Annex A(5)

Analytical Evidence to Support Guyana's Green State Development Strategy: Vision 2040

Resilient Infrastructure and Spatial Development

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A 5 Resilient Infrastructure and Spatial Development

A 5.1 Introduction

Guyana's non-urban infrastructure including coastal protection and road and rail transport connections to the hinterland and between coastal towns is a vital cornerstone of the green transition. To ensure that Guyana can continue its green transition and achieve economic prosperity, well-functioning and reliable infrastructure that can support trade flows and travel and protect economic assets and human settlements from natural catastrophes, is paramount. To sustain urbanisation and the absorption of labour from agriculture and mining into higher value-added sectors located in coastal towns, reliable and fast links to Guyana's rural areas and hinterland are critical.

These links will ensure equitable access to services and amenities, which will inevitably remain concentrated in coastal regions as a result of spatial-economic path dependencies, to rural and hinterland populations. Economic activity further heavily relies on access by road to the neighbouring countries as well as good port infrastructure. This increases the competitiveness of timber and other natural resources, adds higher value-added products, thus making them more competitive in international markets. It would also allow for diversified agricultural development by unlocking suitable areas in the hinterland, particularly in the Intermediate and Rupununi savannahs.

The coastal zone is at risk of environmental hazards as a result of climate change: Guyana is considered as one of the most vulnerable of CARICOM member states to sea level rise, as a majority of its coastal plain is 2.5 metres below mean high tide sea level. This poses a very significant risk as the coastal zone represents 7.5% of Guyana's land area, hosts 90% of the population, and accounts for production of the majority of GDP. Historically, this area has experienced catastrophic flooding from the Atlantic Ocean as well as during rainy seasons. Flooding in 2005, for example, caused damages estimated at USD 465 million (60% of GDP). So far, coastal protection along 200 kilometres where critical and residential infrastructure is located has relied mainly on sea-defence infrastructure, including sea walls and drainage and irrigation canals. However, most of this infrastructure is currently considered to be ill-equipped and no longer adequate to withstand current and future climate related impacts.

Box 1: Summary Analysis of Guyanese Infrastructure

Extracted from "IDB Group Country Strategy with Guyana 2017-2021"; October 2017

III. Strategic Areas; D. Delivery Critical Infrastructure (p. 16 and 17)

"Guyana's high energy and logistics costs, coupled with a poor connectivity, constrain efficient service delivery and increase business costs, hurting the prospects of formal job creation in the economy. According to the GCI, out of 140 economies, Guyana ranks 104th in terms of road infrastructure, 87th in port infrastructure, and 93rd in air transport infrastructure. Potential economic synergies with its neighbours are unexploited in part because the existing infrastructure network does not adequately connect these economies; sales to Guyana's main export destinations (United States, Canada, Trinidad and Tobago, and the United Kingdom) are hampered because shipping costs in and out of the country are high relative to other countries in the Caribbean, due to the lack of deep water ports and insufficient domestic logistics infrastructure. Road density, measured in terms of area (0.024), is far lower than the LAC regional average (0.462). The Liner Shipping Connectivity Index, which measures maritime connectivity, ranks Guyana below all other Caribbean countries. The private participation in infrastructure is scant as a result of institutional deficiencies in strategic planning and project management, a lack of adequate regulation, and a nascent public–private partnership framework".

"Management of the infrastructure assets is further complicated by the impact of climate change. It threatens existing infrastructure, delays project implementation, and increases the cost of construction and maintenance, creating debilitating conditions for the Guyanese people and businesses if left unaddressed. According to models of sea-level rise, Guyana is forecast to be one of the most affected countries in the LAC region, with some scenarios anticipating as much as 60 miles of coastline lost by 2050. Such a result would threaten much of the country's present-day arable land, and existing infrastructure. The climate change impacts on the sustainability of economic and social well-being extends to the agriculture sector, which generates one-fifth of Guyana's GDP and employs one-third of the country's economically active population,118 decreasing yields due to greater drought-like conditions. It also threatens housing and increases the vulnerability of residents. The crucial factors that will determine the ability of countries to adapt to and mitigate the effects of climate change are institutional capacity and the economic structure. The country's ability to attract and deploy affordable resources and investments in climate-resilient infrastructure under appropriate modalities to respond to its infrastructural challenges must be strengthened".

The remainder of this chapter analyses the general context of each key infrastructure subsector, as well as the adequacy of existing infrastructure and improvement requirements.

The key infrastructure subsectors prioritised are: Land Transport; Ports and Airports; Information and Communication Technologies (ICT); and Coastal Protection.

A 5.2 Land transport

A 5.2.1 General context

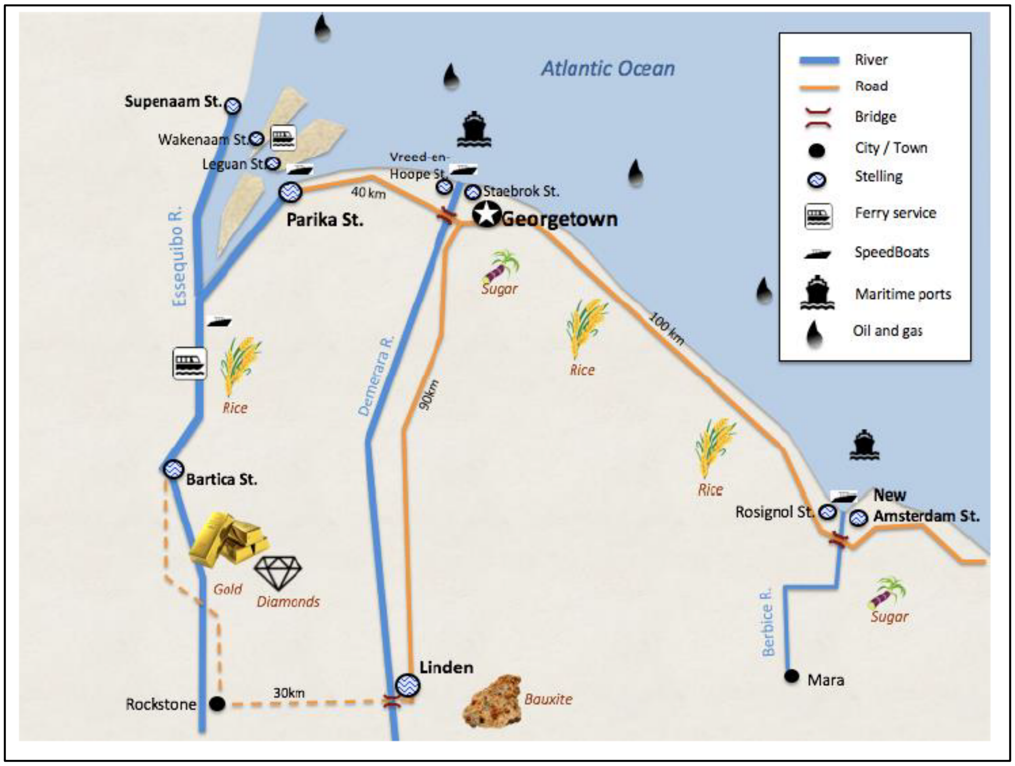
The national road transport network is the main pillar that supports the economic, social and cultural activities of Guyanese through the movement of people, goods, agricultural products, construction material, equipment and mining supplies from one place to another. There are 428 km of primary roads, 583 km of secondary roads and 1,593 km of interior roads which includes trails.[1] A total of 2,604 km of roads are recorded in the national road network system. The main roads along the coast and those along the river banks are all paved roads and account for 35% of the total roads, whereas, the interior roads are unpaved and account for 65% of the total roads in the network.

Land Transport is still limited in Guyana and pavement is mostly restricted to the coast. The road network stretches along the coast from Charity on the Essequibo Coast Moleson Creek in Berbice, along the banks of the main rivers, and inland to the interior from Georgetown to as far as Lethem in the South. The main roads along the coast and those along the river banks are paved roads and account for one third of the total roads, whereas, hinterland roads are unpaved and account for two thirds of the total roads in the network. The general condition of these unsurfaced roads varies from road to road but in general they all display varying levels of distress such as poor drainage, improper cross sections, rutting, pot holes and excessive dust. During the prolonged rainy seasons, the un-surfaced roads usually experience significant deterioration due in part to inadequate drainage and in part to indiscriminate road use.

River crossings are key constraints on the road network. Bridges on the coast are currently congested and require upgrading, especially the Demerara Harbour Bridge (DHB). For the hinterland network, the main crossings are located at Kurupukari/Surama, for the Linden to Lethem stretch, at Kwakwani for the Linden to Kwakwani Stretch, at Mango landing when going to Mahdia, Sherena when going to Bartica via Rockstone, and at Iterbally when travelling to Puruni via Bartica. The load limitation on the crossings sometimes poses restrictions on freight, especially when transporting equipment for mining.

[1] According to records prepared by the Central Transport Planning Unit (CTPU) - October 2013; National Land Transport Strategy and Action Plan 2016-2026, Ministry of Public Infrastructure, June 2017

Map 1: Main Transport Networks, Stellings and Productive Activity in Guyana



Source: Consultancy Services for the Regulatory, Institutional, and Technical Requirements for The Modernization of Riverain Transport in Guyana, GSDplus, April 30, 2018, p. 55

A 5.2.2 Adequacy of existing infrastructure and improvement requirements

For an assessment of adequacy, the road network is divided into four groups according to its characteristics and usage: Coastal, Bartica – West, Linden – East, and Southern (up to Lethem).

