (high, moderate, low or not replaceable) and importance to beneficiaries (Essential, high, moderate and low). This classification was done for ecosystem services types for regions 1-4 (ERM & EMC, 2018).

### **Prediction**

The potential of Guyana’s mangrove forest as carbon storage was studied by Jaikishun et al (2017). As such data is available for quantification of aboveground biomass, carbon storage of mangrove species and amount of carbon stored in mangrove soil (Jaikishun et al., 2017).

### **Missing data**

No study on the species abundance and diversity of organisms living in the mudflat habitat.

## Biodiversity and Biological occurrences

### Birds

#### Distribution

Aerial imagery with location of important bird habitats and species in regions 1-4 is available.

**Shorebirds** - species richness and abundance for these birds are available by region 1-4.

**Seabirds**- species richness and abundance is also available for this classification of birds by region 1- 4 along with imagery data.

**Assessment** - assessment impacts on birds, particularly marine birds was done and data is available (EPA, 2020).

**Prediction** - Sea birds migration are likely to be affected by lighting and potential exposure to radiant from flaring of gas from oil production activities. In addition, under residual risk rating, seabirds are listed as minor and risk rating as moderate for marine resource to be potentially impacted by an oil spill (EPA, 2020).

### Fishes

The Fisheries Department, Ministry of Agriculture, is the agency with the mandate to manage, regulate and promote sustainable use of Guyana's fishery resources. However, World Wildlife Fund (WWF) is also involved in Guyana's fishery resources offering primarily technical support. Fishery data that is held by the Department is not accessible through open access but can become available upon written request from the Fisheries Department. Some other data are available through open access via the internet from other sources and through reports from Environmental Impacts Assessments and biodiversity research permits and CSBD database (University of Guyana).

**Distribution** - spatial distribution of the various sample location from deep shore, continental shelf, nearshore and estuarine are available on maps. Sample depth, coordinates and distance from coastline for each sample location is also available. Species, biomass, abundance, reproductive status and sexual ratio data is available with photographs of species. Geographic distribution of several selected fish species is available (ERM, 2018). Species and abundance of trawl-caught fish was recorded as well as fish fauna zones by Lowe (McConnell), (1962). Biomass of commercial fish species, GPS location of haul site, duration of haul, quantity of fishing vessels and gears and bycatch are data that are collected by the fisheries department. There are spatial data available for fisheries landing sites, Trawl fisheries and aquaculture that can be access through formal request.

**Assessment-** Assessment of species based on International Union for the Conservation of Nature (IUCN) ranking is available (EPAS, 2020).

**Prediction** - Prediction of negative impacts from oil spill has been assessed and ranked as moderate with a cumulative impact ranking of minor (EPA, 2020), although water quality is expected to deteriorate at oil production site.

## **Invertebrates**

**Distribution** - map with geographic location where benthic species were collected during assessment of Guyana's fish species is available (EPA, 2020). In addition, there is another map with geographic location of sample site where benthic invertebrates were caught (Willems, 2018). Invertebrate species data through eDNA analysis from Oil and Gas exploration activities for ESIA are also available through formal strict access from EPA and other relevant authorities.

**Assessment-** Assessment of Guyana's marine invertebrates from the benthic community were done and species diversity is available along with imagery data (Willems, 2018). In addition, stock assessment of Seabob is available <sup>(30)</sup>.

No data is available for prediction.

Need for modelling of impacts to these organisms and their ecosystem from fishing activities.

## **Mammals**

**Distribution** - Location of marine mammals sighting relative to the Stabroek Block is available on spatial map. Number of species of marine mammals is listed in table format (EPA, 2020).

**Assessment** - key potential impact on marine mammals from oil production activities is noted in table format (EPA, 2020).

**Prediction-** From assessment of oil exploration and production, findings suggest that marine mammals can be affected by two types of sounds, continuous sound from vessels and machinery operations, and impulse sound from Vertical Seismic Profiling (VSP). Furthermore, marine mammals potentially impacted by an oil spill are listed as moderate under residual risk rating

## **Reptiles**

“The Guyana Marine Turtle Conservation Society (GMTCS) works to ensure the future existence and population recovery of all the four species of marine turtles known to nest in Guyana, while at the same time addressing the needs of the user communities.” (GMTCS, 2019).

