State of the Environment Report 2016

Developed by the Government of Guyana with funding from the United Nations Development Programme (UNDP)

ACKNOWLEDGEMENTS

The preparation and printing of this State of the Environment (SoE) Report was funded by the United Nations Development Programme and executed by the Environmental Protection Agency (EPA) in collaboration with the Ministry of Natural Resources (MNR). The foresight of the MNR and the UNDP in conceptualizing the Project to develop this Report must be commended. Further, the MNR provided oversight and coordinated the Project to bring it to successful completion, while the EPA supported the Consultants both with its insights and with coordination of data collection.

This SoE Report is the product of dedicated efforts of professionals within Government Agencies and Ministries, Non-Governmental Organisations, Private Sector, and the University of Guyana. Among the contributions were verbal and written inputs towards the preparation of different Chapters and the Report in general. In addition, numerous persons participated in the stakeholder meetings which helped to determine the most relevant and critical environmental issues to be covered in the SoE.

The work of the Consulting Firm AAE which was engaged to prepare the Report under the Project, is also acknowledged. AAE was able to meaningfully engage the relevant stakeholders to plan, streamline and develop the Report. The AAE's approach of co-authorship of chapters of the Report by professionals from various government sectors and NGOs will no doubt result in stronger valuing and ownership of the data contained in this Report.

PREFACE

The economy of Guyana and the livelihoods of her people largely depend on the utilization of her rich natural resource base. This resource base is increasingly under pressure from human activities, resulting in environmental degradation, depletion, and impacts on human health. It is, therefore, imperative that Guyana ensures the sustainable use, effective management, conservation, and protection of its natural resources and the environment. One of the key challenges for intervention in the natural resource sector is a lack of up-to-date information and baseline data to drive risk-informed decision-making at all levels. Existing information is often out of date, too general in coverage and rarely centralized. In a climate of limited human and financial resources, maximizing synergies and avoiding duplication of effort is critical to the smart allocation of both funds and time.

A State of Environment Report presents a critical analysis of the current specific condition of the environment; the pressures and the drivers; the management interventions initiatives and systems in place to address environmental concerns, and their impacts. The Report captures and provides an overview of the current policies, institutional capacities and environmental co-operation experience with clear recommendations for the integration of the environment in the economic and others sectors; it offers important tools for providing up-to-date and accurate information for decision-making and monitoring, as well as reports on progress made towards achieving sustainable development.

Through the State of Environment Report, UNDP supports strategic planning, decision making and monitoring with respect to sustainable use of natural resources. The Strategic Framework for the Ministry of Natural Resources and the Environment 2013-2018 was used to provide direction and inputs to the preparation of the Report. Several key points made in the Report are worth emphasising: i) Implementation of a multi-faceted environmental governance approach to increase participation of impacted stakeholders and to increase stability in the institutional frameworks; ii) formalising the system to strategically integrate biodiversity conservation and management into sectoral and cross-sectoral plans, programmes and policies; iii) establishment of an overarching operational and administrative organisation, such as a National Water Agency, with responsibility for all water management matters; iv) finalise and operationalise the Draft National Waste Management Strategy and implement the Regional Waste Management Plans; and, v) continue and deepen ongoing efforts to better coordinate the exploitation and use efficiency of natural resources.

UNDP commends the process of broad stakeholder engagement that was used during the compilation of the Report that could ensure that this document is a) widely utilized, and b) as complete as possible with regards to its content. Moreover, broad stakeholder engagement on the formulation of the Report will help to drive inter-stakeholder communication and coordination with respect to environmental initiatives and projects in Guyana. This should be useful in avoiding duplication of activities and ensuring greater synergy for the future.

The State of Environment Report is timely in contributing to the formulation of the Green State Development Strategy and Guyana's roadmap for Agenda 2030 to achieve the Sustainable Development Goals. Formulating projects related to sustainable development in Guyana will benefit from the State of Environment Report, which serves as a central repository for the latest available data in the environment and natural resources sectors. UNDP commends that regular comprehensive updates will ensure that this document never outlives its use.

Mikiko Tanaka
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May 2017

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SECTION 1

Introduction, Drivers and Profile

INTRODUCTION

This State of the Environment Report (SoE Report) was commissioned by the Government of Guyana and UNDP in order to obtain a central repository of the latest available data in the environment and natural resources sector. This repository and analysis of current information intends to facilitate the identification of information gaps, point towards areas in need of further research and highlight significant matters that need to be tackled by government institutions.

The SoE Report has been developed using the DPSIR framework (Drivers, Pressure, State, Impact, Response) methodology. As described in Figure 1, the DPSIR framework provides an ideal platform to identify the links between human activities and the state and trends of the environment and to show how such changes in the environment are positively and negatively affecting human well-being.

The production of this SoE Report consisted of different phases, all of which included significant stakeholder participation. During the first phase of recompilation of existing information, there was participation from government and non-governmental actors and international organizations with presence in the country. A second phase of preliminary information analysis, took place before the participatory consultation workshop, conducted in February, 2016.

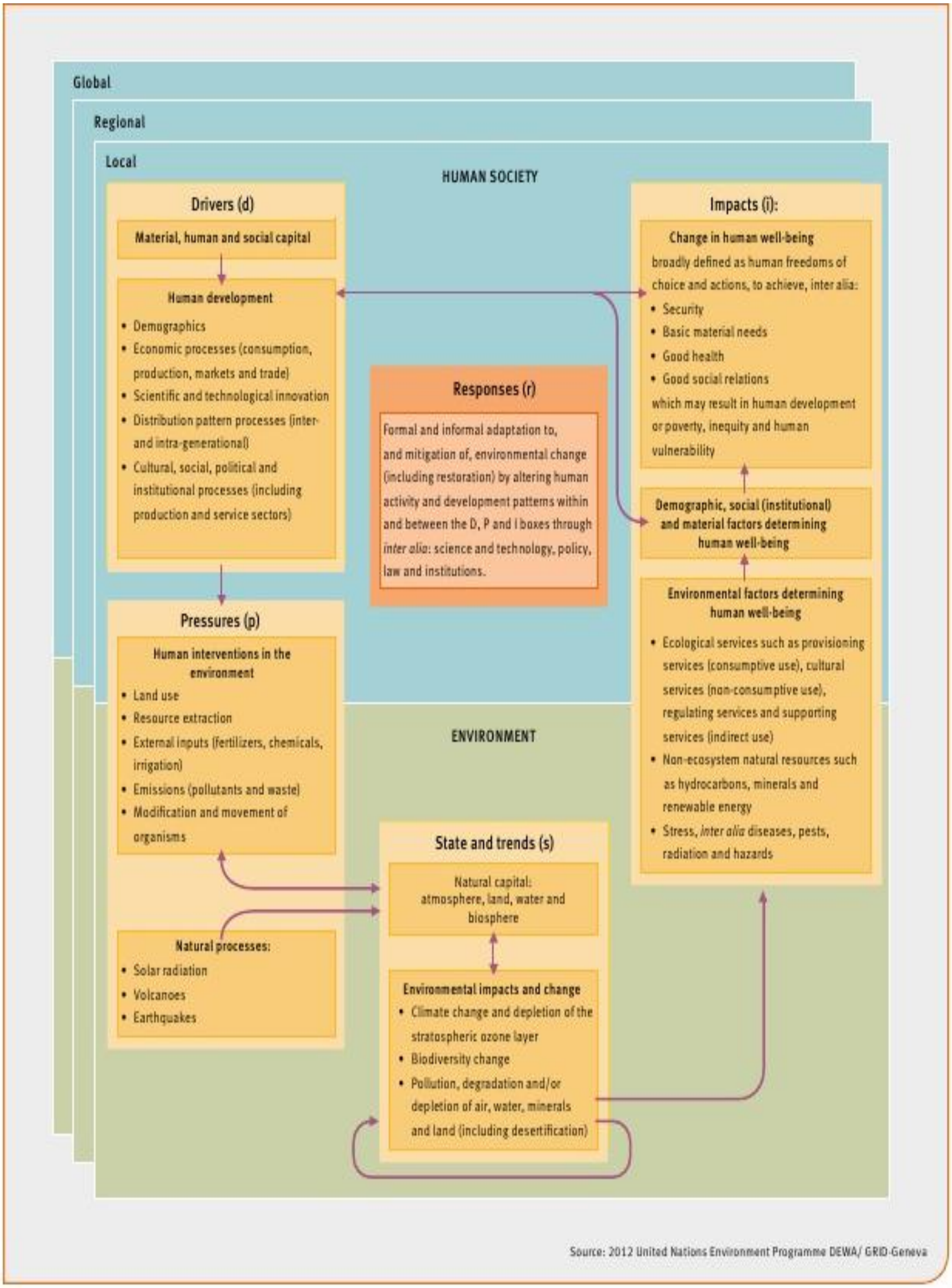
The consultation workshop, represented an opportunity to identify new information sources and documents. With the help of participants, information shortfalls were addressed and new information was suggested to be integrated in the analysis.

During the consultation workshop, the main environmental issues for Guyana and for inclusion in the SoE Report were identified. This workshop was also key for the finalization of the structure of the SoE Report and identification of the major Drivers, Pressures, Trends, Impacts and Responses (DPSIR) for each of the prioritized sectors. Through a participatory methodology (see GEO Resource Book 2007), the participants navigated through the DPSIR and provided the backbone for this Report.

The consultation workshop was also a milestone in relation to the identification of key contributions to the Report. One of the characteristics of this Report is the wide participation by government and non-government actors in the drafting process. More than fifteen (15) authors have submitted information, drafts, figures, maps, data and other resources, making this report a collective effort by different actors related to the environment in Guyana.

In addition, during the review process, government, non-governmental organizations and all stakeholders had the opportunity to provide comments and suggest the inclusion of new material to this Report.

Figure 1. The GEO-5 DPSIR conceptual framework



The Report is divided in two Sections.

Section 1 focuses on the main drivers of environmental change in Guyana. Drivers are described in the Resource Book as "indirect or underlying drivers or driving forces and refer to fundamental processes in society, which drive activities having a direct impact on the environment"

This Section is a summary of the main environmental issues in the way of a country environmental profile and it provides the basis for the analysis in the rest of the chapter. In Section one, the links between socio-economic drivers and environmental change are identified for their further development in Sections 2 and 3. Climate Change, a key environmental driver for Guyana and Waste, a priority issue identified in consultations, are included in this Section.

Section 2 is centred on pressures, trends and impacts on the sectors prioritized during the consultation workshop. The analysis in this Section of the Report is conditioned by data availability. Most up-to-date existing data was used for this Report and is some cases e.g. water, existing information had to be re-processed in order to be analysed. The identification of key data gaps is also an important element of this Section.

Another key component of Section 2, and of the Report in general, is the analysis of how environmental change is affecting the different components of human well-being (health, economy, environment and society).

Section 2 also includes existing sectorial responses to changes in the state of the environment. Forest loss, for example, may already be the subject of specific legal or policy responses. In this Section, for each component of the environment, existing sectorial (e.g. forestry, agricultural) response (s) will be described.

Section 2 finalizes with general conclusions and recommendations.

CHAPTER 1

Socio Economic Context - Profile

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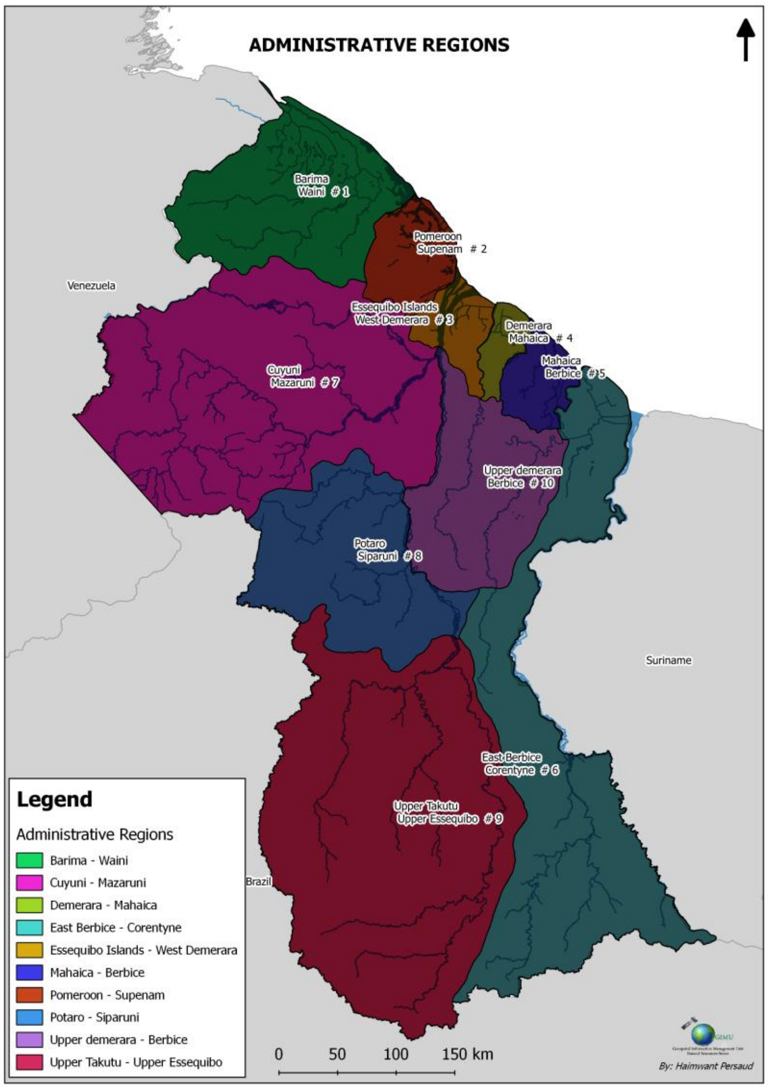
GEOGRAPHIC AND SOCIAL CONTEXT

GEOGRAPHICAL CONTEXT

Guyana´s land territory of 215,000 km^2, is situated entirely within the Guiana Shield, in northern South America. It borders with Venezuela to the west, Brazil to the south, Suriname to the east and has more than 400 km of coast on the Atlantic Ocean to the north east. The country is divided into ten (10) Administrative Regions (Figure 1.1), and has four distinct geographic landforms[1].

Figure 1.1: Administrative Regions of Guyana. Source MNR, 2016



[1] Some classification systems describe five physiographic regions (Coastal Plain; Interior Alluvial Plains and Low-lying Lands; White Sand Plateau and Older Pedi plains; Crystalline Shield Uplands; and Highlands, Mountains and Plateau.