A 5.2.2.1 Coastal network

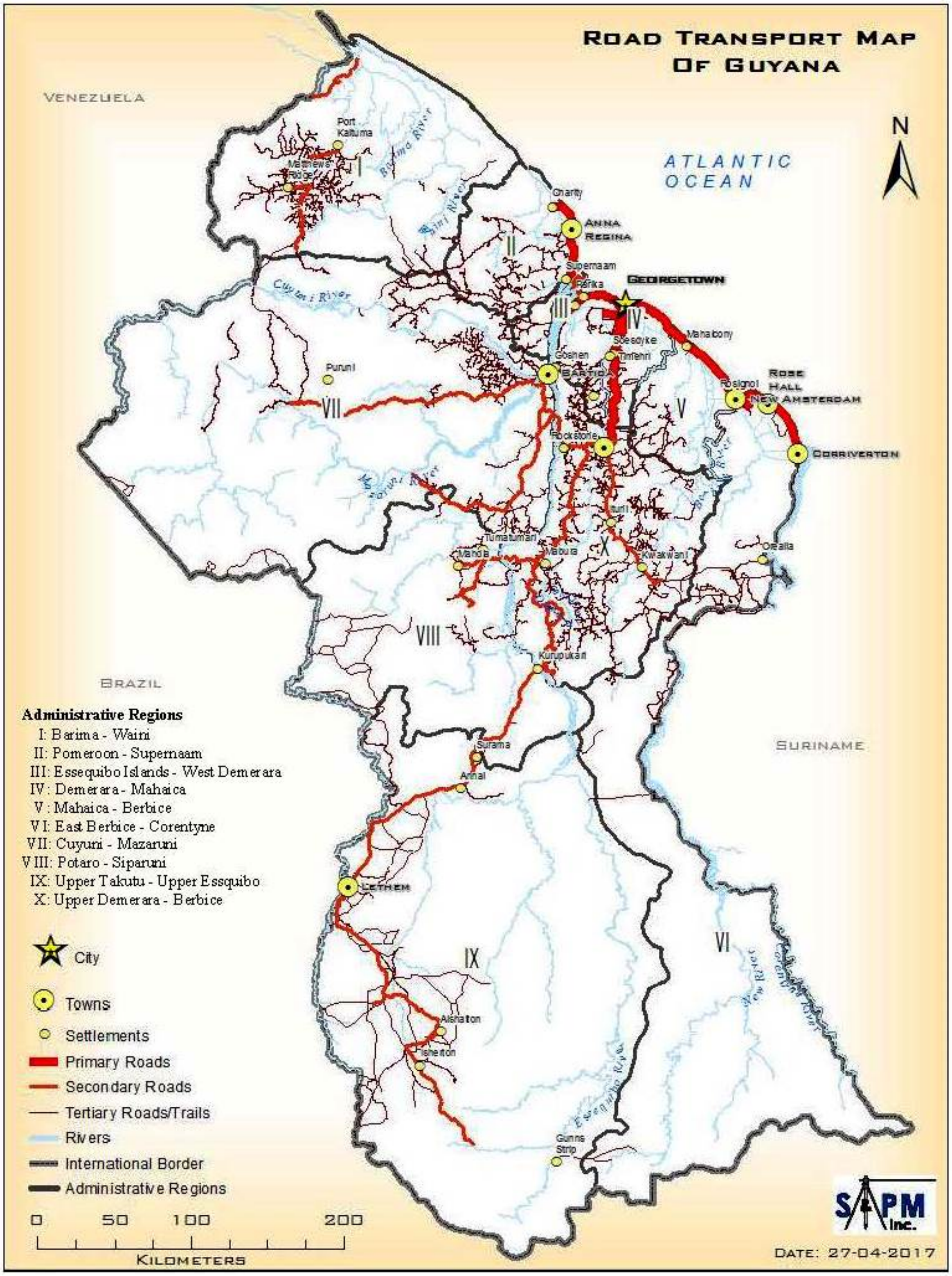
The main coastal roads are all paved, from west to east, the Essequibo Coast Road, the Parika/Vreed-en-Hoop Road, the East Coast Demerara and West Coast Berbice Roads, and the Corentyne Highway from New Amsterdam to Moleson Creek. The coastal network runs then along the coast from Charity on the Essequibo Coast to Moleson Creek on the Corentyne River and is in fairly good condition. This roadway accommodates all classes of vehicular traffic. The only interruption to road traffic flow along this stretch is the river crossing at the Essequibo River, between Supernaam and Parika, where a ferry is used. The remaining section of the coastal stretch is easily traversed by vehicles. There are however occasional delays for bridge crossings at the Demerara Harbour Bridge (DHB) and the Berbice River Bridge due to scheduled/unscheduled bridge openings for vessels or mechanical problems.

The DHB serves as the critical link between Georgetown and all the activities west of the Demerara River. The Demerara Harbour Bridge (DHB) is a two-lane floating bridge built in 1978, 2km long, near the mouth of the Demerara River and it connects road traffic between the East and West Banks of the river. It is primarily a low-level bridge which possesses an elevated span with a vertical clearance of 9 m in the middle of the river to permit small craft to pass. In addition, across the shipping channel, there are two spans which retract to permit the passage of ocean going-vessels. It accounts for a significant volume of traffic entering Georgetown on a daily basis and as a consequence, its location contributes to major congestion on the east and west bank mainly at the junctions of the bridge approaches and the main roads. Traffic congestion and traffic delays are also caused by the bridge retraction schedule to accommodate river traffic. There is no doubt that the DHB has outlived its usefulness. At the time of its construction, its lifespan was estimated to be 20 years, but it has now exceeded this time period by 20 years. Additionally, it was not envisaged that over time the volume of traffic would have reached the current volume.

The road network also extends on the west bank of the Demerara River from Georgetown to Patentia and on the east bank from Georgetown to Timehri. South of Georgetown the primary road is the East Bank Demerara Road, a two–lane road which runs from Georgetown to Timehri, where the Cheddi Jagan International Airport – Timehri (CJIA) is located. From the DHB to the Soesdyke junction (27 km), the road is a single carriageway asphalt pavement, approximately 6m wide. The land use is mainly urban to peri-urban with typical ribbon development, less than a kilometre deep. On both sides of the road there is a mixture of residential, religious, commercial and industrial activities. In places, the road reserve is less than 2 metres as a result of encroachment from small shops and other premises.

The portion of the East Bank road between the DHB and Georgetown is extremely congested. Indeed, most of the East Bank road is likely to become even more clogged because of increasing economic and housing activity in the catchment area which it serves. In times when Georgetown has flooded, there is also inadequate road capacity between Georgetown and Timehri to enable the rapid transport of persons from Georgetown and its environs to higher ground. It is therefore necessary both to widen the road in this area, and to construct an additional route for commuters and other citizens.

Map 2: Road transport map of Guyana



Source: National Land Transport Strategy and Action Plan 2016-2026, Ministry of Public Infrastructure, June 2017

A 5.2.2.2 Bartica – West Network

Bartica is an important settlement which provides services to the interior area but not as important as in the glory days of gold mining when small groups of gold seekers called "pork knockers" used to travel by large vessels to Bartica where they bought their ration and supplies. Bartica is still an administrative and economic centre, but its importance has declined due to the fact that many mining employees fly directly from Georgetown to the mining regions.

During the 1960's a plan was developed which entailed the development of a road that would link Parika with Makouria, close to Goshen and just across the river to Bartica[2]. This project was called the "Del Conte Project" which was named after a Venezuelan company who acquired the contract. Unfortunately, this was abandoned after a small portion was completed. The completion of this project alongside a bridge to get to Bartica is essential for improving the connection to the capital and consolidating Bartica as the main gateway to western Guyana.

In the period 1974–78, an attempt was made to build a road between Rockstone and Kurupung to facilitate the construction of a large hydroelectric station. From Rockstone it headed north to Suribanna, where a pontoon ferry was installed across the Essequibo River to Sherima. From Sherima the road goes westward, intersecting the Bartica – Mahdia Road at Allsopp Point 19 miles from Bartica. This is currently the main road access to Bartica. A ferry also operates from Bartica to Parika (near Georgetown) transporting people and cargo between the two towns. From Allsopp Point the road follows the existing road towards Bartica then branches off 5 miles from Bartica going towards Teperu in the lower reaches on the Mazaruni River. At Teperu a pontoon ferry is installed across the Mazaruni River to Itaballi. From Itaballi the road then turns westward to Peter's Mine on the Puruni River. From Peter's Mine the road continues as a penetration road to Kurupung. This road is referred to as the UMDA Road; it is the access road to western Guyana and its condition needs to be improved.

A 5.2.2.3 Linden - East Network

Linden is an important mining town (mostly bauxite) and a main hub for road transportation in the hinterland, as it connects to Georgetown to the north, Kwakwani to the east, Bartica to the west and Lethem to the south. In the period 1966–68, Soesdyke, located along the East Bank Demerara Road, was connected to Mackenzie by a modern two-lane highway, now called the Soesdyke–Linden Highway. The Highway is a 74-km, single carriageway paved road, approximately 7m wide and in good condition. It traverses a region, which comprises intermittent patches of subsistence farming including cassava, mango and papaya trees, small-medium scale sand mining and charcoal burning. Apart from the main coastal road network of primary roads, this is the only significant stretch of paved road. There is in addition a hinterland east – west main road system which extends from Linden to Kwakwani in the east (through Ituni) and from Linden to Bartica in the west (through Rockstone and Sherima). The segment Linden – Rockstone (15km) is a two–lane road with modern geometry and surfaced with laterite and in reasonable condition. The other segments of the road are not adequately maintained and travel on it is rough, uncomfortable and sometimes impossible.