**Distribution-** spatial map available with location of sea turtles sightings and satellite tracks relative to Stabroek block. List of marine turtle species present in Guyana's water is also available (EPA, 2020). Distribution of nesting sites is available on map (Dow et al., 2007).

**Assessment** - tagging of leatherback turtles to track their movement was done and spatial data is available for their various locations (ERM & EMC, 2018). Threats to sea turtles nesting and foraging/migration is also available in table format (Dow et al., 2007).

**Prediction** - Sea turtles potentially impacted by an oil spill are listed as moderate under residual risk rating with a cumulative impact rating of minor form oil spill and other activities associated with oil exploration and production (EPA, 2020).

## Flora

Data is available for species of mangroves on Guyana's coast and other species found in the Shell Beach Protected Area (EPA, 2020). The Mangroves department under the National Agriculture Research and Extension Institute is the agency with responsibility for management and research of this species. However, data is no free access through their website but can be accessible upon request. The type and kind of data that is available is not known.

Distribution - spatial distribution of mangroves forest is available (ERM & EMC, 2018).

Assessment data is not available.

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## Governance

"Governance" is a top-level category of data that represent the boundaries of geographic areas that are defined for governmental, administrative, or management purposes. Governance data for marine planning are those that identify governance entities that have effects on environmental processes or human activities that impact the coast, Great Lakes, or ocean (Lightsom et al 2015).

## Marine Protected area

The Protected Areas Commission (PAC) is the agency with the mandated to manage, maintain, promote and expand the national protected areas system in Guyana (PAC, 2020).

## Distribution

Shell beach was established as a protected area in 2011 and covers an area of 119459 hectare. It is Guyana's only marine protected area and its geographic location is shown on a map with other geographic information (Kandaswamy, 2014).

Assessment and prediction data not available

## De facto MPAs

There are no known areas on the coast that can fall under this category except for Shell Beach Protected Area. Assessment and prediction data is not available

## Tribally Governed area

### Distribution

The Guyana Land and Survey Commission (GLSC) provides Guyana's survey needs and as such has the responsibility of providing all data pertaining to mapping of Guyana including tribally governed areas. These areas are called Amerindian Reservations or Amerindian land title. These maps can be found with the Ministry of Indigenous People Affairs or the GLSC as well as the Bureau of Statistics. Geographic locations of these areas are provided along with area covered.

Assessment and prediction data is not available

## Jurisdictional Boundaries

Jurisdictional Boundaries.—“Jurisdictional Boundaries” data delineate domestic, tribal, and international areas established by a law or treaty that determines who has the authority to interpret, apply, and enforce the laws within those areas (Lightsom et al., 2015). The Guyana Lands and Survey Commission has data for all boundaries, domestic, tribal and international areas. However, some data is open access but can be accessible upon request and maybe paying a small processing fee.

### Distribution

The ministry of communities has the overall governing authority for Regional Democratic Councils (RDC) Neighbourhood Democratic Councils (NDC), Municipalities and other local organs. The delineate boundaries of these government entities can be found on maps that gives their geographic location and area covered. Much of these entities are subset within a larger area.

**Regulatory Use Restrictions.**—“Regulatory Use Restrictions” data delineate specific locations for which some uses are restricted in order to meet regulatory goals (for example, regions in which Total Maximum Daily Loads have been defined for particular pollutants) (Lightsom et al., 2015).

No data is available for regulatory use restriction.

## Infrastructure

“Infrastructure” is a top-level category of data that represent the locations of permanent or temporary installations intended to support basic human activities or needs, including communication, transportation, shoreline protection, housing, recreation, and utilities. Data required for marine planning are limited to infrastructure that has effects on environmental processes or human activities that impact the coast, Great

Lakes, or ocean <sup>(9)</sup>. The Ministry of Public Infrastructure is the institution with the key responsibilities for planning, creation and maintenance of major public civil works infrastructure throughout Guyana. Its mission statement is “To plan, build and maintain a reliable, safe, efficient and cost-effective Main Road Network and Sea and River Defense system to protect life and property; support the movement of people, goods and services; reduce the cost of transportation; promote economic growth and quality of life and protect the environment”( <https://mopi.gov.gy/about-us>). Under this ministry, the Maritime Administration Department (MARAD), Ports and Harbor Division, has responsibility for management and development of ports in Guyana.