NATURAL REGIONS

To the north east, lies a flat coastal belt (Coastal Plain), where most of the agricultural activities are concentrated. This coastal belt, represents 4.3 per cent of the country´s territory and is the smallest of its four (4) natural regions. This narrow belt ranges in width between eight (8) and sixty-five (65) km and holds most of the agricultural production of the country. Most of the Coastal Plain is below sea level and has a system of sea defences and drainage and irrigation canals that protect the area from flooding.

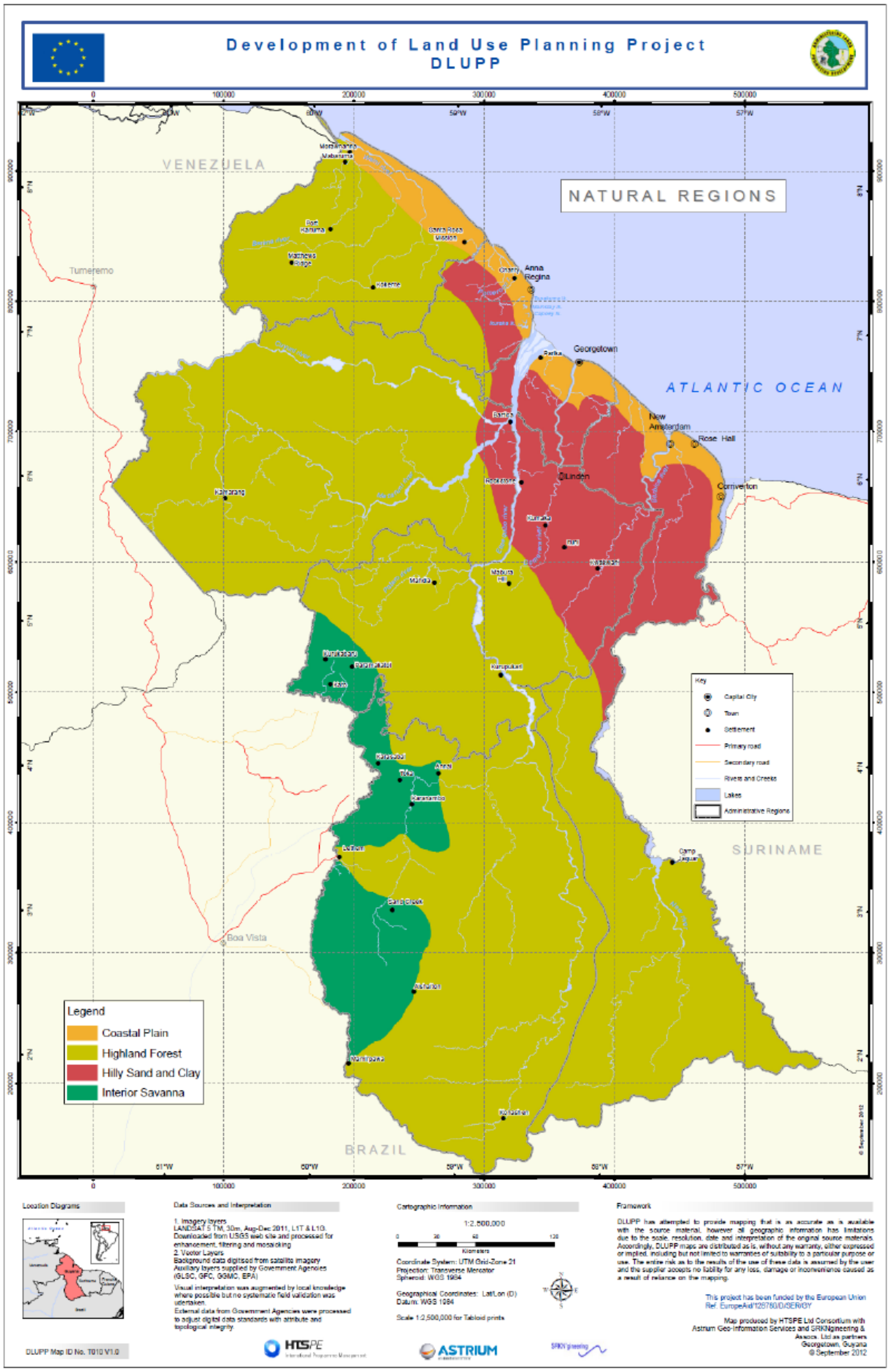
Below the coastal plain to the east, lies a sand plateau (Hilly Sand and Clay Region) consisting of gently undulating landscapes from fifteen (15) to one hundred and fifty (150) m above sea level and representing 13.7 per cent of Guyana´s territory. This region with its sandy soil is very low in nutrients and one of the most vulnerable ecosystems of Guyana (EPA 2014).

The Forested Highlands is the most extensive natural region of the country representing seventy-four per cent (74 %) of the country, and is a densely forested, and in many places, almost inaccessible. Mountain elevations range from two hundred to twelve hundred (200 to 1200) m, with fast interflowing rivers, creating waterfalls and a dissected terrain.

The Interior Savannahs are located west of the Forested Highlands, bordering with Brazil and occupy eight per cent (8 %) of the country. These savannahs are flat with wetlands to the north, during the Amazonian wet season. The Northern Savannah plain ranges in altitude from one hundred to more than nine hundred (100 – 900) meters at its highest peak. The Southern Savannahs are flat plains ranging from one hundred (100) metres to over seven hundred (700) meter plains, see Figure 1.2.

Guyana is an Amerindian word meaning “The Land of Many Waters”. The three main river systems in Guyana are the Essequibo, the Demerara, and the Berbice. They all drain northwards into the Atlantic Ocean and form the three distinctive freshwater ecoregions that exist in Guyana (EPA 2014). These are the Orinoco Delta, the Essequibo and the Guianas.

Figure 1.2 Natural Regions of Guyana. Source: GL&SC, 2013



CLIMATE

Guyana´s tropical climate has two wet and two dry seasons [2]and is characterised by high but variable rainfall, high humidity and a small temperature range. Annual rainfall varies within the country. The coastal region has an average rainfall of 2,200mm, precipitation inland averages 2,800mm and the highest precipitation occurs in the Upper Mazaruni Mountains area with over 4,000mm (see Figure 1.3). Temperature ranges are between 25 and 27.5 degrees Celsius, except in upland regions, where the range is lower, being between 20 and 23 degrees Celsius. Section 2.2 provides additional details with reference to Guyana's climate.

SOCIO ECONOMIC AND DEMOGRAPHIC CONTEXT

Guyana, the only English-speaking country in South-America, became an independent Nation in 1966. Its ten (10) administrative regions are governed by Regional Democratic Councils (RDC's) responsible for the delivery of health and education services. It also has nine (9) municipalities and seventy-six (76) Amerindian Village Councils. Despite being situated in South America, Guyana has stronger links with English-speaking Caribbean countries and is a member of the Caribbean Community (CARICOM), which has its Secretariat in the Capital City, Georgetown. Guyana is also a member of Unión de Naciones Suramericanas (UNASUR) and Amazon Cooperation Treaty Organisation (ACTO).

For the past seven (7) years, Guyana has witnessed an unprecedented growth in Gross Domestic Product (GDP). The highest rates were experienced in the early 2010s and despite the recent decrease in rates of growth, GDP has continued to grow at high rates. As seen in Figure 1.4, this persistent growth has increased Guyana's GDP per capita to the point of narrowing the gap with Caribbean states, which was six (6) fold in the early 2000s and decreasing to just over two (2) fold in 2015.

Given the high dependence of Guyana´s economy on natural resources (mainly agriculture production), this significant growth represents an increase in pressure on the environment. This growth also drives change in other sectors, for example, waste collection data shows a ten percent (10%) increase between 2008 and 2015, representing a growing pressure on existing waste treatment facilities, as it is described in Chapter 3.

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[2] There is an Amazonian influence in southwest Guyana, where there is one wet season and one dry season.

Figure 1.3 Climatic Regions of Guyana. Source, GL&SC, 2013

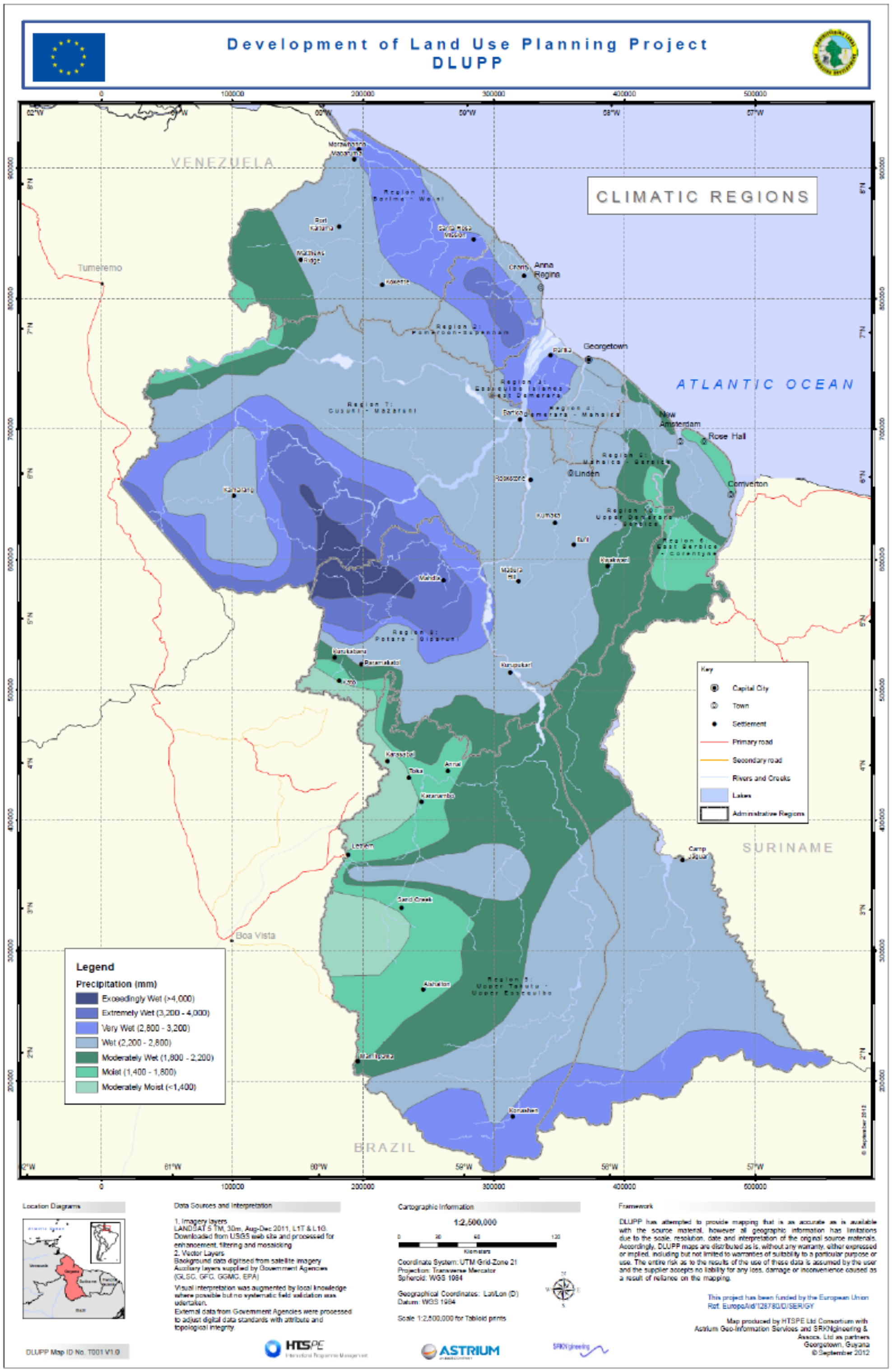
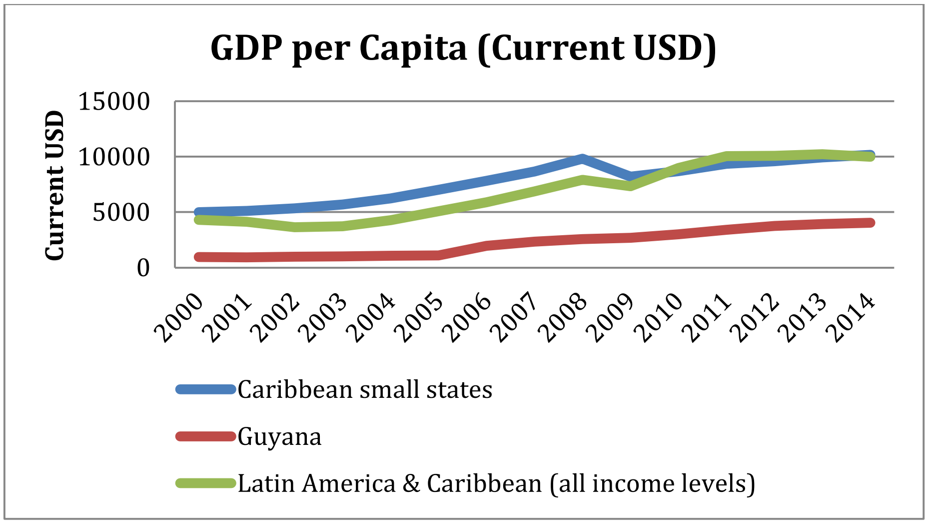


Figure 1.4 GDP Per Capita. Source: World Bank (World Development Indicators)

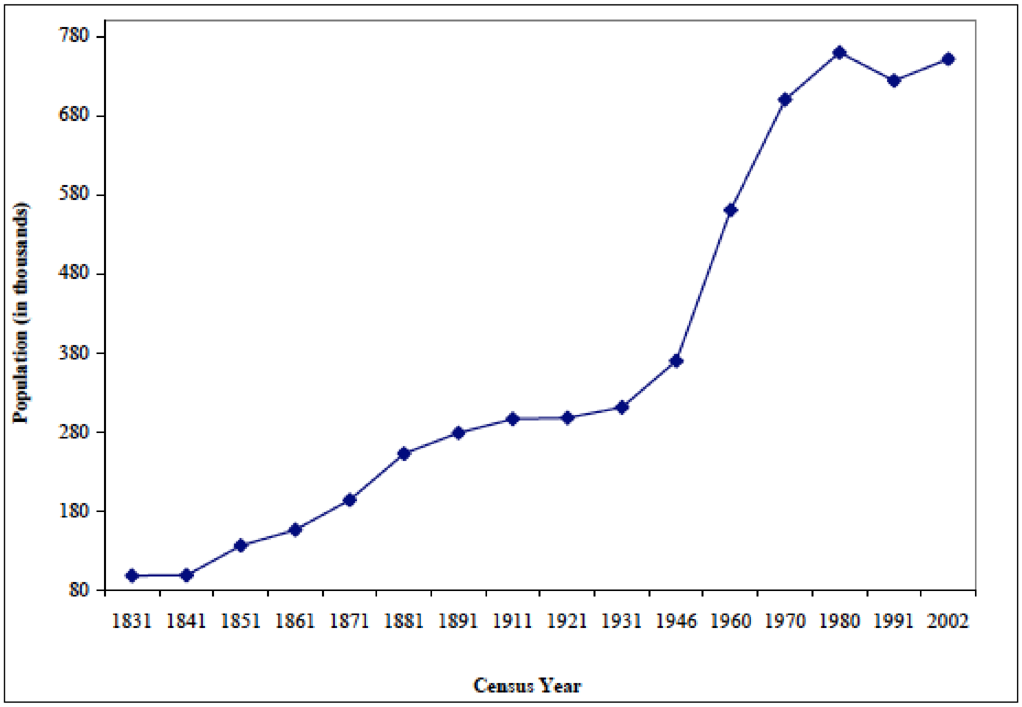


Guyana's economic performance in the past years has been supported by favourable external conditions and rising foreign direct investment, particularly in natural resources. The challenge is to maintain economic growth over the next years in the context of a sustainable natural resource management strategy that does not jeopardize long-term economic development.