[2] Invest Guyana 2017/2018, Guyana Office for Investment

A 5.2.2.4 Southern Network (Up to Lethem)

The existing road between Linden and Lethem (453.7 km) is almost entirely unpaved and forms part of a potential corridor from the Brazilian border at Lethem to Georgetown (558 km)[3]. The Linden-Lethem section extends from the road junction just west of the Wismar Bridge (Linden) at the northern end to Lethem at the southern end, at the point where the access road to the new Takutu Bridge and the Brazilian border begins. In 1968 a bridge was built across the Demerara River at Linden, and in 1974 it was decided that the route to Lethem would cross the Demerara River at Linden and go south, along the watershed of the Demerara and Essequibo Rivers, through Mabura, to Kurupukari. From Kurupukari it would run parallel to the old cattle trail to Annai, and from Annai it would follow an already existing road to Lethem. In 1990–91 a two–lane laterite road was constructed between Kurupukari and Annai and a vehicle ferry installed at Kurupukari. Since there was already an existing road between Mabura and Kurupukari, and between Annai and Lethem, it was now possible for vehicles to travel between Georgetown and Lethem.

The section from Linden to Mabura Hill (122km) begins with a failed BST[4] surfaced road (9.6 meters width) and continues as an unpaved laterite surfaced road with an average formation width of 15 meters. The condition of this unpaved section is two-fold. The riding quality for approximately 90 km is very poor with average speeds of 35 km/hr while the remaining 32 km is in good condition with average travel speeds of 60 km/hr.

The section from Mabura Hill to Kurupukari (108km) is an unpaved laterite and white sand/sand clay surfaced road with an average formation width of 6 meters. The first 25.75 km is in relatively good condition with average travel speeds of 60 km/hr. The remaining 82.4 km is in poor condition, inundated with large potholes, with average travel speeds of 30 km/hr. This section of road is a forestry type road which has replaced the engineered road because of the collapse of a bridge on the engineered road a few years ago. The geometry of the road between Mabura and Kurupukari, and the design of the bridges, do not meet modern highway standards and are considered dangerous. At Mabura Hill (226 km) the road passes through the Demerara Timber Limited sawmill complex and through its timber concession for the next 109 km until just before Kurupukari.

At Kurupukari, there is a toll ferry which crosses the Essequibo River and operates during daylight hours and upon request. The pontoon ferry at Kurupukari has limited capacity. As a result, waiting time is long if the number of vehicles arriving for a particular crossing exceeds the ferry capacity. Immediately south of the ferry crossing, one enters the Iwokrama International Centre for Rain Forest Conservation and Development, one of the protected areas in Guyana, and the road passes through it for some 75 km. At km 418 there is a marked transition from forest to open savannah, namely the Rupununi Savannah. The Kurupukari to Annai section (102km) is an unpaved laterite surfaced road with an average formation width of 9.3 meters. However, this width is reduced to 6.8 meters for much of the length due to

[3] Guyana – Brazil Land Transport Link And Deep Water Port (Gy-T1098), Technical Cooperation Document, Inter-American Development Bank

[4] Bituminous surface treatments (BST) refer to a range of techniques that can be used to create a stand-alone drivable surface on a low volume road, or rehabilitate an existing pavement

encroaching vegetation. The surface is in relatively good condition with average travel speeds of 65 km/hr.

The Annai to Lethem section (119km) is an unpaved laterite surfaced road in fair to good condition, permitting average travel speeds of 50 km/hr. This section has however been subject to seasonal flooding.

A 5.3 Ports and Airports

A 5.3.1 General context

A 5.3.1.1 Ports

Guyana's foreign trade is handled by foreign shipping companies and virtually all exports and imports are transported by sea. The largest bulk exports are bauxite, rice, timber and sugar, and the largest volume imports are petroleum and wheat flour. International shipping is handled at the ports of New Amsterdam and Everton, both on the Berbice River, and the ports of Georgetown and Linden both on the Demerara River.

The Georgetown Harbour is the main Guyanese port. Located at the mouth of the Demerara River, handles general cargo, sugar, grains, petroleum products and other goods for the general population and consists of a number of separate facilities scattered along the east bank of the Demerara River, most of which are privately owned. The port is shallow, with an average depth of 4.5 metres at low tide (maximum draught in the channel is 5.5m), and draught constraints limit the size of vessels using Georgetown's harbour to 15,000 deadweight tonnes (DWT). About 50 vessels of all types are dispatched each month on average in Georgetown, and port traffic amounts to some 1 million tonnes of exports and the same amount of imports.

Although there is no dedicated container terminal, the majority of vessels calling at Georgetown consist of container vessels. As containers are not part of the internal transport system, they are loaded and unloaded at the ports. Containerised general cargo at Georgetown amounted to 66,000 TEU (twenty-foot equivalent units) in 2012, marking an increase of 21% over the last four years. Since 1 July 1999 the port has been run by a Maritime Administration Department (MARAD) operating under the aegis of the Maritime Act. Navigation services, such as pilotage are provided by the MARAD. There is a permanent pilots' station in Georgetown.

The two remaining ports, Linden and New Amsterdam, are focused on bauxite operations. Linden, about 56 km South of Georgetown, handles calcined bauxite. Import cargoes are fuel oil and diesel fuel and other commodities required for the bauxite industry. Three berths are available for oceangoing vessels at Linden. New Amsterdam on the Berbice River is the largest port in Guyana in terms of throughput. The major facility there is a multi-buoy mooring (MBM) for midstream transhipment of bauxite from river barges to bulk carriers. Besides the MBM, there are a number of other shore-based berths scattered along both banks of the river, handling small volumes of a variety of products. There are about 10 vessels per month in New Amsterdam, mainly vessels with bauxite were loaded and a few tankers for the petroleum product supply were discharged. However, improvements in the channel in the Berbice River have made it possible for ships of up to 55,000 DWT to dock there.

A 5.3.1.2 Airports and airstrips

The Cheddi Jagan International Airport (CJIA) is the main international airport of Guyana. It is located at Timehri, 40 km southwest of Georgetown, and has two runways of 2,270 m and 1,525 m, respectively, both being 45 m in width. Customs, immigration and security services are based at the airport. A major push has been made to improve international airlift capacity and airport infrastructure. As mentioned in the analysis of the tourism sector, eight carriers currently provide international service at CJIA, which is a major improvement over the state of affairs a decade earlier, when there were only three international carriers.

The CJIA Timehri facility and the international airport is in the process of modernisation and set to be transformed upon completion of the project. In November 2011, The Government of Guyana signed a contract with CHEC of China for the expansion of the runway at the CJIA and the construction of a modern terminal building at an estimated cost of USD 138 million. The runway was extended from 2,300 m to 3,300 m. The existing terminal building will be completely rehabilitated and used for departures only, while a new terminal building will be constructed for arriving passengers only. A boarding corridor with two passenger boarding bridges will connect directly to the terminal buildings, and a new diesel generator building and a fire pump station will be constructed.

A second airport for Georgetown is located at Ogle, on the East Coast Demerara, much nearer to the city (9.7 km south-east). In late 2001 the Government leased out the management and operation of the Ogle aerodrome, a former sugarcane airstrip, to Ogle Airport Inc (OAI). The lease is for a minimum period of 25 years with extension periods of 25 years on request of the lessee. The objective was to develop Ogle Aerodrome to full international standards (for example, Fire, Crash and Rescue (FCR), security, customs, immigration) and to act as a backup to CJIA in the event of an emergency, disaster, accident or some other un-serviceable situation. In 2010, the International Civil Aviation Organization (ICAO) conferred "international" status to the air terminal (IATA: OGL, ICAO: SYGO).

Intra-regional and domestic services were developed at Ogle, which is the hub for domestic flights to Guyana's interior. In anticipation of increased regional air traffic to the facility, an EU-subsidized construction project began in January of that year, intended to upgrade the terminal building and extend the primary paved runway to a usable length of 1,200 m. It offers once-daily service to the in-town airstrip in Paramaribo, Suriname and provides links with other member states of the CARICOM Community, whose headquarters were re-located from Georgetown to a purpose-built site at Turkeyen close to the airport.

Of more than 200 airstrips in Guyana, only 24 have frequent scheduled services (a further 73 have frequent non-scheduled services). Parts of the country's south, south west and south-east have large areas that are only accessible by air. The 24 airstrips with scheduled services are used for tourism, general aviation associated with gold mining, and to serve isolated communities in the interior.

A 5.3.2 Adequacy of existing infrastructure and improvement requirements

A 5.3.2.1 Ports

Existing conditions in the Demerara harbour threaten to limit the potential for growing maritime trade. As in Suriname, Guyana primarily is serviced by smaller feeder vessels and general cargo ships, mainly because of severe draft restrictions in the ships' access channels that have, for years, been hampered by heavy siltation arising from the Amazon River outflows. The most urgent problem in the Guyanese port structure is the water depth in Georgetown Harbour and, specifically, in the access channel: from a depth of 6 metres over many years, the period 2008 to 2011 has seen a dramatic shallowing to approximately 4.5 metres. As a result, the cargo capacity of vessels transiting the harbour has been reduced to between 60 and 70% of previous levels and has translated to higher freight rates. More plainly, the maritime owners and operators usually provide for revenues from full loads – cargo plus dead-freight – in all voyages but these higher rates at reduced capacity ultimately translate into higher prices for the individual consumer. In addition to problems with the draught, there are other problems, including incidents of piracy, theft and loss from international and local vessels; the lack of a fire-fighting vessel; poor pilotage services due to insufficient equipment and human resources; and a lack of adequate navigational aids.