## **Ports**

The Maritime Administration Department (MARAD), Ports and Harbor Division, provides pilotage services to international vessels in and out of port Georgetown and New Amsterdam. It's also in charge of buoyage and dredging of the ships' channels in Georgetown (MARAD, 2019).

## **Distribution**

The Maritime Administration Department, ports and harbor division, produce navigation charts for all rivers and tide tables are developed for tidal prediction for the entire country <sup>(15)</sup>. Information of ports is available (<https://www.shipping.org.gy/ports>). It gives types of imports, exports, traffic, storage, equipment, maximum draught in the channel, anchorage depth, list of facilities and containers statistics. There is a map showing the locations of ports (DOE, 2020).

**Assessments** - feasibility study of a new Demerara harbour bridge and impacts on the environment is available <sup>(31)</sup>.

Prediction data is not available; however, an increase of ocean vessels traffic was noted as a possible source of impact as a result of offshore oil exploration and production activities.

## **Cable, Pipelines and Power Grids**

The Guyana Power and Light and the Guyana Telephone and Telegraph (DOE, 2020) are the only two institutions that have submarine cables in the waters of Guyana. However the distributions of these cables are not available through open access and maybe accessible upon request.

There is no data available for assessment and prediction

## **Buoys and Navigational Aids**

The Maritime Administration Department is responsible for has location, position (latitude and longitude), character and period and structure in table format of navigational aids (MARAD, 2018).

### Structures

There are several agencies that have the mandate for management and maintenance of structures that are linked to marine and coastal environment. These are the Maritime administration Department (MARAD) and National Drainage and Irrigation Authority (NDIA). Guyana’s drainage and irrigation system is a complex network of conservancies, canals, sluice gates/kokers, and pumping station for flood control and water storage and distribution for agricultural and domestic purposes. There are four man-made conservancies along the coastal plain (DoE, A5, 2019).

### Distribution

Data is available through graphical representation showing sea defence by region, length and types of sea defences within each region. There is also map showing location of conservancies present on the coast (DoE, A5, 2019).

### Summary table

Section	Key Points
Marine Spatial Planning	<ul style="list-style-type: none"> <li>• Provides a comprehensive and systematic approach to utilizing marine space in a way that ensures sustainable development</li> <li>• Only human input can be controlled</li> <li>• Requires knowledge of resources to effectively plan</li> </ul>
Guyana	

<p style="text-align: center;">Geography</p>	<ul style="list-style-type: none"> <li>• Lies within the tropics, slightly above the equator</li> <li>• Three zones in Guyana, namely the Northern coast, a region of white sand and hilly topography, and the interior highlands composed of mountains, forests, and savannahs</li> <li>• Guyana a part of the Guiana Shield formation made of metamorphic rocks</li> <li>• Numerous rivers, with many tributaries, flowing into the Atlantic Ocean</li> </ul>
<p style="text-align: center;">Climate</p>	<ul style="list-style-type: none"> <li>• Tropical climate with high humidity, precipitation, and temperatures year-round</li> <li>• Climate affected by ITCZ, ENSO, and Northeast tradewinds</li> <li>• Temperatures fluctuate more in inland regions while humidity is lower, and precipitation is higher in forested regions</li> <li>• Guyana has two dry seasons and two wet seasons, but the savannahs only experience one season each</li> <li>• Climate change expecting to cause more intense wet seasons and scarce precipitation through rest of year</li> </ul>