DEMOGRAPHIC CONTEXT

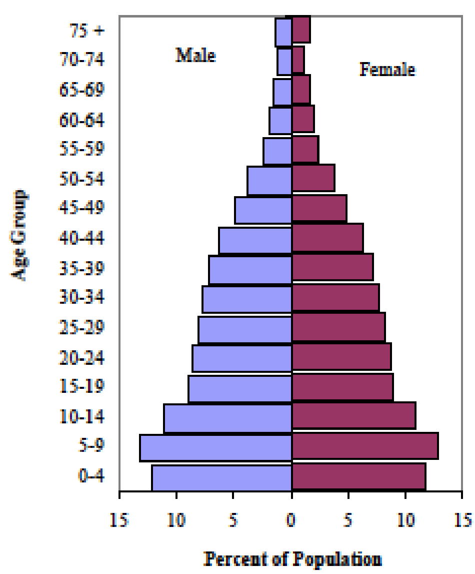
Most of the information presented in this section comes from the preliminary report of the 2012 Census, published by the Guyana Population and Housing Census (Bureau of Statistics, 2014). Guyana conducted Censuses during 1980, 1991, 2002 and 2012 and has published the Census Reports. Full data from the 2012 Census, has not yet been released, therefore, information on ethnicity, distribution by age and other demographic facts was derived from the 2002 Census.

Figure 1.5 Population of Guyana. Source: BoS, 2014



The population of Guyana had its major growth in the post war years (see Figure 1.5), coinciding with the worldwide post-war baby boom. The population decrease registered in the 1991 Census, is consistent with emigration flows, which peaked during the 1980s. According to the last two Censuses, the population of Guyana has been growing since, and is currently at 747,884. The population pyramid from the 2002 Census shown in Figure 1.6, shows a recovery from the 1980s migration.

Figure 1.6 Population Pyramid from 2002 Census. Source: Bureau of Statistics



Population density is 3.5 persons per square kilometre but varies significantly throughout the country; population distribution also varies (see Figure 1.7). The coastal region currently holds eighy-nine per cent (89%) of the total population but this percentage has been decreasing during the past three (3) censuses (see Figure 1.7). The hinterland region has been growing in absolute numbers and percentage for the past three (3) Censuses.

Figure 1.7 Population Living in Coastland and Hinterland. Source: Bureau of Statistics 2014

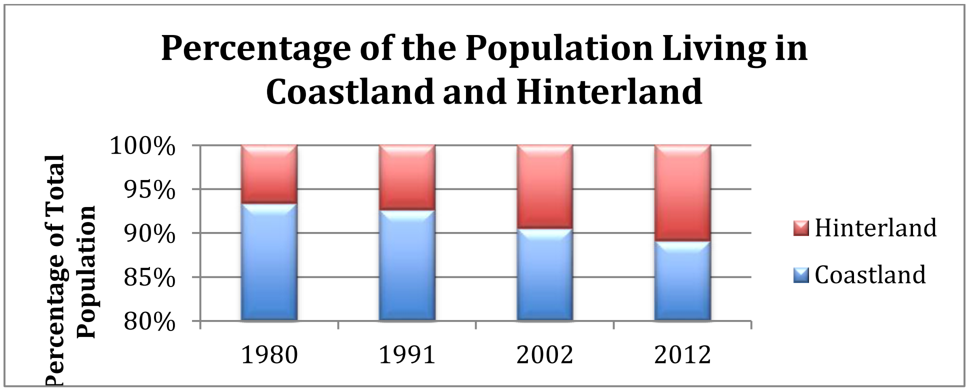
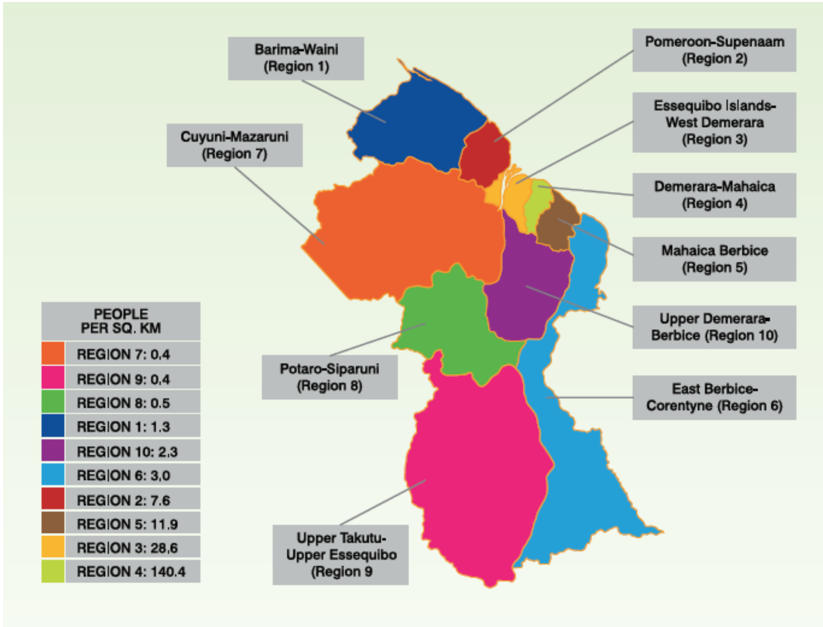


Figure 1.8 shows that the coastal region, which depending on the definition, ranges between a maximum width of 65 km and a minimum width of 8 km, and represents a relatively small region (7.4%) of Guyana´s land area, but holds the majority of its population (89%). This concentration of population in the coastal area is typical of the Latin American region and increases vulnerability to climate change and sea-level rise. In the case of Guyana, this is exacerbated by the fact that the coastal region lies approximately 1.5m below sea level at high tide. Chapter 2 further analyses the vulnerability of the population and presents the potential impacts described for the region by some of the climate change scenarios.

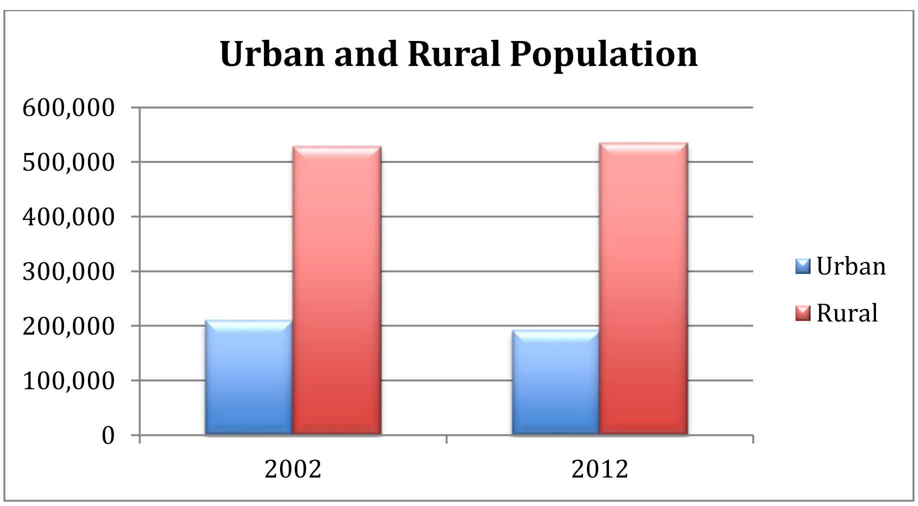
Figure 1.8 Population Density by Region. Source: Bureau of Statistics 2014



URBAN

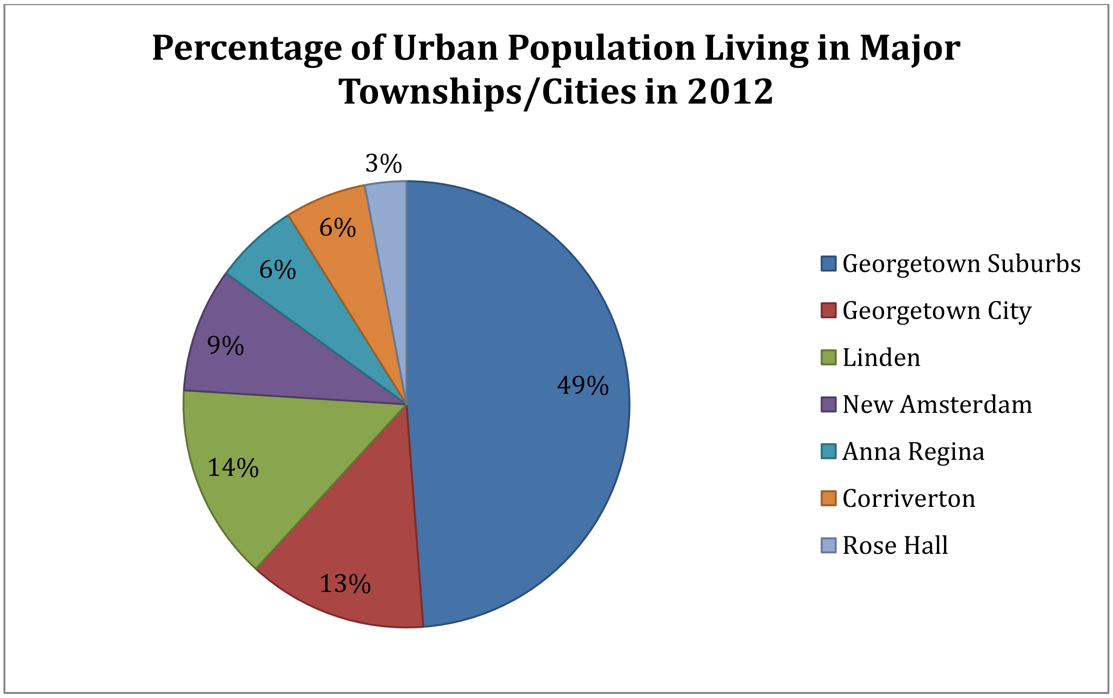
Guyana's population remains as mainly rural with seventy-three (73%) of the population living in rural areas. Urban population has slightly decreased since the last Census, both in absolute numbers and in percentage of total population (Figure 1.9).

Figure 1.9 Urban and Rural Population of Guyana. Source: Bureau of Statistics 2014



Within the nine (9) areas that Guyana has officially classified as urban townships (Anna Region, New Amsterdam, Rose Hall, Corriverton, Linden, Georgetown city and Georgetown suburbs Bartica, Mabaruma, Lethem), the population distribution of six (6) of them is shown in Figure 1.10.

Figure 1.10 Urban Population Distribution. Source: Bureau of Statistics 2014.



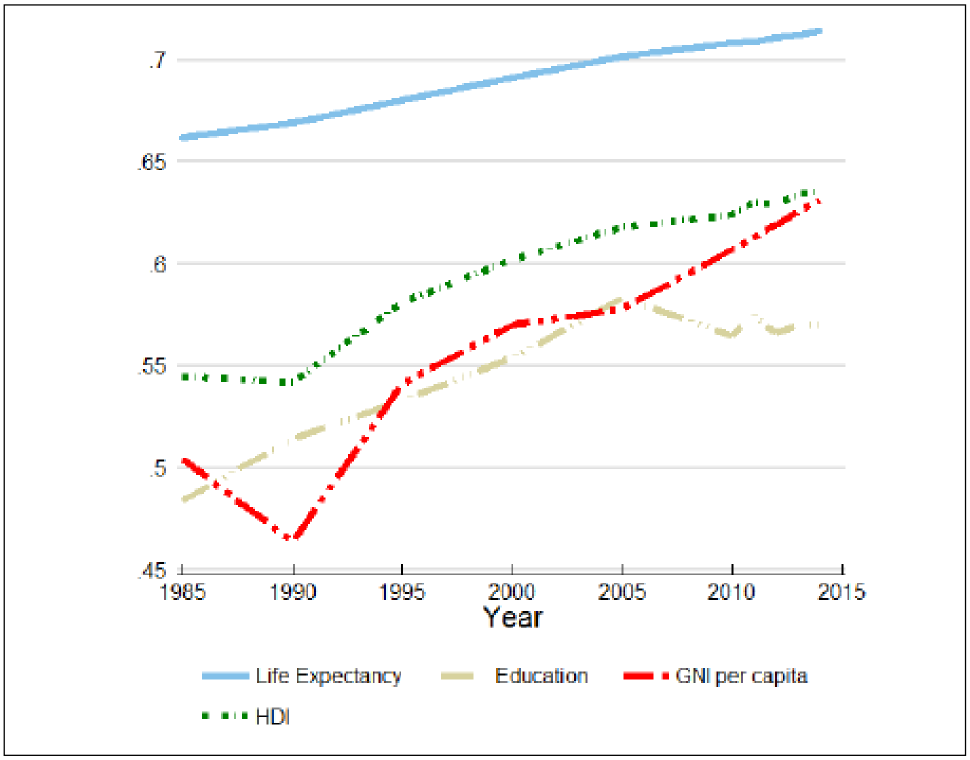
The population of Guyana is ethnically heterogeneous and includes a native Amerindian population and descendants of immigrants who arrived in the country as slaves or indentured labourers (Bureau of Statistics 2002). According to the 2002 Census, East Indians represent fory-three per cent (43.5 %) of the population followed by persons of African Heritage (30.2 %), people of mixed heritage (16.7 %) and Amerindians (9.2 %). These figures may change based on the results of the 2012 census.