In the medium term, the creation of an export/ import route to Brazilian landlocked States of Roraima and Amazonas may constitute a significant economic development opportunity for Guyana[5]. The trend growth of Manaus' (Amazonas State) deep sea container traffic between 1998 and 2012 was just under 7% a year; it is estimated that this growth will continue. Meanwhile, siltation in the Amazon River between Manaus and Belem (State of Pará) on the coast, where sediments have accumulated to levels hampering the efficiency of movement in navigation channels, has resulted in substantially increased freight costs and transit times for Northern Brazilian exporters. While the distance savings by road would be greater for Boa Vista than for Manaus to an Atlantic port, both could enjoy time and cost saving by utilizing the Guyana route for exports/ imports to and from these cities. According to a feasibility study for the Linden-Lethem road, the time taken for a 40ft container to travel along the Amazon River from Manaus to a port in Brazil for further transhipment to Caribbean or North America is 3 days more than it would take using the Linden-Lethem corridor; the river route is also estimated to cost 50% more than the Guyana land route.

A deep-water port would facilitate exports/ imports to and from Roraima and Amazonas. Potential sites for the deep-water port are currently being studied by the Inter-American Development Bank (IADB) in the estuaries of the Essequibo, Demerara and Berbice Rivers including the current Demerara port site, in consultation with the Guyana Land and Surveys Department, Transport and Harbours Department and the Maritime Administration (MARAD).

A 5.3.2.2 Airports and airstrips

Airport capacity seems to be adequate for the near-term future. At both of the main airports, investment programmes currently under way appear adequate to cater for demand in the medium term. Works on the Cheddi Jagan International Airport (CJIA) expansion project are in progress and is on schedule for completion during 2018.[6] In addition to the new Arrivals Terminal building, an extended runway and two boarding bridges, there are plans to install another two bridges at a later stage, a renovated Departures Terminal, additional duty-free shops and increased parking facilities. Meanwhile, private investor funds have equipped Ogle

[5] GUYANA – BRAZIL LAND TRANSPORT LINK AND DEEP WATER PORT (GY-T1098), TECHNICAL COOPERATION DOCUMENT, Inter-American Development Bank

[6] Invest Guyana 2017/2018, Guyana Office for Investment

airport whose structure, despite its relatively small size, seems adequate for handling domestic and intra-regional traffic.

There is opportunity to improve land connections to the airports, in order to maximize their use and to stimulate residential and commercial real estate development around these areas. First, an improved road access between Ogle and Timehri Airports would allow for better connections for international passengers flying to the hinterlands and to other countries in the region; currently, these passengers need to pass through the center of Georgetown, which increases significantly travel times and adds to the city's traffic. Second, as mentioned in the land transport section, the link between the capital and Timehri/ Soesdyke needs upgrading. Currently, the majority of this link is served by a single lane, which leads to congestion in peak hours. Given that most of this road Is already surrounded with real estate development, expropriation costs might be prohibitive and a parallel bypass alternative is recommended.

Finally, some investment on key hinterland airstrips is still needed, in addition to improvement of airstrips on touristic sites, such as Kaieteur and Orinduik. Investment on aerodromes and airstrip development in local hubs such as Bartica, Mahdia and Lethem is currently under consideration. Upgrading these airstrips will ultimately create employment and economic input into the respective Regions.

A 5.3.3 Information and communication technologies (ICT)

A 5.3.3.1 General context

Guyana Telephone and Telegraph (GTT) holds a legal monopoly on land line and international telephone services.[7] It is 80% owned by the Massachusetts-based American company Atlantic Tele-Network (ATN) and 20% owned by a Hong Kong investor. GTT has invested heavily in the Guyanese telecommunication infrastructure, including fibre over land and undersea. Although its exclusivity does not extend to the broadband retail market, the company is the only digital subscriber line (DSL) operator in Guyana. The only effective competition comes from fixed-wireless broadband providers. GTT's mobile unit, Cellink, competes with Digicel Guyana for market share; both companies operate GSM/GPRS networks.

GTT's monopoly on the long-distance voice and data telephony markets came under serious scrutiny after the Americas II fibre optic cable suffered damage in May 2008. As an emergency measure Digicel was granted an interim long-distance license by Guyana's government to route communications via satellite. Since then, Digicel has been engaged in legal disputes with GTT for years over its exclusivity; on the other hand, GTT has accused Digicel of using illegal bypass operations.

The telecom industry does not have competition and prices are not very negotiable. GTT's fixed-line monopoly was renewed for 20 years in December 2010, but, before renewing the contract, the government drafted a new Telecommunications Amendment Bill, approved in mid-2017, aimed at opening the telecoms sector to competition. The new Telecommunications Bill promises considerable changes in the sector, and licenses have been

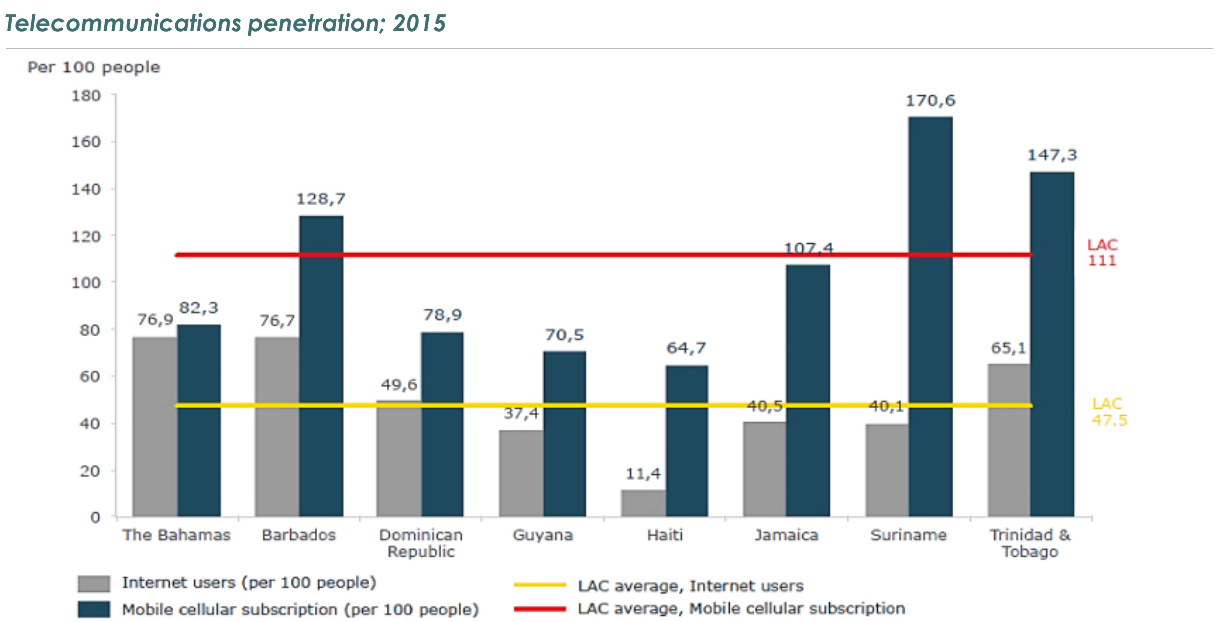
[7] https://www.export.gov/article?id=Guyana-Information-and-Communications-Technology

issued to GTT and Digicel to offer 4G services for the first time. The Government of Guyana and GTT are currently in negotiations to open the communication market.

A 5.3.4 Adequacy of existing infrastructure and improvement requirements

Guyana's investment climate remains hampered by poor telecommunications infrastructure, slow and costly internet connectivity, and a single international voice and data gateway. Fixed broadband services have improved, especially since the opening of the SG-SCS submarine cable in mid-2010, but they are still comparatively slow and expensive, and the number of broadband subscribers is limited. Guyana's telecommunications offer is lower than the regional average, with fixed-line teledensity is 20%; mobile penetration is 70%; and internet usage below 40%. Access prices are high: the cheapest plan for broadband home access costs around GYD 10,000 (USD 50); for more bandwidth, costs increase to GYD 30,000 (USD 150). This makes broadband access unaffordable to a significant portion of the population.

Figure 1: Telecommunications Penetration in Guyana (2015)



Source: World Bank Country Profiles

Currently, Internet and broadband infrastructure in Guyana is concentrated in the coastal region, and inland, there are sparse and even more expensive connectivity options. Digicel provides only mobile but they do service several remote communities. Generally, low density (647,500 square km and only three quarters of a million people) is a challenge, but the situation is much worse in the Hinterland regions, which comprise about two thirds of the country's landmass, but only 11% of the total population. Because of the geographic spread of homes and businesses across in interior regions, it is difficult for government and other services to reach the poorest. Cost and other barriers affect those residents' ready access to vital services available in urban and rural areas. A 2016 survey[8] confirms that the accessibility of

[8] National ICT Needs Assessment Consultancy, by Detecon International GmbH

telecommunication services is very diverse in Guyana and this pattern is reflected in the statements of respondents: The inhabitants on the coast complain about the price and quality of services, while inhabitants in the interior resent the lack of access to infrastructure.