<p>Natural Regions</p>	<ul style="list-style-type: none"> <li>• Four natural regions widely recognized</li> <li>• Low coastal plain to the North, with rich soil and flat, low-lying land</li> <li>• Hilly sand and clay region south of low coastal plain, filled with gentle hills, savannahs, and hardwood forests</li> <li>• Forested highland region covers two-thirds of Guyana and comprised of neotropical forests and mountains</li> <li>• Interior savannahs to the South West made up of sparse trees, hills, open grasslands, and low-flowing streams</li> </ul>
<p>Boundaries</p>	<ul style="list-style-type: none"> <li>• Bounded by Venezuela on the West along the Schomburgk line, by Suriname on the East by the Corentyne river, by Brazil to the South by the Acarai mountain range, and to the North by the Northern Atlantic Ocean</li> </ul>
<p>Coastal Regions</p>	<ul style="list-style-type: none"> <li>• Six regions lie along the coast of Guyana</li> <li>• Most regions are involved in rice farming, but some also conduct coconut farming, sugarcane farming, and cattle farming, while only a few conduct logging and mining</li> <li>• Region 4 is the administrative center of the country due to the capital city, Georgetown, being located there</li> </ul>
<p>Socioeconomic</p>	<ul style="list-style-type: none"> <li>• In 2012, GDP was US \$2.85 billion/year and US \$3,586 per capita/year</li> <li>• Gender inequality index scored at 0.524</li> <li>• Human development index scored at 0.638</li> </ul>

Population	<ul style="list-style-type: none"> <li>• 2012 census recorded population as 747,884 individuals</li> <li>• Regions 1, 2, and 5 populations lower than 50,000 individuals</li> <li>• Regions 3, 4, and 6 populations between 105,000 and 315,000 individuals</li> </ul>
Area/Size	<ul style="list-style-type: none"> <li>• Coastal regions account for 72,945 km<sup>2</sup> of the country's landmass</li> </ul>
Coastal Zone and Marine Environment	<ul style="list-style-type: none"> <li>• Coastal zone defined as interface between land and water where they interact with each other.</li> <li>• Marine environment defined as navigable water and the land and resources within and below it</li> </ul>
Guyana's Coastal Zone	<ul style="list-style-type: none"> <li>• Mudflat created from deposition of sediment from rivers</li> <li>• Also consists of mangrove forests, beaches, lagoons, and swamps</li> <li>• Stretches up to about 22 km seaward</li> </ul>
Guyana's Marine Environment	<ul style="list-style-type: none"> <li>• Begins at 22 km from coastline</li> <li>• Stratified into brown water over soft mud, green water over sand, and blue water over calcareous rock</li> </ul>
Administrative Boundaries	<ul style="list-style-type: none"> <li>• Coastal zone stretches up to 480 km in length and 77 km in width</li> <li>• Marine environment starts at 22 km and ends at exclusive economic zone</li> <li>• Continental shelf has average width of 112.6 km</li> <li>• Stable tropical climate affected by ENSO, ITCZ, and Northeast tradewinds</li> <li>• Soils generally rich, and include anthrosols, gleysols, fluvisols, and histosols</li> </ul>

<p>Physical, Chemical, and Biological Characteristics</p>	<ul style="list-style-type: none"> <li>• Coastal waters transition from clear brown to muddy brown to muddy green to clear green to blue-green to blue based on seafloor strata, wind movement, and nutrient content</li> <li>• Biodiversity is richest in mangrove forests in muddy brown zone and in nutrient rich area in clear green zone</li> <li>• Fishing, deforestation, and erosion majorly affect the coastal zone and its resources</li> </ul>
<p>Human Activities</p>	<ul style="list-style-type: none"> <li>• Human activities concentrated on coast and mainly extractive</li> </ul>
<p>Coastal Defense</p>	<ul style="list-style-type: none"> <li>• Coast below sea-level</li> <li>• Hard structures like seawalls, groins, dikes, pumping stations, and sluices, etc used</li> <li>• Mangroves being implemented as a buffer to hard structures</li> </ul>
<p>Aquaculture</p>	<ul style="list-style-type: none"> <li>• Started in brackish water, and now regulated by Environmental Protection Agency</li> <li>• Freshwater aquaculture done in ponds using inland water and specific feed</li> <li>• Brackish water aquaculture done in ponds fed by saltwater and without extra input</li> <li>• Marine aquaculture generally not practiced</li> <li>• Floods and droughts heavily disrupt operations</li> </ul>