POVERTY AND EMPLOYMENT

According to the MDG progress report (Ministry of Finance Guyana 2011), *"Guyana has made very good progress towards eradicating extreme poverty and hunger"* (Ibid: V). The proportion of people living in extreme poverty in Guyana fell from 28.7 per cent to 18.6 per cent between 1993 and 2006 (Ministry of Finance 2011). During the same period, the percentage of people living in moderate poverty fell from 43.2 per cent to 36.1 per cent.

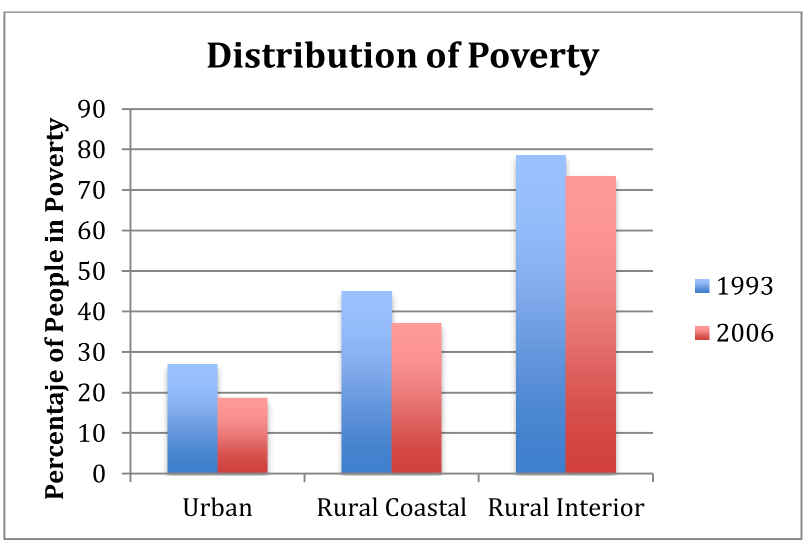
Although there is no recent data on poverty rate, the recent publication of the Human Development Report, 2015, provides valuable information on the Human Development Index (HDI), as well as, other components that are presented in Figure 1.11 (UNDP 2015).

Figure 1.11. Trends in Guyana´s HDI component indices 1985-2014. Source: UNDP 2015



There are significant geographical and generational differences in poverty rates. The most remarkable differences are between urban and rural regions and between the coastland and the hinterland. As Figure 1.12 shows, poverty in the rural interior is significantly higher than in the rest of the country. Younger aged cohorts also have higher poverty rates. In 2006, 33.7 per cent of people aged 16-25 were under the poverty line, almost 10 points more than people older than 41 (24 per cent under the poverty line) (Ministry of Finance 2011).

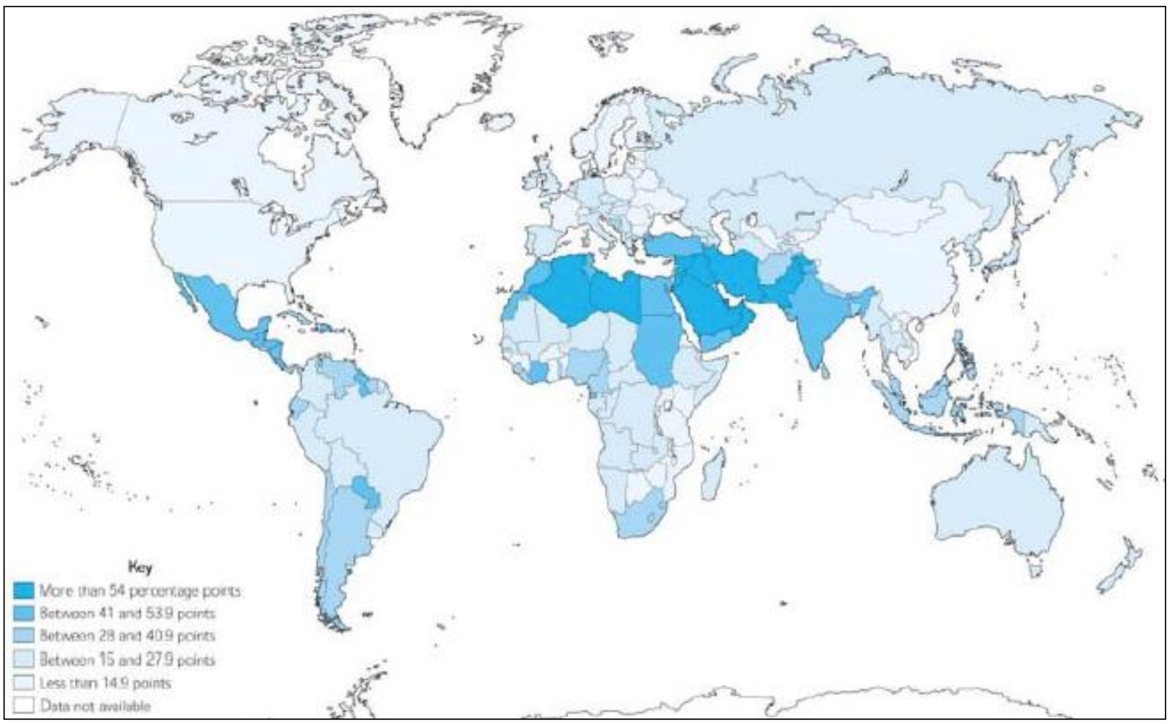
Figure 1.12. Distribution of Poverty. Source: Ministry of Finance



On the other hand, non-significant differences were found between the three major ethnic groups (Afro-Guyanese; Indo-Guyanese and Mixed groups). Although a higher proportion of Amerindians remain under the poverty line, these differences are probably explained by the geographical distribution of this group and therefore explained by location and not by ethnicity (Ministry of Finance 2011).

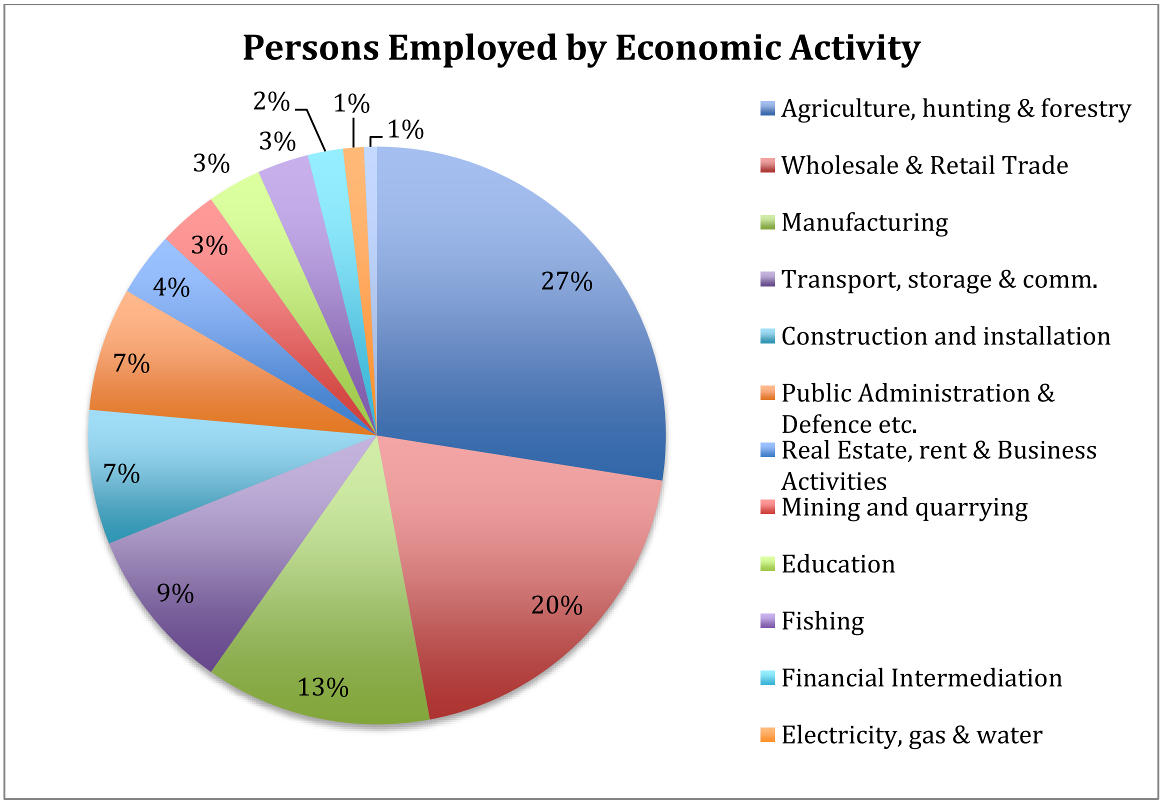
The employment rate was 10.7% in 2006, while female unemployment rate was 13.9 for that same year. However, the number of females in the employed labour force was less than half the number of men in the employed labour force in 2006 (73.000 females and 162.000 males). This represents a large gap in labour force participation rates of males and females and is among the largest ones in the region (see Figure 1.13)

Figure 1.13 Global Gaps in Labour Force Participation Rates of Males and Females. Source ILO



The distribution of persons employed by economic activity shows the relatively important weight of the primary sector, particularly agriculture, which together with hunting and forestry account for 27 per cent of the labour force with the Guyana Sugar Corporation (GUYSUCO) being the largest employer in the country (Government of Guyana 2015a), see Figure 1.14. If the rest of the primary sectors (mining and fishing) are included, the share of the labour force is almost 40 per cent. This figure does not account for the indirect jobs related to the primary sector in the transportation, financial and manufacturing sectors.

Figure 1.14 Persons employed by economic activity. Source: GoG, 2015a.



INDIGENOUS PEOPLES

According to the United Nations Permanent Forum on Indigenous Issues, an official definition of the term "indigenous" has not been adopted by the UN-system body because of the wide diversity of indigenous peoples in the world. The UN-System has, however, developed an understanding of the term based on the following seven (7) elements: (i) self-identification as indigenous peoples at the individual level and accepted by their community as their member; (ii) historical continuity with pre-colonial and /or pre-settler societies; (iii) strong link to territories and surrounding natural resources; (iv) distinct social, economic and political systems; (v) distinct language, culture and beliefs; (vi) form non-dominant groups of society; and (vii) resolve to maintain and reproduce their ancestral environments and systems as distinctive peoples and communities.

The Indigenous Peoples (IPs) in Guyana's context, are the Indigenous Amerindians; the original peoples of Guyana and have been found across the country dating back to about one hundred and fifty (150) years (CADPI, 2012, NDS, 1996). The Amerindians have a rich and diverse cultural heritage and can be found predominantly in the hinterland regions.

GEOGRAPHIC DISTRIBUTION

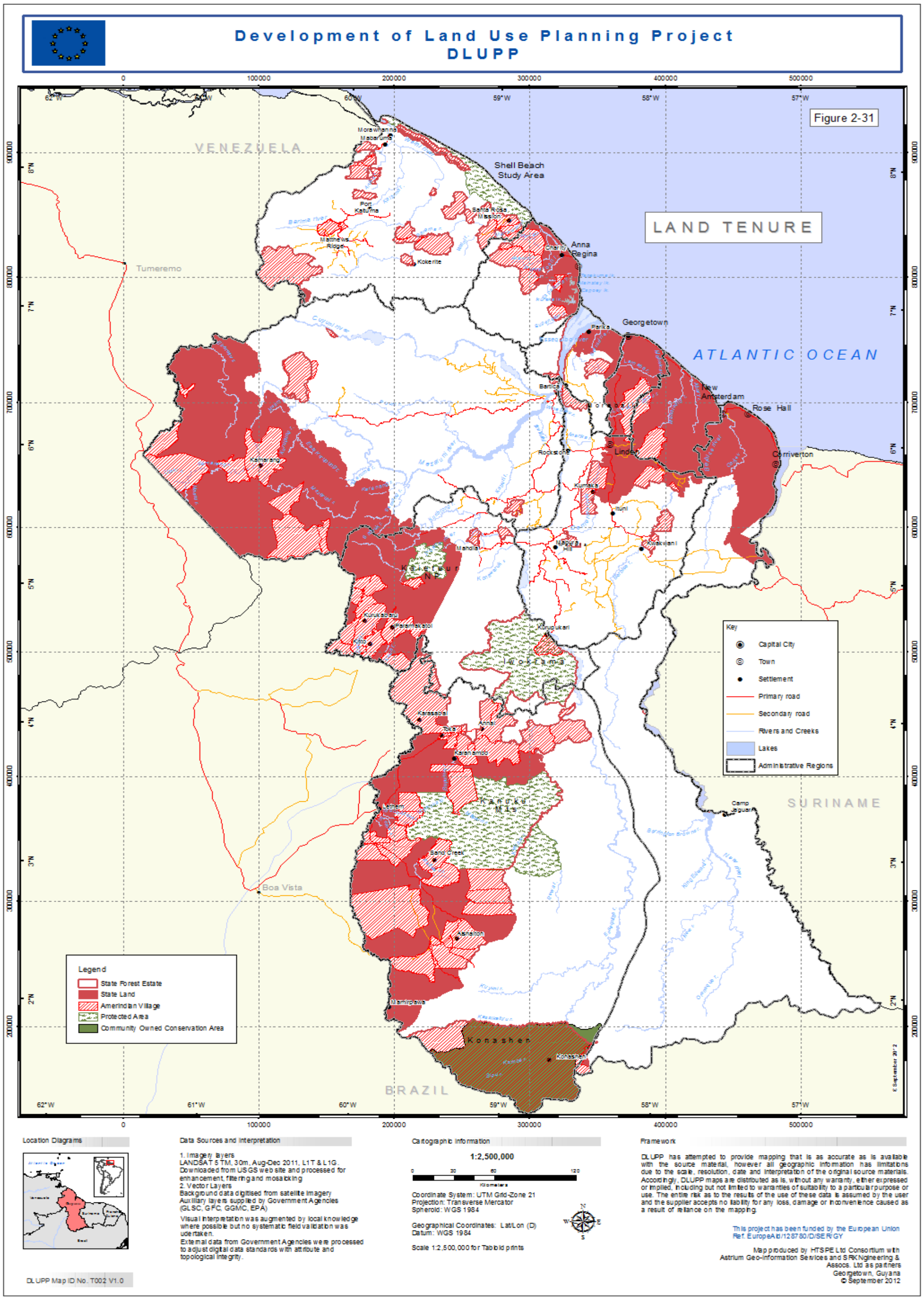
According to the Bureau of Statistics (BoS) 2002 census, the Amerindian population in Guyana is 68,675 comprising almost 10 per cent of the 2002 population (751,223)[3] (BoS, 2007; EPA, 2009). The population increased by 22,097 or by 47.3 per cent over a 12-year period (1991-2002) (BoS, 2007) and in recent times, the country has been recognised to have the largest population of Indigenous Peoples in the Caribbean, according to the Ethnolinguistic Atlas of Indigenous Peoples of Latin America (CADPI, 2012). The Amerindians are heterogeneous as a result of groups traditionally being distinct by languages and natural environment (NDS, 2001-2010). Amerindians in Guyana are of nine (9) Nations[4] mainly found in Administrative Regions 1, 7, 8, 9 and to a lesser extent in Regions 2, 3, 4 & 10 (BoS, 2007) and comprise more than three-quarters of the populations of Regions 8 and 9 with 75.9 per cent and 89.2 per cent, respectively, and representing two-thirds of the population of Region 1 or 62.2 per cent (BoS, 2007), refer to Figure 1.15.