The communities surveyed can be clustered into three groups in terms of the current accessibility of ICT Services:

- Communities with widespread access to a variety of services presented a comparatively better situation than others, regarding ICT accessibility. For instance, in communities such as Albouystown and Kwakwani, services such as 3G, landlines, cellphone signal, and internet are widely available to the public.
- Communities with a relatively limited number of widely-accessible services have access to basic ICT-Services, but lack access to more advanced services. For example, in Mabaruma and Port Kaituma (both in Region 1), the population has access to cellphones, smartphones and narrowband internet. Broadband internet is available only through costly satellite services and landline phones are also relatively rare, being available almost exclusively in some public facilities.
- Communities with very few, very unreliable, quasi or non-existent services, practically cut off from access to telecommunication and information technology. For instance, Kako (in the Cuyuni-Mazaruni region, with more than 2,000 inhabitants) has only a few spots with proper mobile phone signal, while Phillipai village (same region) does not have any mobile signal or landline phone – the high frequency radio is the only device used to communicate with other regions in Guyana.

There is a considerable discrepancy between the accessibility of services in the communities and the statements provided by the telecom operators, who claimed that they are currently covering 98% of the population; in many cases, even if a village had a mobile signal it did not cover the whole village, but only some spots. Furthermore, prices for some devices (mainly laptops and computers) were considered too high. Device access is also a challenge: some communities, for example, Kwakwani, have telecommunication services, but no store or shop, requiring travel into Georgetown to buy respective devices.

A 5.4 Coastal Protection Infrastructure

A 5.4.1 General context

A 5.4.1.1 Geography

Guyana's surface consists of four main natural regions[9] (Map 3):

a) *Coastal plain:* Guyana's coastal plain is the low-lying deltas of the Berbice, Mahaica, Demerara and Essequibo Rivers. This fertile coastal strip (77 km wide in the east and 26 km wide in the west) includes Georgetown the capital city, occupies about 4% of the country's area and is densely populated (666,000 persons, 90% of the total population) in contrast to the Hinterland regions, though this density is not evenly distributed as there are some interior parts of the coastal belt that are also sparsely populated. West

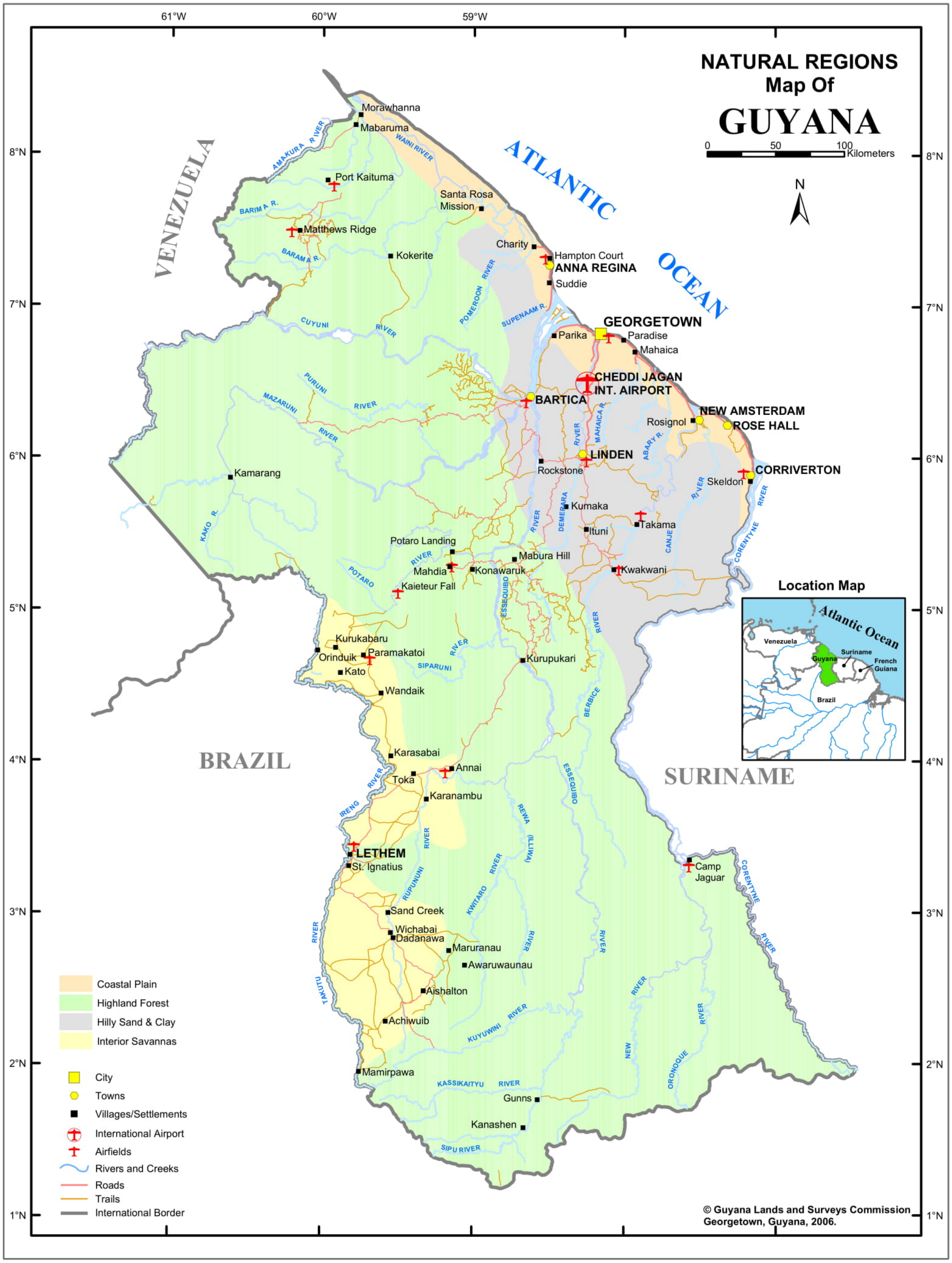
[9] 2013 National Land Use Plan (GL&SC)

of the Essequibo River the coastal plain narrows with extensive “pegasse” (tropical peat) deposits inland. In general, the soils closer to the shore and along rivers are more fertile than the soils further inland, which can have very low fertility. The recent plain occurs at elevations of 2 m below to 3 m above sea level, while the older coastal plain lies at an altitude of about 3-9 m above sea level. Since the normal tide range is about 3 m, sea invasion and sea over topping of sea defences is usual, especially during the wet seasons and during high tides.

Agriculture and settlement in the coastal area have been accommodated by the establishment of an intricate drainage and irrigation (D&I) system consisting of a network of dams, canals and sluices designed in the early to mid-19th century. In addition, its shoreline is protected by 80 km of which are defensive structures that range from earthen banks to concrete walls. Both anthropogenic factors (poor maintenance of drainage, sea and river defence structures and the removal of mangroves), as well as natural processes associated with cyclic movement of mudbanks along the coast, have resulted in significant deterioration and disrepair of the drainage and sea defence systems.

Most of this fertile coastal strip, composed of Amazon clay deposits is below the high tide water level resulting in a highly waterlogged topography. Coastal geomorphology is dominated by westward moving Guyana current that transports large mudbanks. The movement of these mudbanks creates a cyclic pattern of coastal erosion and accretion processes along the shoreline and are a contributory factor to very rapid and dynamic changes in coastal geomorphology and the impacts on the country’s sea and river defence systems.

Map 3: Guyana's natural regions



Source: Guyana – Progress and Challenges in Disaster Risk Management, Civil Defence Commission, November 2014, p.24

b) *Hilly sand and clay region*: which occupies about 14% of the Guyana's surface area. This area is 150 to 250 km wide and consists of low sandy hills interspersed with rocky outcroppings with hardwood forest. Altitudes vary from about 15 m above sea level close to the coast to 150 m above sea level in the south. These sands cannot easily support crops and, if the trees are removed, erosion is rapid and severe.

c) *Forested Highlands*: with an area of 15.7 million ha, comprises 74% of the surface Guyana, and are made up of mostly inaccessible forests and woodlands, with plateaus and flat-topped igneous and metamorphic mountains to a maximum height above sea level of 2,810 m (Mount Roraima).

d) *Interior Savannahs*: account for up to 8% of the surface area. The Rupununi Savannah is divided into the northern (100-110 m in altitude) and southern savannahs (100-120 m in altitude) by the Kanuku Mountains (760-840 m). It presents a variety of soils, with extensive presence of alluvium materials, and is generally of low fertility.