<p>Fishing</p>	<ul style="list-style-type: none"> <li>• Fisheries produced GUY \$14,692,615,448 in 2015</li> <li>• Artisanal fishing done in brown water for finfish and 80 % of catch exported</li> <li>• Semi-industrial fishing done in blue ocean waters to catch snapper, grouper, gill backer, etc</li> <li>• Industrial fishing focuses on seabob and shrimp in green water zone, and needs to be certified by the Marine Stewardship Council</li> <li>• Overfishing is an issue in the fisheries industry, and regulations have been put in place to stop this</li> <li>• By-catch is being addressed by using by-catch reduction devices and turtle-exclusion devices</li> </ul>
<p>Installations and Infrastructure</p>	<ul style="list-style-type: none"> <li>• Infrastructure needs to be protected, and resistant and resilient</li> <li>• Drainage infrastructure needs to be maintained and updated as necessary</li> </ul>
<p>Marine Transport Routes and Traffic Flows</p>	<ul style="list-style-type: none"> <li>• Ports mostly located at coastal towns and some inland</li> <li>• Traffic mainly consists of cargo ships and trawlers</li> <li>• Oil exploration vessels being recruited into the Stabroek block</li> </ul>
<p>Military</p>	<ul style="list-style-type: none"> <li>• Coast guard mandated to patrol coastal waters and enforce laws</li> <li>• Coast guard has fast-patrol boats, offshore patrol craft, and helicopters</li> </ul>

<p>Nature and Species Conservation Sites and Protected Areas</p>	<ul style="list-style-type: none"> <li>• Shell Beach Protected Area established in 2011 to protect flagship species of migrant birds and turtles</li> <li>• Urban parks host biodiversity</li> <li>• Mangrove forests being protected and conserved by Mangrove Restoration Project</li> <li>• Coastal zone has potential RAM-SAR sites</li> </ul>
<p>Raw Material Extraction Areas</p>	<ul style="list-style-type: none"> <li>• Mangrove forests for firewood, poles, heart of palm, wildlife, and crabwood oil</li> <li>• Water from coastal aquifers for domestic use</li> <li>• Oil and gas 183 km offshore</li> </ul>
<p>Renewable Energy</p>	<ul style="list-style-type: none"> <li>• Committed to 100% renewable energy shift by 2025</li> <li>• Government buildings, street-lights, and hinterland communities using solar power</li> <li>• Wind power and hydro power plants being proposed</li> <li>• Biofuel being produced</li> </ul>
<p>Scientific Research</p>	<ul style="list-style-type: none"> <li>• Research limited by funding</li> <li>• Biodiversity assessments by Exxonmobil</li> <li>• Coastal mapping and climate change research required</li> </ul>
<p>Submarine Cables and Pipeline Routes</p>	<ul style="list-style-type: none"> <li>• E-Networks fiber-optic cable in place</li> <li>• Exxonmobil fiber-optic cable to be approved</li> <li>• Array of pipelines within Stabroek block</li> </ul>

<p>Tourism and Recreation</p>	<ul style="list-style-type: none"> <li>• Tourism mainly within Georgetown</li> <li>• Eco-tourism for birdwatchers at mangrove forests</li> <li>• Educational tourism at Shell Beach Protected Area</li> <li>• Cruise ships unable to dock due to lack of seabed data</li> </ul>
<p>Underwater Cultural Heritage</p>	<ul style="list-style-type: none"> <li>• Guyana committed to preserving underwater cultural heritage</li> <li>• No underwater cultural heritage found offshore currently</li> <li>• Several cultural heritage sites onshore</li> </ul>
<p>Spatial Policy</p>	<ul style="list-style-type: none"> <li>• Guyana Lands and Surveys Commission mandates land use and spatial planning</li> <li>• Environmental Protection Agency mandates protected areas</li> <li>• Shell Beach Protected Area is the only area with offshore mandated area</li> </ul>
<p>Socio-economic Data</p>	<ul style="list-style-type: none"> <li>• Current population estimated at 780,000 individuals</li> <li>• Imports total more than exports</li> <li>• Unemployment rate 13.8 %</li> <li>• Most complete primary school education</li> </ul>

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