The Amerindian Act 2006, provides for Amerindians to obtain legal titles to lands they occupy. Amerindians, therefore, have ownership of approximately 3,316,000 hectares (GFC *et al*, 2015) (33,160 km^2) or over 15 per cent of the total land area of the country, making this group the second largest land holder after the State. It is important to recognise that while Amerindians have legal ownership of 3,316,000 ha of land, through traditional practices, they are also able to access and use resources outside titled lands.

There are approximately one hundred and sixty-nine (169) Amerindian Communities, including Satellites, Settlements and Villages where ninety six (96) communities have legal titles to lands they use and occupy (MoIPA, 2016). According to the Ministry of Indigenous Peoples Affairs (MoIPA) (2016), within the ninety six (96) titled communities, there are several sub-communities that may share a single titled land space and Village Council but are sometimes counted as separate communities. The Ministry also recognises a number of 'mixed[5]' settlements where Amerindians reside (MoIPA, 2016).

[3] Data on the distribution of population by ethnicity is not yet available for the 2012 census based on the release of the 2012 population census preliminary report. Data on population composition by ethnicity were sourced from the 2002 census report for this report.
[4] These are the Wai Wais, Macushis, Patamonas, Arawaks, Caribs, Wapishanas, Arecunas, Akawaios and Warraus (MoIPA, 2016).
[5] Mixed settlements according to the MoIPA comprise people of various ethnicities (MoIPA, 2016).

Figure 1.15 Distribution of Amerindian Villages across Guyana. Source: GL$SC 2013



SOCIOECONOMIC CONTEXT

Administration

Titled Amerindian Villages are administered by Village Councils comprising Toshaos or Chief/Captain and Councillors. The Toshaos and Councillors are elected by their respective communities to the Village Councils. The Village Council is the legal local governing mechanism of villages as prescribed by the Amerindian Act, 2006, of which a foundation was provided for, since the passing of the Amerindian Act, 1951. The Amerindian Act, 2006, sets out the provision for the Village Council to be recognised as a body corporate and to discharge its functions collectively thereby giving the Amerindian People the right to self-determination (AA, 2006).

The Council has the power to make its own governing rules to manage and administer the affairs of the village. In doing so, the Village Council can determine who accesses or resides in the community, occupies and uses village lands, the level of protection and sustainable utilization of wildlife inclusive of restrictions on harvesting (fishing, hunting, trapping etc.), and manages agriculture, water supplies, infrastructure and research (AA, 2006).

Further, the Village Council by legislation can determine how to manage village resources and the strategic direction of the village and this can be defined in a community or village plan. The Council can also promote the sustainable use, protection and conservation of village lands and resources therein; encourage the preservation and growth of the Amerindian culture; and protect and preserve the village's intellectual property and traditional knowledge, among others (AA, 2006).

Communities also have governance structures in place at the District level to guide or reinforce the traditional shared systems and jurisdictions and also allow a space to address pertinent issues or collectively agree on issues to be addressed by regional or central governments (David *et al*, 2006). These structures are evident only in Region 9, with the North Rupununi District Development Board (NRDDB) and its equivalent, the South Central District Development Council (SCDDC).

At a national level, the Amerindian Act, 2006, provides a space through the National Toshaos Council (NTC) for Toshaos and selected Councillors to meet at least once every two (2) years[6] to discuss village governance issues, identify priority areas for development and plan at a strategic level for the protection, conservation and sustainable management of village lands and their natural resources therein. It further allows for guidance, advice and recommendations to be provided to the Minister of Indigenous Peoples on a number of issues including

[6] Even though the Amerindian Act stipulates a meeting of the NTC once every two (2) years, the Statutory Body has agreed to meeting annually.

protection of the Amerindian culture, village development and changes to legislation and policy, as well as, their impact on the Amerindian Peoples.

Education

Updated data on the level of education by Regions or ethnicity is currently not available. The Ministry of Education (MoE) publishes summary statistics on enrolment numbers aggregated by types of institution. As such, very little information is available on education specifically for hinterland regions or Amerindians. The BoS in its 2002 Census, presented information on education of the school system in Guyana, and focused mainly on school enrolment, coupled with information on the attainment of primary, secondary or tertiary level education disaggregated by Regions.

The Administrative Regions with the highest population of Amerindians, Regions are 1, 8, and 9. Total net primary enrolment[7] in Region 1 was 3,777 of a population of 4,526 within the primary age range, representing a net enrolment of 83.5 per cent. The total net primary enrolment in Region 8 was 1,395 of a population of 1,654, within the primary age range, representing a net enrolment of 84.3 per cent. In Region 9, 3,295 of the primary-aged population of 3,729 were enrolled, representing 88.4 per cent enrolment (BoS, 2007).

Total net secondary school enrolment[8] in Region 1 was 1,109 of the secondary age population of 2,828, representing a net enrolment of 39.2 per cent for the Region. The total net secondary enrolment in Region 8 was 551 of the secondary age population of 1,243, representing a net enrolment of 44.3. Region 9 recorded a total net secondary school enrolment of 1,301 of the secondary age population of 2,818 representing a net enrolment of 46.2 per cent (BoS, 2007).

The BoS (2007) noted that the hinterland regions (1, 9, 8 and 7), collectively, were found to have the highest illiteracy rates. The report concluded that illiteracy rate ranged from as high as 27 per cent in Region 1 to 15 per cent in Region 7, with a trend of higher female illiteracy than males.

In accordance with the MoE Strategic Plan 2008-2013 and the Education Act (Cap 39:01), the MoE has developed an Amerindian Peoples Plan under the Global Partnership for Education (GPE) that focuses on early childhood education specifically in the hinterland regions and remote riverine areas (MoE, 2014). This plan focused on improving literacy and numeracy outcomes for children at the nursery level and primary Grade 1 through (i) the building of capacity for Nursery and Grade 1 teachers in the hinterland regions and targeted remote riverine areas; (ii) providing resource kits to classes in the listed areas; and (iii) educating parents and caregivers in those areas. Specifically, children attending the two (2)

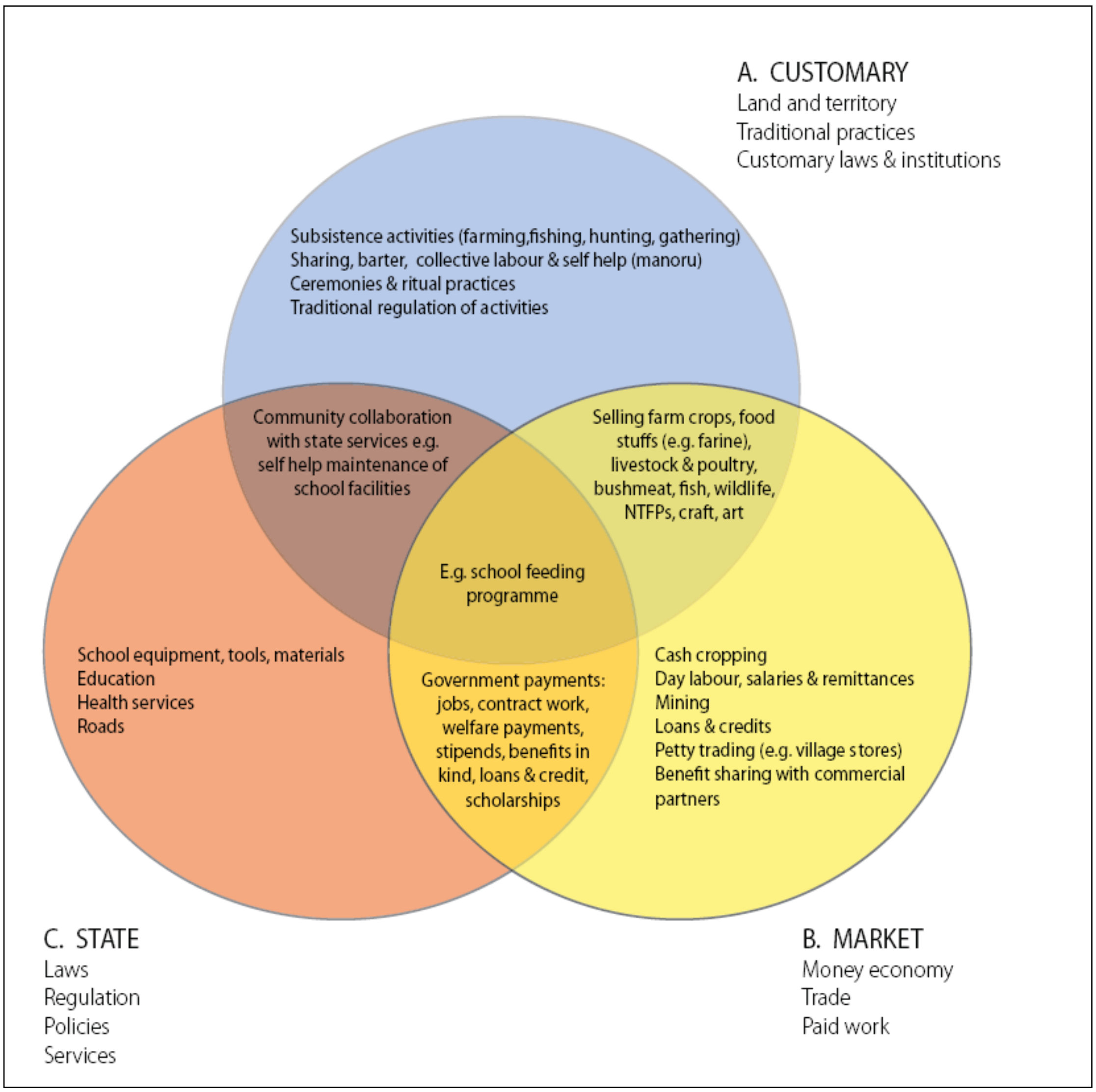
[7] Net primary enrolment for the 2002 census measures the enrolment of the official age group for the given level of education expressed as a percentage of the corresponding population in that age group. The official primary age is 6-11 years (BoS, 2007).
[8] The official secondary age is 12-17 years (BoS, 2007).

years of nursery education and Grade 1, aged 3 years 6 months to 7 years in the hinterland – Regions 1, 7, 8 and 9 and riverine areas in Regions 2, 3, 5, 6 and 10 are expected to benefit (MoE, 2014). Accordingly, this translates to about 8,000 children annually and their families, as well as, 440 nursery and grade 1 teachers.

Economic

Guyanese Amerindians are recognised to have mixed livelihoods or a mixed economy, refer to Figure 1.16. Their livelihood activities are both subsistence and cash-based and the extent to which these vary is based on the level of integration and reliance on the market within communities and across communities and Administrative Regions (Griffiths & Anselmo, 2012).

Figure 1.16 Mixed economy profile. *Source: Griffiths & Anselmo (2012) as adapted from Altman (2006)*



Amerindians core traditional practices are based on rotational farming along with subsistence activities such as hunting, fishing and gathering. Griffiths & Anselmo (2012) noted that the bitter cassava, a staple in Amerindian diet, along with other ground provisions, fruits, fibres are among some of the crops grown. They further stated that traditional farming grounds are an important cultural space for the transmission of ancestral knowledge and skills. Moreover, it was stated that *"subsistence farming, hunting, fishing and gathering activities in the hinterland are often underpinned by extensive tenure and customary land use systems along with traditions of sharing, reciprocity and self-help work that supports indigenous food and livelihood security* (Griffiths & Anselmo, 2012).

Amerindians generate income mainly through employment with the private enterprises in the surrounding areas, activities supported by government agencies and community enterprises. Griffiths & Anselmo (2012) found that an average of one to ten percent (1- 10%) of households in Amerindian communities have members with full-time jobs such as teachers. Additionally, many Amerindians are also involved in forestry and mining activities or other cash-based enterprises that allow for the sale of raw and processed foods crops (cassava and cassava bread, farine, ground provisions, pines, peanuts, peanut butter cocoa sticks, casareep), livestock and fish and crafts. They are also employed as labourers, drivers, boatmen and guides for tourism or research based activities (Griffiths & Anselmo, 2012; NDS, 2001-2010).

In recent years, community enterprises have developed and flourished in many Amerindian Communities as additional sources of livelihood. Communities collaborate or partner either with the private sector or non-governmental organisations (NGO's) to develop enterprises, refer to Box 1.1. This not only provides a source of income through employment but brings the community together and fosters the development of additional skills and expertise to successfully manage the enterprise. Some examples, especially in the ecotourism sector, are joint ventures with Wilderness Explorers, Iwokrama and the Fairview Community to manage the Canopy walkway and Lodge and Surama Ecotourism community enterprise.