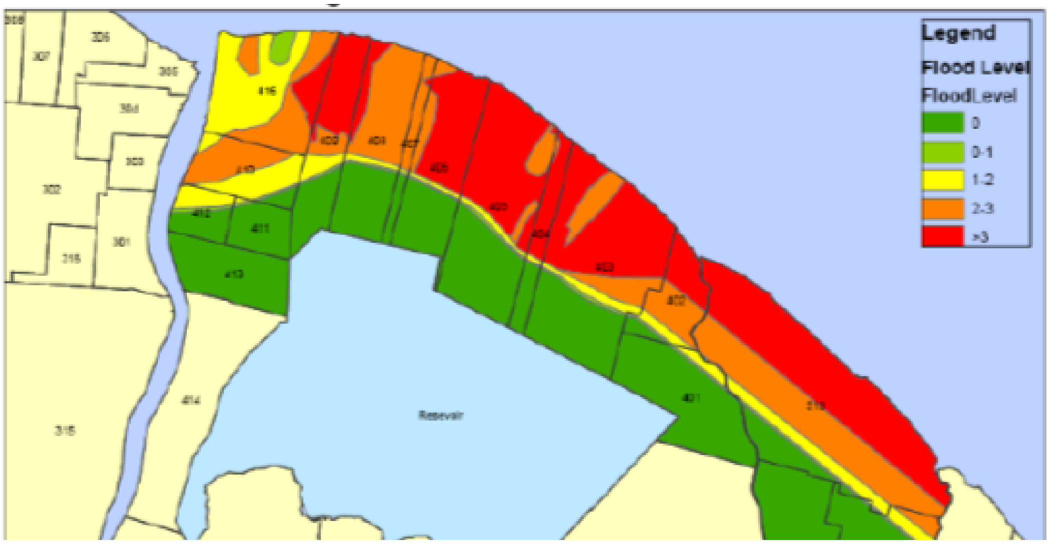
The surface of Guyana is mostly flat, except for the Kamoa Mountains on the southern border, and the Pakaraima Mountains to the Brazil-Guyana-Venezuela trilateral border. The highest mountains are Mount Ayanganna (2,042 m), Mount Caburai (1,465 m) and Mount Roraima (2,810 m).

A 5.4.1.2 Exposure to climate hazards

Guyana is currently exposed to extreme weather events, which can be caused by a range of factors including heavy rainfall, sea state and tidal conditions, and inadequate or poorly maintained drainage and sea defence infrastructure. In terms of average annual loss to natural hazards, floods represent by far the greatest threat with United Nations International Strategy for Disaster Reduction (UNISDR) reporting that 99.9% of the expected losses per annum is associated with small, moderate and extreme flood events.

Guyana is classified as a high flood risk country, with the greatest vulnerability experienced within the coastal zone. Indeed, especially since 39% of Guyana's population and 43% of its GDP are located on the coastal zone in regions that are exposed to significant flooding risk by virtue of the concentration of the population, economic activities, critical infrastructure (for example, transport) in these areas. The IDB Disaster Exposure Index (DEI) identifies Guyana as the fourth most exposed country, 0.60 on a scale of 1.00, in the Latin American and Caribbean region to natural disasters. This is primarily the result of the Guyana's high exposure to and experience of flooding as well as drought. Guyana's DEI score is particularly high given that the country is not significantly exposed to tropical storms, is not on the Caribbean hurricane belt and also has no significant earthquake or volcano risk.

Map 4: Flood map of Georgetown



Source: Guyana National Land Use Program, Guyana Lands and Surveys Commission June 2013, p.89

In January 2005, an unusual weather system produced the heaviest rainfall on record in Guyana resulting in the most devastating floods in Guyana's history, as illustrated in Box 2.

Box 2: Impact Of Floods On The Agriculture Sector In Guyana

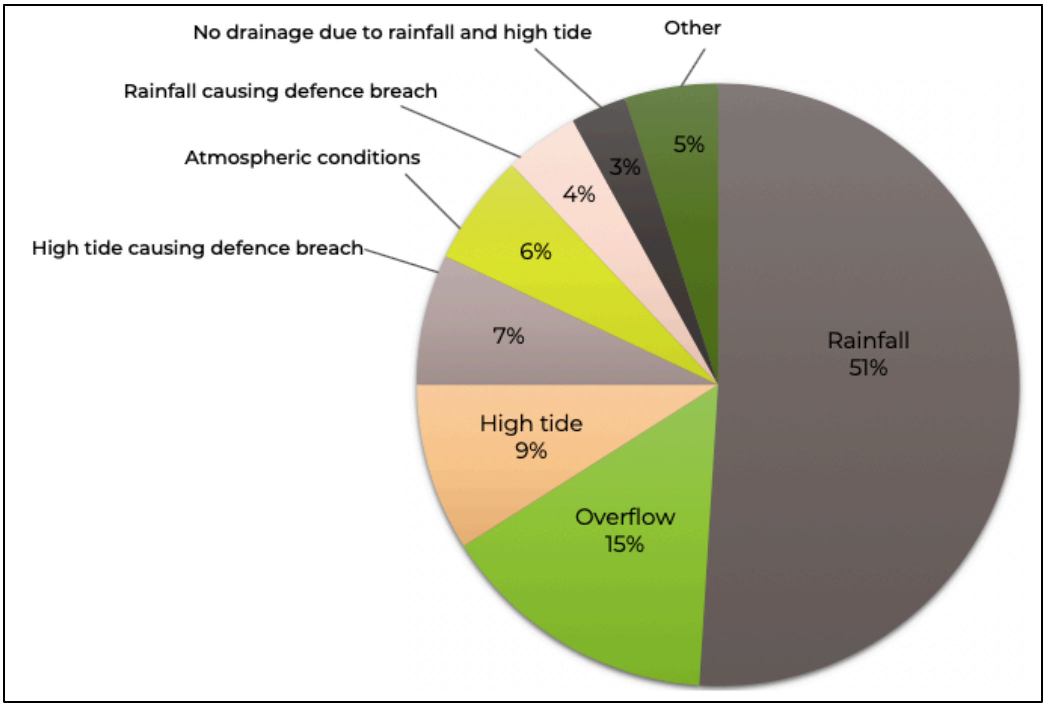
One of the most significant flood events occurring in recent history was in January 2005. This event is reported to have affected close to 275,000 people (37% of the population) and caused economic damage estimated at USD 465,000,000 (60% of GDP). It was caused by a combination of a wetter than average December (2004), which left the ground saturated, followed in January (2005) by some of the heaviest rainfall Guyana has experienced since records began in 1888. The heavy rainfall also caused an increase in the water levels of the East Demerara Water Conservancy Dam (EDWC), which came close to a critical breaching level (18m) and could have resulted in the failure of the dam wall.

A socio-economic assessment of the damage and loss caused by the 2005 floods revealed major impacts to the agriculture sector, particularly in the regions of West Demerara/Essequibo Islands, Demerara/Mahaica and Mahaica/West Berbice. Region 4 was most severely affected, experiencing close to 55% of the total damage, followed by Regions 2 (23%) and 5 (19%). Households across regions 3, 4 and 5 were significantly and directly impacted, with reports of water levels of as much as 120-150cm of standing water, which remained for several days; in total, 70,000 households were affected, which is 37% of total number of households in Guyana and 58% of Regions 3, 4 and 5. Considerable losses were recorded in the sugar, rice, livestock and other crop (fruits, vegetables, roots and tubers, and herbs and spices) subsectors as well.

The January 2005 floods served to galvanise Guyana towards a more proactive approach for vulnerability reduction; and has seen the development of improved policies and strategies for vulnerability reduction with the support of its development partners.

Although a disaster of similar magnitude has not since occurred, the Government of Guyana has noted with increasing concern that heavy precipitation events are occurring more frequently, resulting in flooding and disruption to the social, productive and infrastructural sectors. Indeed, since 2005 there have been seven extreme rainfall events which resulted in floods in 2006, 2008, 2010, 2011, 2013, 2014 and 2015. The UNISDR estimates that the floods of 2006 and 2008 affected approximately 135,000 people and those of 2006 and 2010 resulted in cumulative economic damage of USD 183.7 million. Records detail about 834 emergencies and disasters since April 1973[10]. Prevalence of flooding and/or gales is high (216 occurrences), as these are found in 75% of the years in the reported period. Flooding occurs due to a number of factors such as: high precipitation, river overflowing, sea swell, overtopping or breach of sea defences and conservancy dams, and sometimes from a combination of high tides and heavy rainfall.

Figure 2: Percentage of Floods & Gates (April 1972 – April 2012)



Source: Vivid Economics, based on Desinventar database in Guyana – Progress and Challenges in Disaster Risk Management, Civil Defence Commission, November 2014

A 5.4.1.3 Projected future climate trends

The climate scenarios for Guyana indicate that temperatures will increase, and that sea level will continue to rise resulting in higher storm surges. Ensemble median projections also indicate that average annual precipitation will decrease and that the proportion of heavy rainfall events will increase. There is uncertainty about these values as both positive and negative projections of change are generated when minimum and maximum values are

[10] The Desinventar Database (http://online.desinventar.org consulted June 2014).

considered. Table 1 provides a summary of the direction and extent of change for the 2030s, 2040s-2070s and 2070s-2100.

Sea level has been rising globally since the end of the last ice age, but the rate of that rise has accelerated significantly. From 1993 to 2009, the annual rate rose to around 3.4 millimetres — nearly twice the 20th Century average. Scientists attribute this recent acceleration to human–caused climate change. Oceans expand as they warm, and the Artic, Greenland and Antarctic ice sheets and mountain glaciers add water to the oceans as they shrink. After looking closely at the volume of water that could come from shrinking glaciers and ice sheets, scientists project a rise of 80 centimetres by 2100—or possibly as much as 2 meters, depending on the pace of heat-trapping emissions and assumptions about ice sheet behaviour.

Table 1: Summary of climate change scenarios for Guyana

Climate variable	2030s	2040s – 2070s	2070s - 2100
Average annual temperature (°C)	↑ 0.4°C to 2.0°C	↑0.9°C to 3.3°C	↑1.4°C to 5.0°C
Average annual precipitation (% change)	Median: 0% to -4% Min-max: -29% to +14%+	Median: -4% to -8% Min-max: -41% to +13%+	Median: -4% to -5% Min-max: -63% to +20%+
Proportion of total rainfall that falls in heavy events	No data	Median: ↑ 1-2% Min-max: -3% to +10%+	Median: ↑ 2-3% Min-max: -8% to +12%+
Sea level rise (m)	↑ 0.14m to 0.26m	↑ 0.21m to 0.43m	↑ 0.25m to 0.51m
Sea level rise + storm surge (m)	↑ 2.94m to 5.94m	No data	↑ 2.93m to 6.19m

Source: Climate Resilience Strategy and Action Plan for Guyana, Ministry of the Presidency, November 2015, p.18

Scientists have found that the Guyana coast is subsiding, owing to groundwater extraction, soil compaction, and drainage of wetlands. Besides global sea level rise, several other factors influence regional sea levels, including sinking (subsidence) or rising (uplift) of the land, circulation of the atmosphere and the ocean, and the origin of meltwater. From 1951 to 1979, the sea level off Guyana rose at a rate some six times the global average, (10mm per year), around 6 times the 20th Century average or 3 times the 1993 to 2009 annual average.

In Guyana, a one metre rise in sea level is projected to increase the risk of inundation across all coastal administrative regions; with regions 4 and 6 having the highest expected exposure. Changes in sea level of this magnitude will cause significant increases in overtopping discharges for sea defences, increased flood volumes and frequency, and enhanced coastal erosion. The rate of shoreline recession will increase in areas not protected by seawalls. These physical impacts will cause a range of knock-on consequences for communities, infrastructure and economic activities located in these areas, and the rise in informal housing settlements in Guyana, especially within the coastal zone, increases the degree to which socio-economic systems could be affected by climate change. It should be noted that sea level rise will also have impacts far inland due to the salinization of agricultural lands and the attendant reductions in productivity compounded by changing climatic conditions.

Sea level rise could devastate agricultural production, if saltwater inundates fields and intrudes into the estuaries used to irrigate them. Guyana's coastal plains are home to some three quarters of the country's economic activities including almost all the Guyana's agricultural production—critical for both food and export. Aquifers are becoming brackish in the coastal belt, contaminating freshwater supplies used for drinking and other domestic and industrial activities and requiring costly treatment.

Management of infrastructure assets is further complicated by the impact of climate change. It threatens existing infrastructure, delays project implementation, and increases the cost of construction and maintenance, debilitating conditions for the Guyanese people and businesses. By 2030, the annual loss due to flooding in Guyana is projected to be USD 150 million. This at-risk value has been estimated by using flood maps that combine an assessment of flood risk, population density, and economic activity. Additionally, an extreme event similar to the serious flooding in 2005, could result in USD 0.8 billion in losses and harm to more than 320,000 people. According to models of sea-level rise, Guyana is forecasted to be one of the most affected countries in the LAC region, with some scenarios anticipating as much as 60 miles of coastline lost by 2050. Such a result would threaten much of the Guyana's present-day arable land, and existing infrastructure.

A 5.4.1.4 Adequacy of existing Infrastructure and improvement requirements

Guyana's sea and river defence system is critical for adaptation to the potential adverse effects of climate change, but sea level rise is likely to cause significant increases in overtopping of sea defences; increased flood volumes and frequency; enhanced coastal erosion; and increased rates of shoreline regression in areas not protected by seawalls.

Closely interlinked is the drainage and irrigation system which is connected to the 136 sluice gates/kokers which are located along the seawall. However, with sea level rises consequentially limiting the number of low tide days, opening of the sluice gates/kokers to expel water to sea is becoming increasingly restrictive hence increasing the risk of flooding and further exposing Guyana's population and assets located in low-lying coastal regions. Additionally, blocked drains and disabled pumps exacerbate the problem of water expulsion. Therefore, the functional relationship between the drainage and irrigation system and the sea wall needs to be optimized for both systems to efficiently preform their critical roles. A fault in one could comprise the integrity of the other and efforts are on the way to address some of the shortcomings of the drainage and irrigation system.

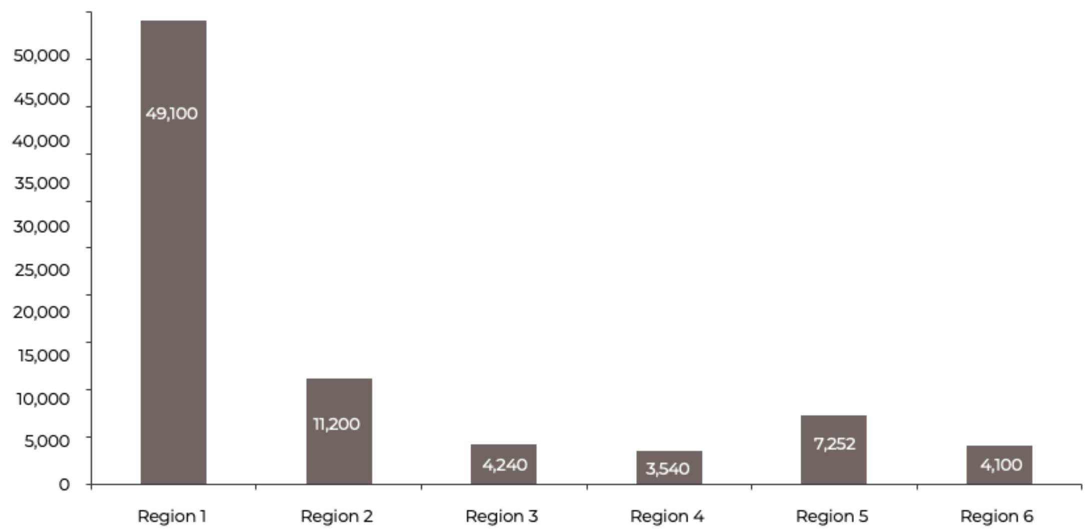
A 5.4.1.5 Mangroves and sea defences

Mangroves can form effective barriers to certain types of coastal erosion, keeping soil together, trapping sediments, breaking down pollutants, and absorbing most of the wave energy. There are three main species of mangroves in Guyana: the dominant Black mangrove ("Courida bush", *Avicennia germinans*), the Red mangrove (*Rhizophora mangle),* and the White mangrove *(Laguncularia racemosa*). As highlighted by the *National Mangrove Management Action Plan 2010-2012,* the typical composition pattern of the mangrove forest, with *Rhizophora* forming the seaward fringe, and *Avicennia* and *Laguncularia* established within this, does not prevail in Guyana. *Avicennia* is almost always found as the outermost species, with *Rhizophora* restricted to riverside and estuarine environments.

Certain conditions are needed for the growth of mangroves, pertaining to tidal inundation, rate of siltation, availability of fresh water and sedimentation. Therefore, measures to improve the characteristics of the coastal fringes need to be put in place. Mangrove vegetation grows in a coastal saline environment; however, it is capable of tolerating only a certain degree of salinity. This tolerance varies with the species. The salinity of the soil is affected by tidal and wave action, and rainfall and riverine discharge patterns. Additionally, sea defences modify the fresh water run-off and allows the wave-energy to progress directly onto the coast. Moreover, the distribution of different species is an important determinant of the ability of mangrove ecosystems to deliver shoreline protection.

Mangrove areas along the coast relatively thin (tens of meters wide), due to the historical clearance of mangroves for obtaining fuel wood and resources for the tanning industry, localized damage caused by fishing boats, dumping, and the grazing of livestock in mudflats. The connection between mud banks and areas of mature mangrove is severed by channels, reducing the likelihood of the natural vegetation of mudflats occurring through seed dispersion. Moreover, changes in trapping capacity of the coastal fringes reduce the level of maturation of mud banks, as well as consolidation of sediment and cracking. This also reduces natural colonization. Nevertheless, Guyana accounts for more than 80,000 hectares of mangrove forest, most of them (75%) in Barima-Waini and Pomeroon-Supenaam.

Figure 3: Estimated Area (ha) of Mangrove Forest per Region (2001)

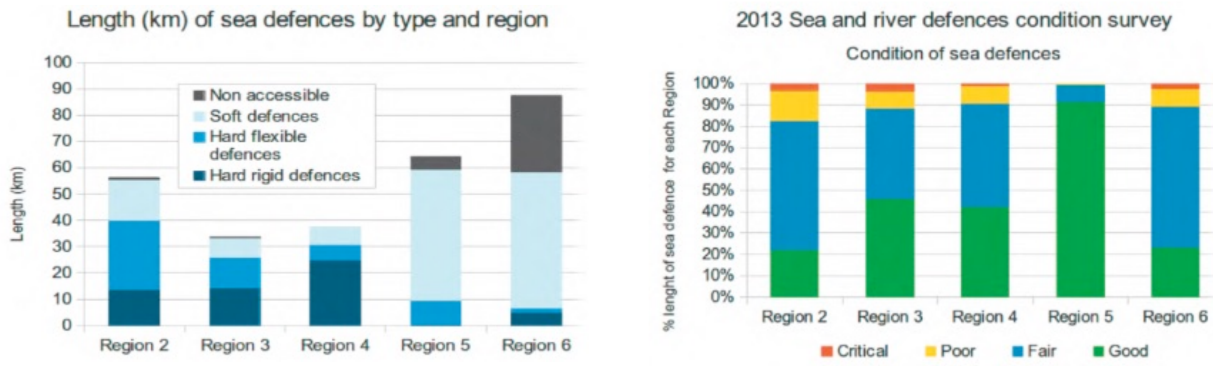


Source: Guyana Forestry Commission (GFC), in Guyana – Progress and Challenge in Disaster Risk Management, Civil Defence Commission, November 2014

Since the Dutch colonial period in the late 1600s, the natural system of mangroves on the coastline has been partially replaced by a complex system of sea defences, dykes, polders, canals, sluice gates, irrigation and sewerage networks, and conservancies. The infrastructural sea defence system of Guyana is 279 km long and consists of hard (for example, concrete sea walls) (109.27km) and soft engineering structures (also called managed realignment, for example, mangroves) (123.67km). Mangroves function as natural breakwaters along the coast and represent one of the most important natural sea defences available for Guyana.