Box 1.1: Enabling Local Sustainable Development through Community-based Enterprises

Introduction

Globalization and growing interconnectivity introduces new opportunities and threats to intact landscapes. Improved accessibility can improve trade by reducing the cost to move people and goods but can lead to major negative social and environmental impacts (CI-Guyana and CI, 2014). Reduced trade costs within, can put biological and cultural assets at risk by improving the prospects for potentially unsustainable conversion and extraction for economic gains within important landscapes. Local enterprises that derive livelihood, economic and other benefits while maintaining natural and cultural wealth can help better secure sustainable development in these contexts. These enterprises fit well within the socioecological and policy context of the landscape and therefore fostering their growth is essential to enhance sustainable development in biologically and culturally important landscapes. This is especially important in the context of national policies for green development (Jordan, 2015).

Rupununi Low Carbon Livelihood Project

CI-Guyana is testing ways to strengthen and create sustainable community-based enterprises (CBEs) in the Rupununi, one of the most biologically and culturally important regions of South America. This initiative focuses on nature-based tourism, agriculture and related enterprises as stakeholders identified them as having the best prospects for addressing the needs of the Rupununi whilst remaining within the ecological and social limits of the region (CI-Guyana, 2013, 2015). The project aims to enable CBEs to (1) enhance and ensure sustainability of livelihoods; (2) grow village, regional, and national economies; and (3) maintain the capacity of the Rupununi to provide environmental services such as climate regulation and biodiversity habitat for future generations (CI-Guyana, 2013).

Results/Outputs

Specific strategic interventions to enhance livelihoods by improving profitability and competitiveness of CBEs were identified using the Participatory Market Systems Development (PMSD) approach (Figure 1) (Practical Action, 2014). The PMSD approach aims to develop sustainable enterprises at scale in an inclusive manner based on participation, systems thinking and facilitation, and it has been used in many parts of the World (Practical Action, 2016a). Project interventions have primarily focused on the provision of technical support and capacity for sustainable business planning and development, enhancing networking amongst enterprises as well as between CBEs and potential markets, and improving access to affordable financing (CI-Guyana, 2015). The support of a local financial institution – the Guyana Bank for Trade and Industry (GBTI) – and the Government of Guyana has provided enterprises in the region with access to business financing for sustainable ventures on preferential terms (CI-Guyana, 2014).

Challenges and Lessons

Indigenous and local communities in the Rupununi have shown strong interest in developing sustainable enterprises and sustainable development of the region. The PMSD approach provided an effective means of identifying hurdles to the success of sustainable CBEs across the entire system, including policy and regulatory constraints. The integration of civil society, private sector and government stakeholders for sustained provision of technical support, capacity development and financial services is proving to be critical for the long-term success.

Conclusion

The approaches employed thus far to enhance the prospects of sustainable enterprises in the Rupununi have shown great promise. Further exploration and expansion of their application can help to effectively downscale achievement of national low-carbon green sustainable development to local contexts.

Health

Recent health statistics disaggregated by region or ethnicity is not available. Although dated, the National Development Strategy for the period 2001 to 2010 presented an overview of the health conditions related to Amerindians that in some ways still pertains today. It noted that women and children, especially, are vulnerable to diarrhoeal-related diseases due to unacceptable water and sanitation conditions (NDS, 2001-2010), as well as, respiratory illnesses and malaria. The NDS noted concerns with issues of teen pregnancy and maternal health.

The use of pit latrines in the hinterland still pertains today. As such, there could be increased cases of diarrhoea related illnesses during the rainy season, especially if the runoff from the ground, transfers faecal matter into the rivers that are utilized as a source of potable water, without purification or treatment. This becomes evident ever so often, with the reported cases of diarrheal outbreaks in Region 1 in recent years.

Moreover, hinterland communities depend on creeks and rivers or shallow ponds for water supply. Those communities located in close proximity to mining areas or downstream of mining operations increasingly lack safe sources of potable water. Water-borne diseases and skin rashes were found common in most interior locations (NDS, 2001-2010).

The NDS (2001-2010) pointed out, at the time of its preparation, 8 out of 10 inhabitants in Region 1 had malaria and over 50 per cent of the children in Region 8 and more than 30 per cent in Region 7 were affected with respiratory tract infections. Moreover, it found Region 9 had the highest percentage of children with diarrhoea[9].

[9] These statistics should not be taken as a reflection of the current situation. These were presented to provide an idea of what pertained in the hinterland region at one (1) time in the absence of current data.

ISSUES IMPACTING AMERINDIANS

As a result of increased activities, in particular, in the forest and mining sectors in the hinterland regions and close to community lands, as well as, external influences – mainly from the coastal regions, changes in Amerindian attitudes and way of life were observed. As communities pursue more income generating activities, greater monetary values are being placed on the goods and services that were once considered free (NDS, 2001-2010). Additionally, the young people in communities are oftentimes forced to seek employment outside of the community either in forestry or mining operations due to lack of opportunities. Consequently, this impacts the perception of the younger generation who now places greater value to the possession of consumer goods and as a result migrates out of villages and as well, displays reluctance to engage in subsistence agriculture or traditional practices (NDS, 2001-2010).

Access to potable water is another critical issue affecting the hinterland communities. Many communities have little or no access to potable sources of water due to traditional sources (creeks, rivers) increasingly coming under threat of pollution mainly from mining activities. These activities are most times upstream and external to the communities. However, communities by legislation can allocate their lands to 'outsiders' to undertake mining that could potentially impact surrounding water sources in the absence of adequate environmental safeguards.

In addition to cassava, Amerindian diet consists of fish or meat as sources of protein but these have been affected due to changes in the environmental conditions from anthropogenic activities. In recent years, mining activities in the interior regions have increased, particularly at the level of small and medium-scale operations fuelled by the world market prices. This places ever more pressure on the exploitation of river-alluvial type deposits and the alluvial saprolite-hosted deposits using heavy-duty earth moving equipment and dredges. The methods of extraction such as hydraulicing and river dredging, and even ground sluicing to some extent, require the use of a large volume of water daily, at high pressure to create slurry that needs to be processed. As a result, the run-off generated from the operations most times are discharged directly into the environment thereby increasing the suspended solids and turbidity of surface water, refer to Chapter 5 for additional information. High turbidity not only affects water quality but also impacts aquatic life and harm fish and other aquatic biodiversity by reducing their food sources and spawning grounds. The use of mercury in the mining industry and discharge of effluent into the environment can cause this heavy metal to enter the aquatic ecosystem forming toxic products and also bio-accumulate in species, especially carnivorous fishes, refer to Chapter 6 for additional information. Habitats for animals traditionally consumed by Amerindians could be threatened due to extensive land clearing for mining. Forest harvesting operations can also cause habitat disturbance if not properly managed, especially due to collateral damage of the surrounding trees.

Conservation efforts and management of lands

The Amerindians are the second largest landholders after the State, currently occupying approximately 3,316,000 hectares (GFC *et al*, 2015) or 33,160 km^2. This means this group has control over a significant percentage of Guyana's total land and by law, and has the right to determine how these lands and the resources therein could be utilized and managed.

Communities have traditionally, been recognised as stewards of their lands, based on their customary use and practices and inherently, understand the need to protect and conserve their resources for future generations. This is not only evident in how they maintain and manage the shared (within and between communities) traditional use space, adjacent to their titled lands, but have been enshrined in the Amerindian Act, 2006, where the Village Council can mandate the sustainable use, conservation and protection of village lands (AA, 2006). Across the country, some communities and by extension, Administrative Regions are more active in the areas of management, conservation and protection of their resources than others. In particular, the NRDDB and the SCDDC have been pivotal in promoting conservation and managing the resources in the Rupununi region. The communities in Administrative Region 9, have been at the forefront in leading the way to ensure greater management and protection of their resources and have made significant progress to-date, in not only identifying and allocating resource use areas through participatory processes, but also influencing national level changes in the management of traditionally used lands to be designated a national protected area – the Kanuku Mountains Protected Area. A community group – the Kanuku Mountains Community Representative Group (KMCRG) has been instrumental in the planning process for the protected area, especially as it relates to representing the interests of the surrounding communities. Moreover, the communities in Region 9, have advanced their village planning process for the utilization of their resources, through the development of Community Development Plans, refer to Box 1.2.

Additionally, the Wapichan communities in the South-Central Rupununi undertook a study and to identify steps to increase protection of their customary use of biodiversity in the savannahs, forests and mountains in the South-Central and South Rupununi. This extensive documentation of the custom and culture of the people and their inherent drive to sustain the use of their shared resources and way of life and was aptly documented "Wa Wiizi Wa Kaduzu: Our Territory, Our Custom" (David *et al*, 2006).

Moreover, the Wai Wai communities in the Deep South Rupununi were the first to designate portions of their titled lands for conservation as stipulated under the

Amerindian Act, 2006. The Community-Owned Conservation Concession is one of key protected areas in Guyana managed by indigenous peoples, especially since it houses a number of endangered species and important habitats.

Box 1.2: Community Planning for Sustainable Development – Maintaining Natural and Cultural assets

Introduction

Indigenous communities currently own approximately three million hectares of Guyana's landmass (GFC, 2015) and have rights to traditional resource use significantly beyond this. The lands owned and used by communities are some of the most biologically important – they are covered by rare ecosystems, house important species, provide essential goods and services, among other things. The traditional practices of these communities have maintained natural assets over many centuries. The capacity of indigenous communities to continue good stewardship of their land and resources is severely constrained by their limited capacity to create and implement strategic plans for their development. These plans are needed as communities are becoming more integrated into the mainstream cash-based market economy (CI-Guyana, 2012) that introduces many pressures on traditional economy, society, and the environment. These pressures in turn, affect the resilience of communities and stymie their sustainable development efforts.

Piloting Tools for Robust Community Planning

Conservation International-Guyana (CI-Guyana) collaborated with the Kanuku Mountains Community Representative Group (KMCRG), to design and test a series of simple tools to assist communities to develop robust Community Development Plans (CDPs). A simple planning process and associated tools were tested with eleven (11) villages surrounding the Kanuku Mountains Protected Area (KMPA) in Administrative Region 9 (see Figure 1.17) (CI-Guyana, 2012). The community-led process is intended to help secure the wellbeing of communities by integrating resource management into community development, build the capacity of the villages to better understand the resources/assets available to them, and plan for the sustainable use of those resources. It also helped communities to step beyond their boundaries and develop integrated approaches to resource management at a watershed or eco-regional level thus reducing inter-community conflicts that could have otherwise resulted.

Results/outputs

This initiative has resulted in the production of a clear and comprehensive "tool kit" for community planning for sustainable development (CI-Guyana, 2012). The development and testing in communities surrounding the KMPA, and with the KMCRG's leadership, also allowed for identification and address of issues of collective resource management to be identified and addressed. Consequently, a more secure future of the natural wealth of the region, including the KMPA, is more attainable, as is improved management of resources across Guyana. The planning process and tools are currently being further refined and improved towards their use by indigenous communities across Guyana (MoIPA, 2016).

Challenges and Lessons

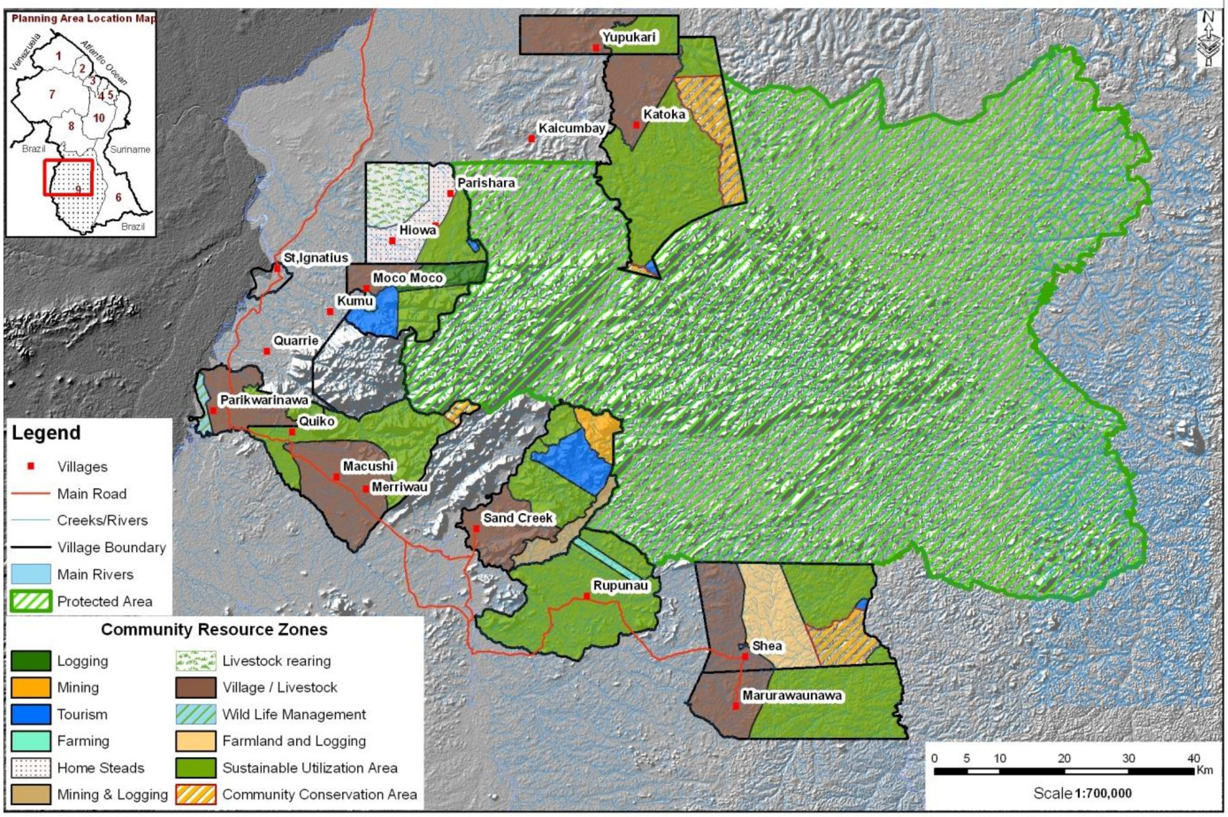
Initially, gender and age dynamics within the communities were not factored into the manner in which the planning process was deployed. Creating the enabling space for inclusion of interests and perspectives of women, youth and other vulnerable groups is essential for resilient planning.

The initial deployment of the process in the KMPA communities demonstrated the need for the process and tools to include focus on issues of climate change, and the preparation of sound annual implementation plans and targets that are clear, simple and measurable by the communities. Revision of the planning process and tools is addressing these needs.

Conclusion

The Community Development Planning tool kit and process designed by CI-Guyana and the KMCRG provides an opportunity to realize improved management of the natural and cultural wealth in more than 14% of Guyana's land mass.

Figure 1.17 KMPA communities with zoning informed by the Village Resource Development Planning process



In recent times and with the expansion of monetized industries in communities, there has been an increasing interest to venture into forest harvesting, mining and agricultural activities at larger scales. This means having to allocate areas to undertake specific developmental activities, and even though, communities have rights to manage and utilize their own land[10], commercial-scale investment requires adherence to national procedures and requirements, including environmental safeguards. However, if these activities are not properly planned, managed and monitored, adhering to stringent safeguards and best practices, degradation and environmental pollution of the very areas communities aim to protect, will occur.

In the forest industry, Amerindians contributed twenty-two per cent (22%) of timber production from Amerindian areas, operating State Forest Permits[11] (SFPs) in 2014, the third largest producer, which is significant when taken in the context of national-scale production volumes[12] where thirty-five precent (35%) of forest production originated from large-scale operators holding Timber Sales Agreement and Wood Cutting Leases and forty-one percent (41%) from other

[10] Communities have surface rights only not mineral rights.

[11] SFPs are issued for two (2) years at a time covering areas of less than 8,000 hectares (GFC *et al*, 2015).

[12] In total, small scale operators, including Amerindians, account for 63 per cent or the largest share of timber production in the forest sector for this reporting year (2014) (GFC *et al*, 2015).

small-scale operators (GFC *et al*, 2015). The GFC as part of its national-scale forest monitoring also assesses forest area changes and degradation in titled Amerindian areas.

As such, the Year 4 assessment conducted for the period January 01, 2013, to December 31, 2013, recorded a deforested area of six hundred and sixty hectares (660 ha) at a rate of 0.03 percent, an increase when compared with historical assessments – Years 1 & 2 (GFC *et al*, 2015).

The GFC concluded that mining contributed the most significant land-use change. Mining contributed to ninety-two percent (92%) of the total forest area change for the assessed year (2013) and ninety-one percent (91%) of total deforestation for 2014. In 2013, mining operations in Amerindian areas contributed to twenty-eight percent (28%) of total degradation, which increased in 2014, accounting for seventy-one percent (71%) of total forest degradation (GFC *et al*, 2015). The GFC commenced reporting on the contribution of subsistence farming (or shifting agriculture) to forest degradation in 2013, and for Year 4 (2013) and Year 5 (2014), took into account new areas (>0.25 hectares in area). It was found that shifting agriculture contributed to sixty-two percent (62%) of the total area of forest degradation for 2013, which reduced to twenty-nine percent (29%) for 2014 (GFC *et al*, 2015).

There is a greater risk of increasing impacts should these activities continue unchecked. Clearly, there is need for more effective management and use of resources and the impacts of development activities on the environment in Amerindian areas given the observed increases as a result of the GFC's national monitoring of forest area changes.

HEALTH

According to the WHO (2009), *"Guyana's health care system is based on the primary health care principles but there is a major challenge of ensuring equitable access to health care for populations in the hinterland due to limited infrastructure."* This situation is exacerbated in the rural hinterland, where the percentage of people living in poverty conditions is twice that, in rural coastal areas.

Communicable diseases such as HIV/AIDS, Malaria, Tuberculosis and other vector borne diseases remain a public health challenge for Guyana. At the same time, lifestyle related health problems are increasingly becoming a public health challenge. Substance abuse, injuries and violence, together with mental health issues together with "the so called neglected diseases such as *filariasis* and *geohelminths*" are highlighted in the last Country Cooperation Strategy from WHO for Guyana (WHO 2009: 7).

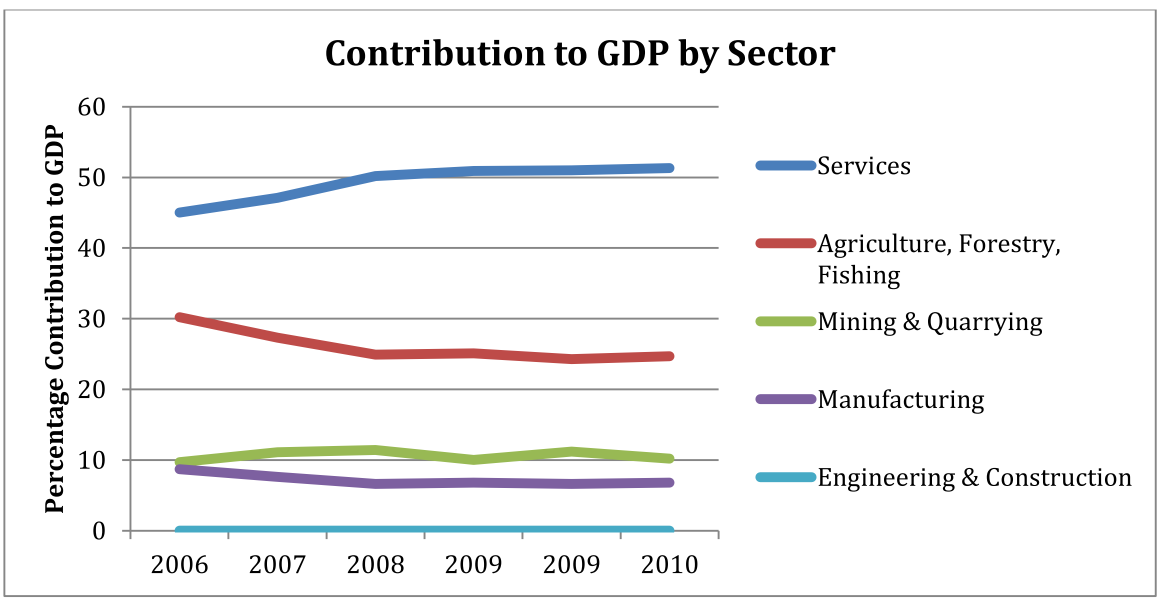
Environmentally related health risks remain a concern for Guyana. Although there has been significant progress in relation to access to piped water, from seventy-nine percent (79%) in 2005, to ninety-two percent (92%) in 2009 (Ministry of Finance 2011), "major problems with quality, continuity and reliability of service persist both along the coastal strip and in severely under-served hinterland regions" (WHO 2009: 29). As described with data analysed in Chapter 5, water quality in some locations has been degraded. Such problems with water quality result in high rates of diarrhoea, as was the case with children under the age of five (5) living in urban coastal areas (WHO 2009)

Inadequate waste management also represents a health risk, mainly in urban areas. During the 2005 floods, canals were not adequately draining, partly due to waste accumulation in them. This contributed to outbreaks of leptospirosis (WHO 2009). As Chapter 3 describes, progress has been made during the past years with waste management and recent campaigns in Georgetown have succeeded in improving the situation in the capital.

MAIN SECTORS DRIVING THE ECONOMY

Guyana´s economy is driven by the extraction and export of its natural resources. More than one third of the GDP is directly related to the primary sector (see Figure 1.18), and despite a recent growth of the manufacturing sector, exports continue having very limited value added.

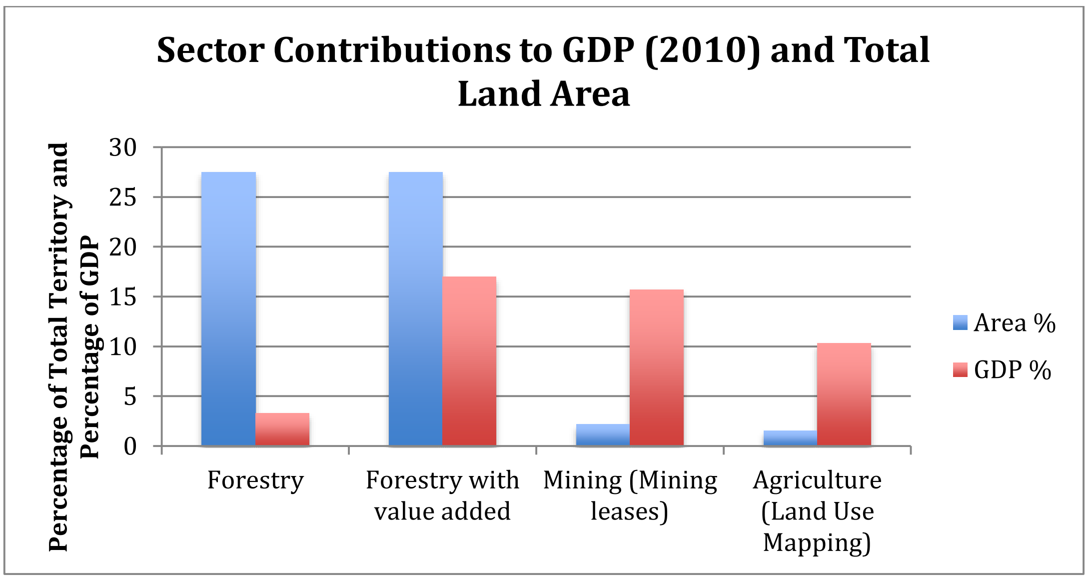
Figure 1.18 Contribution to GDP by different sectors of the economy. Source: Bureau of Statistics



Agriculture and mining cover small land areas in comparison to Forestry but generate significantly higher percentages of GDP. In terms of employment, the Guyana Geology and Mines Commission (GGMC) reported that the gold industry officially had 9,800 workers and the mining sector as a whole had 11,189 employees in 2010. The gold industry's share of employment represented ninety-one percent (91%) of the total direct employees in the mining sector. An industry representative estimated that there are 60,000 persons directly employed by the industry with an additional 40,000 being indirectly supported by the gold and diamond mining operations (CI-Guyana *et al*, 2014). Moreover, the LCDS Update in 2013, reported direct employment in the sector in 2012, to be 16,500 (GoG, 2013).

It is important to point out, and is highlighted in Figure 1.19 below, that when value is added for the manufacturing of forest products, the contribution of forests to GDP grows from 3.3 to 17 percent. In addition, this does not account for the value of forests considering REDD+, which in some accounts can be more than seven percent (7%) of GDP (GLSC 2013).

Figure 1.19 Land Primary Sector Contributions to GDP (2010) and Percentage of Land Area Cover. Source: GLSC 2013



Also, Figure 1.19 above presents relevant information for the consideration of future development alternatives for Guyana, in particular in relation to land use planning and land use change. Mining and agriculture occupy a relatively small area, but contribute a relatively large proportion of GDP and jobs. It can be expected that future job and revenue generation will come partially from the exploitation of untapped mineral resources and from agricultural activities in unexploited areas with suitable soils.

Based on data from 2009-2010 and 2010-2011, it can be concluded that mining and agriculture are the main drivers of deforestation and that mining is responsible for more than ninety percent (90%) of total deforestation in both periods (GFC *et al*, 2015). Chapter 4 assesses the current situation in terms of land-use and examines the current and potential environmental and social impacts from current and potential land use.

Strategic Environmental Assessment is a crucial instrument that needs to be considered for the assessment of the Guyana National Land Use Plan and for different infrastructure proposals that have been presented and will be presented in the near future.

FORESTRY

Chapter 4 will describe in more detail the different forest types and the development and evolution of forestry in Guyana. The forest sector has been an important contributor to the GDP during the past years and as it is illustrated in Figure 1.20 below, it has been decreasing its weight in the total GDP, but is stabilized around three percent (3%), since 2011. The total forest sector's contribution includes value-added forest products, (including plywood, furniture, and building components, etc.) which tally to a higher percentage contribution. This statistic is taken as a measure of primary production of logs, sawn wood, round wood and split wood. The average number of persons directly employed in the forest sector over the past five (5) years is 20,000 persons (GFC, 2016).