Despite the significant investments to rehabilitate sections of Guyana's sea defence system, there are still poor and critical sections. The 2014 survey of Guyana's sea defence structures, which covered 91.2% of the total length, shows that 2.28 km (1%) is in critical condition, 20.53km (9%) is poor and 80.22km (34.4%) is in fair condition (see Graph below) (WSG, 2014).

Figure 4: Guyana's Sea Defence by Type, Region and Condition



Source: Civil Defence Commission, Guyana – Progress and Challenges in Disaster Risk Management; 2014

Regions 2, 4 and 6 have the weakest points in the line of defence. A one (1) meter rise in sea level is expected to increase the risk of inundation across all administrative regions; however, Regions 4 and 6 have the highest expected exposure. The most vulnerable Regions, 2, 4 and 6, account for 64.8% of the sea defence structure. It should also be recognised that in both Regions 2 and 4, the sea defence structure is mainly composed of hard structures (58% and 82% respectively); whereas, Region 6 is mainly composed of soft structures (83%). Although only 11% of the sea defence structure in Region 4 is poor and critical, relative to 10% in Region 2 and 20% in Region 6, Georgetown is located in Region 4 and as such, the value at risk is higher in Region 4 than in Region 2 and 6. Administrative Regions 3 and 4, which are two of the most densely populated areas in Guyana, have experienced significant depletion of mangrove forest.

Rise of sea level reduce effectiveness of defences. The seawalls have sluice gates that allow floodwaters from heavy rains and waves that crest the seawalls to drain. However, the gravity–controlled gates cannot open if the tide is not low enough. As sea level rises even more, the risk that the gates will not open also increases. Some locations already rely on pumped drainage, and more are likely to need it, raising the cost of protecting coastal development. Coastal mangrove fringes are particularly at risk from sea–level rise. Mangroves naturally move slowly landward as sea level rises. However, because the Guyana coast is developed, the mangroves cannot do so, and slowly die off from being pinned in place as sea level rises. This exposes more of the coast to damage from saltwater inundation, storm surges, and reduces the nursery habitat for commercial fishing.

A 5.4.1.6 Water Conservancies, Drainage and Irrigation

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:

i) *The East Demerara Water Conservancy (EDWC)*: built in 1888 in Region 4 – West Demerara/ Mahaica – linked with the east coast irrigation system, provides water storage and flood control mechanisms for Guyana's most populous region (Region 4, Demerara-Mahaica, 313,429 people, 42% of the total population), including the capital city of Georgetown. The EDWC is a large shallow reservoir bounded on three sides by a low earthen dam in length, with a capacity of 340 hm^3 and an area of 550 km^2.

This area lies around or below sea level, so that any water collected can only be discharged by pumping, or at low tide when the sea level is low enough to allow for gravity-based release through the drainage channels and the 136 sluice gates. The main channels are the Kofi Channel, Land of Canaan, Maduni, Lama and Cuhna Channel. Currently the Hope Dochfour Channel located in the agricultural lowlands between the Atlantic Ocean and the earthen dam is under construction. The EDWC acts as both a flood defence for the coastal area in the wet season and as a water storage system in the dry season. Weather events – such as the 2005 flood when extreme rainfall caused flooding throughout the coastal lowland – have highlighted the vulnerability of the EDWC system. Drinking and irrigation water is collected and stored within the conservancy behind the EDWC dam. In the coastal lowlands, between the dam and the sea defences, an intricate network of canals manages water for irrigation and drainage.

ii) *The West Demerara Water Conservancy (WDWC)*: built in the 1950's in Region 3 – Essequibo Islands/West Demerara – has a capacity of 165 hm^3 and a reservoir area of 235 km^2. This conservancy is also gravity based, but more commonly used for agricultural purposes rather than drinking water because of the rice crops area that lies on the north. Flood control is managed using the drainage relief structures and drainage channels from the reservoir to the Atlantic Ocean, to the Essequibo river at Namryck and to the Bonasika river at Waramia.

iii) *The Tapakuma Water Conservancy:* operational since 1974, in Region 2 – Pomeroon/Supenaam – has a capacity of 18.1 hm^3 and a reservoir area of 140 km^2. It has drainage channels used for releasing excess water during rainy seasons. The most important channel is the Cozier Canal located at the north boundary of the dam crest, near the Pomeroon River.

iv) *The Abary Dam at Copeman:* operational since 1985, in Region 5 – Mahaica/Berbice, has a capacity of 609 hm^3 and a reservoir area of 808 km^2. The Mahaica-Mahaicony-Abary Project is aimed at constructing dams for the Mahaicony (Phase 2) and Mahaica (Phase 3) rivers, incorporating them in the conservancy, and linking the system with the EDWC. Design of Phase 2 is ongoing during 2014.

Map 5: Location of East Demerara (EDWC), West Demerara (WDWC) and Tapakuma Water Conservancies (TWC) (2013)

Source: Guyana – Progress and Challenges in Disaster Risk Management, Civil Defence Commission, November 2014, p.30

Multiple economic activities, livelihoods and communities are dependent on efficient drainage and irrigation (D&I) systems. These systems are critical for flood control, surface water drainage, but also to provide water for agricultural, domestic and other purposes. In order to carry out the dual role of drainage and irrigation, the systems are operated through the concept of nearly constant water level. A large proportion of Guyana's coastal lands lie below sea level and drainage by gravity is possible only during low-tides, which makes the systems prone to flooding during extreme rainfall events. The losses and damage from the 2005 floods in Georgetown and the surrounding region exposed the system's limitations in terms of handling a greater intensity in rainfall combined with tidal inflow. In the National Adaptation Strategy to Address Climate Change in the Agriculture Sector of Guyana (DPMC, 2009) it was noted that "Drainage structures were designed to accommodate 38.1 mm of rainfall over a 24 hour period. However, annual rainfall intensities have increased and as such the past and some existing parts of the drainage system are unable to cope with the resulting greater intensity in rainfall causing more frequent flash and prolonged flooding and losses."

To facilitate Guyana's agricultural output, irrigation waters are also extracted from water conservancies. During the rainy seasons, conservancies regulate runoff and prevent flooding, while storing water during the dry seasons. The conservancies are critical to farming activities of Guyana Sugar Company (GUYSUCO) and small to medium scale farmers as a means of irrigation during the dry season and to protect settlements from flooding. This role is becoming even more critical given the impending impact of climate change through increased drought conditions. In period of high rainfall or increase intensity in rainfall, the conservancies can become full or near capacity. If this occurs, water is released from the conservancies using a gravity dependent drainage system of canals that lead to the sea (water can also be released into the rivers), stopped only by the 136 sluice gates/ kokers which are located in the 109.27km of seawall.

There is also a network of sluices and pumps to aid drainage and irrigation (Ministry of Agriculture, 2013). There are about 500 km of main irrigation canals and 1,100 km of secondary canals, and about 500 km of main drainage channels and 1,500 km of secondary drainage channels. The network originated in the Dutch Colonial days, and after hundreds of years of operation, population growth and increased agricultural demand, the system is operating at reduced capacity.

The drainage and irrigation infrastructure in Guyana is more than 150 years old and is coming under strain. Traditionally this infrastructure has been able to drain up to 1.5 inches of rainfall within a 24-hour period. The NDIA has been upgrading it to cater for 2.5 inches and above, at a high economic cost. Over the past decades unseasonal rainfall has led to breaches and over-topping of many of the conservancies giving rise to excessive flooding in areas such as East Coast and West Coast Demerara and to a lesser extent on the Essequibo Coast. This has caused damage to crops and loss of livestock as well as damage to property. Breaches in the EDWC can occur also during periods of drought, when the water levels drop below dead storage level, causing tension cracks that can deteriorate into major breaches.

Furthermore, poor maintenance of the drainage and irrigation infrastructure over the past few decades has resulted in much of the system not operating at full capacity, and some sections being inoperable. The city’s drainage system depends mainly on 13 sluices, of which 10 were fully functional in early June. Six pumps are used to drain water off the land when the sluice gates are closed, but at the time only one of them was functional. Among the measures suggested to prevent flooding in the future are more frequent openings of the kokers, regular cleaning of canals and ensuring that drainage pumps are in working order.

Measures are already being taken for reducing vulnerability of drainage and irrigation system. The Conservancy Adaptation Project (CAP) was designed in the wake of the 2005 flood to help Guyana adapt to climate change by reducing the vulnerability of this coastal area to catastrophic flooding. Concluded in 2013, the CAP Phase I is an innovative project for Guyana and the Caribbean applying modern technology to support a long-term strategy to reduce flood risk. Several strategic investments have been identified, totalling over USD 123 million, that include rehabilitation of key drainage relief channels and improved conveyance within the EDWC, strengthening of the EDWC dam and various investments in the east coast drainage systems, including the construction of the Hope Canal, which will drain into the Atlantic Ocean, reducing the volume of water passing through the Madewini and Lamaha sluices. The drainage capacity of the EDWC is also being improved through the construction of the new Hope Canal and head regulator, and through the rehabilitation and widening of the Cunha Canal and sluice (co-funded by the GRIF with the World Bank as a partner entity).