Figure 1.20 Forest Contribution to GDP. Source: Bureau of Statistics 2015

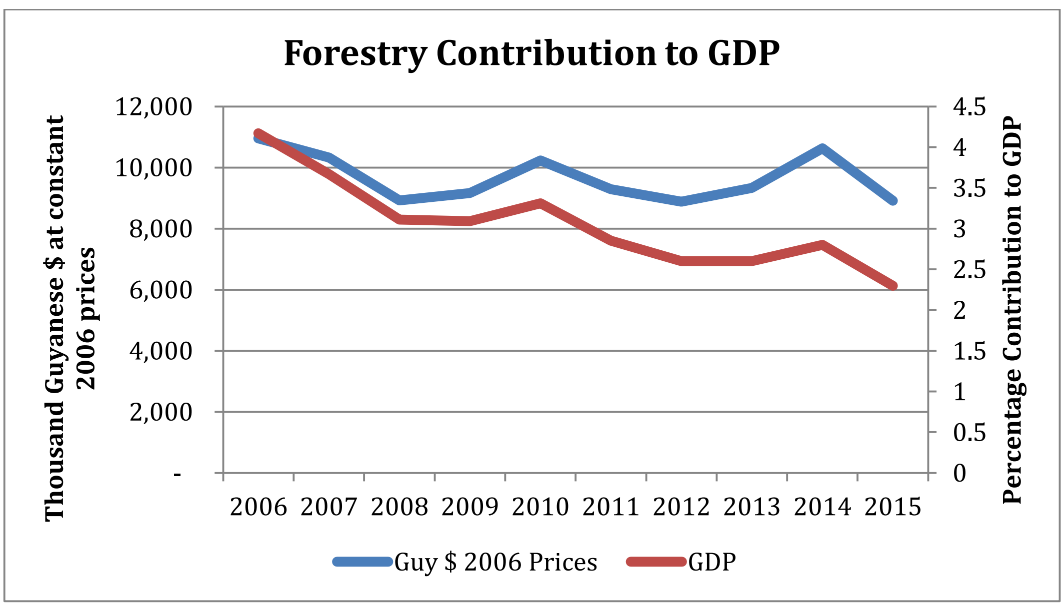
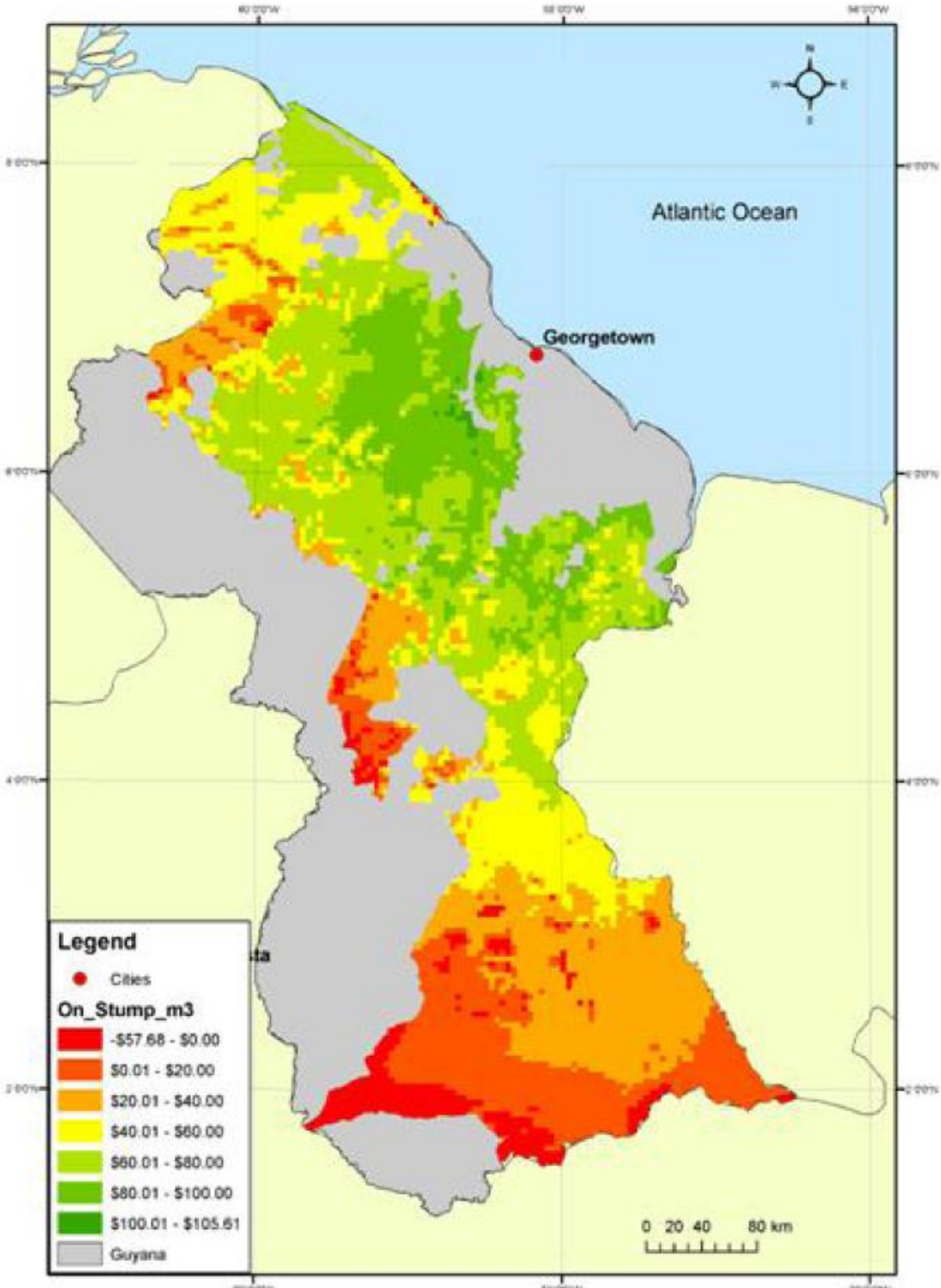


Figure 1.21 presented below from the Guyana National Land Use Plan shows stump value of timber and was done taking into account forest composition and density (GLSC 2013). The map, which includes only the State's Forest Estate shows that the areas with greatest potential for future exploitation are in southern

Region 8 and southern Region 9. Some of the areas with the highest value are not yet under forestry concessions but do fall under mining prospection as is the case in southern Region 9.

This kind of analysis highlights the importance of deepening the coordination between commissions in charge of the planning and administration of natural resources in the country as well as the areas with highest potential for increased pressure and in need of strengthend government presence.

Figure 1.21 Standing Timber Value in State Forests. Source: GLSC 2013 based on GFC 2011.



MINING

Mining is a key economic sector in Guyana and is important in terms of its contribution to socio-economic development, through employment. During the past decade, mining has been attracting Foreign Direct Investment in the country, particularly for the exploration of hydrocarbons and minerals. This situation has been favoured by a relatively stable regulatory framework and improvement in regional infrastructure.

Within the mining and quarrying sector, gold´s share of gross value-added has been growing for the past decade. It was forty-nine (49%) in 2006, and accounted for seventy percent (70%), in 2012. This growth has been explained by favourable price conditions and world demand. All gold extraction, which has been growing for the past ten (10) years, comes from small and medium-scale operators.

The primary export commodities, in order of value, are gold and bauxite. Other minerals, such as diamonds, and quarry products, mainly stone and sand, also contribute substantially to the country's economic wellbeing. Exploratory activities for manganese, rare-earth metals and uranium are on-going and at some point in the future, these minerals may make substantial economic contributions (Bennett, 2013).

In 2015, production from the mining and quarrying industry contributed ten point nine four percent (10.94%) (or approximately GY $42 billion) to the total GDP and is projected to increase in 2016, to twelve point two two percent (12.22%), with gold and bauxite continuing to lead (see Figure 1.22).

Figure 1.22 Contribution to GDP from the Mining and Quarrying Sector. Source: Bureau of Statistics 2015

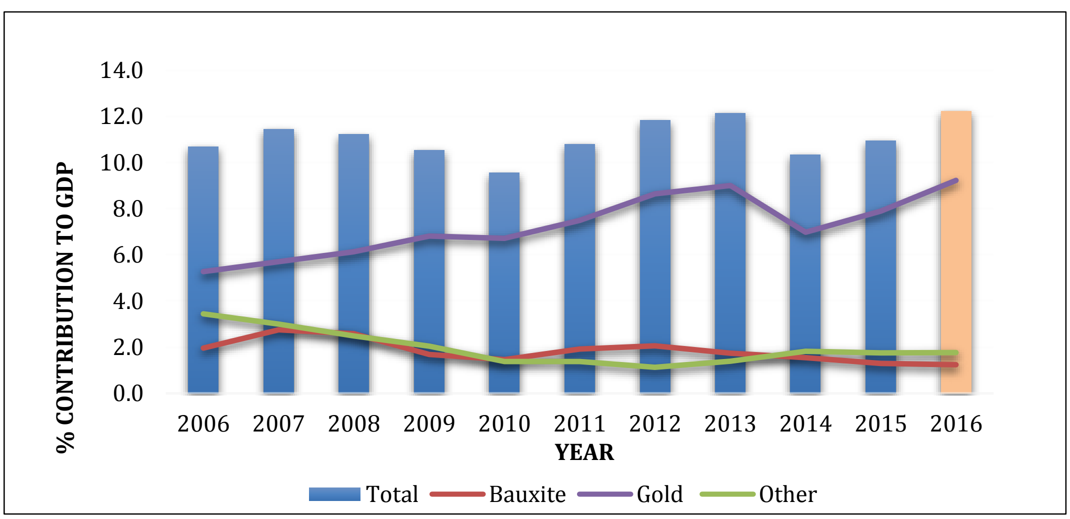
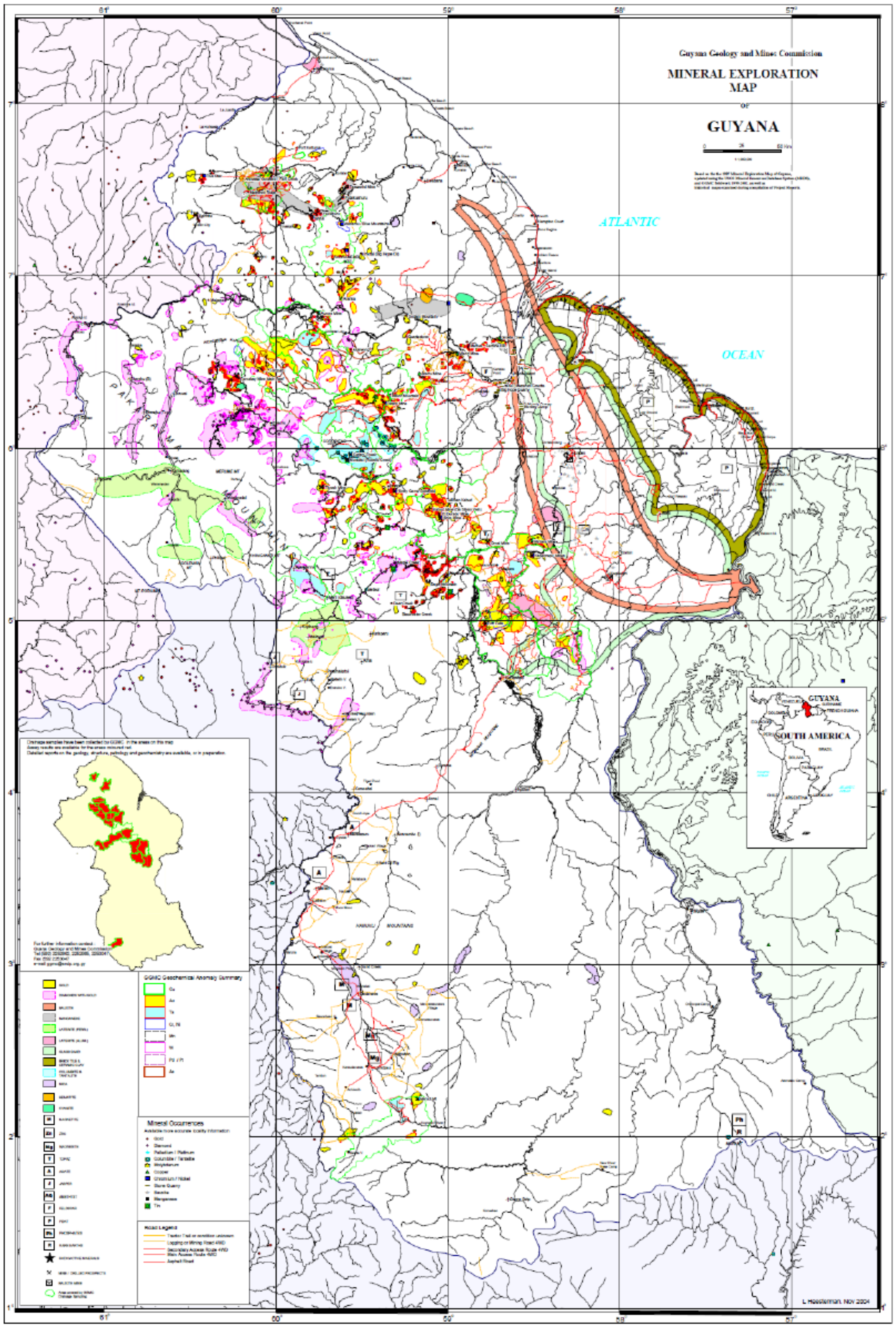


Figure 1.23 shows the distribution of mining concessions and potential mineral resources throughout the country. Known mineral resources are located mainly in the southern portion of Region 1, in Region 7, east of Region 8 and partially in Regions 10 and 9.

Figure 1.23: Mineral Resources Map. *Source: GL&SC, 2013*



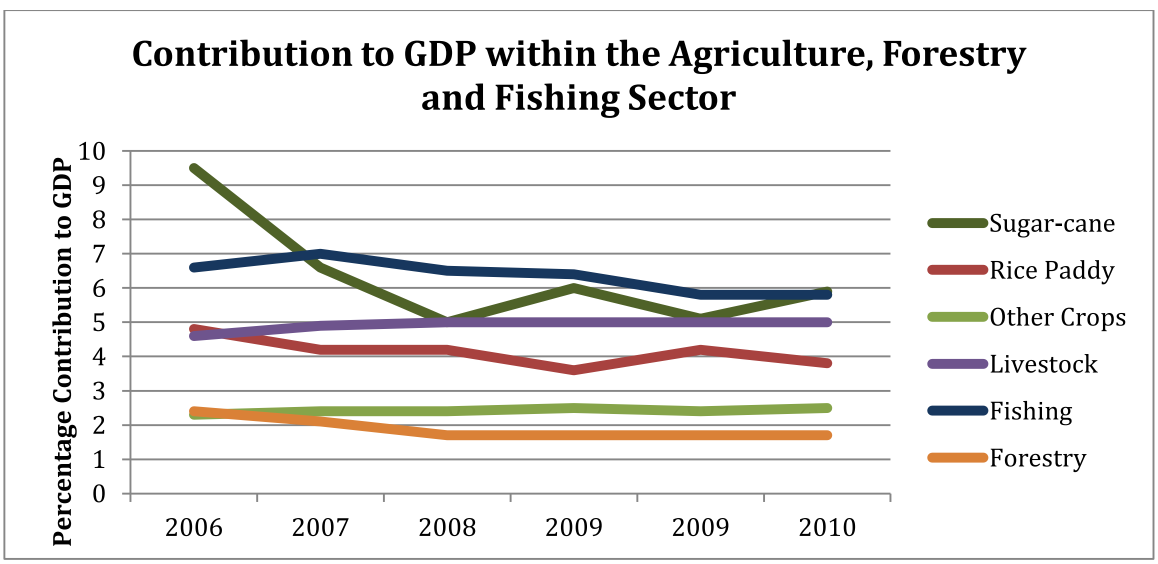
As presented above, mining, in particular the small-scale mining industry, is the most extensive driver of deforestation in the country. Between 1990 and 2009, mining was responsible for sixty percent (60%) of deforestation occurring in Guyana and during 2009-2012, this increased to ninety percent (90%) of total deforestation (Government of Guyana 2015b). By extension, mining is also a major driver of biodiversity loss and environmental degradation in Guyana – especially in areas where mining occurs. Freshwater pollution, attributed to highly elevated levels of turbidity and mercury use, is significant. Mining related impacts felt by the environment and its effects on the wellbeing of local communities have been subject to much discussion and there is a good consensus by civil society that stronger regulation of the sector – and in particular the small-scale mining – is needed.

In addition, many of the forest resources that could be exploited prior to deforestation by the mining sector are not put into good use because of overlapping concessions. An analysis made in 2013 showed that one thousand, three hundred and eighty (1380) mining leases, covering 386.265 hectares, fall within forest concessions not yet exploited (SEA 2013).

AGRICULTURE, LIVESTOCK AND FISHERIES

In Figure 1.18, the heavy dependence of Guyana´s economy on primary resources was illustrated. Figure 1.24 below shows the contribution of each subsector of the Agriculture, Forestry and Fishing sector to the economy.

Figure 1.24 Contribution to GDP by subsectors of the Agriculture, Forestry and Fishing Sector. Source: Bureau of Statistics

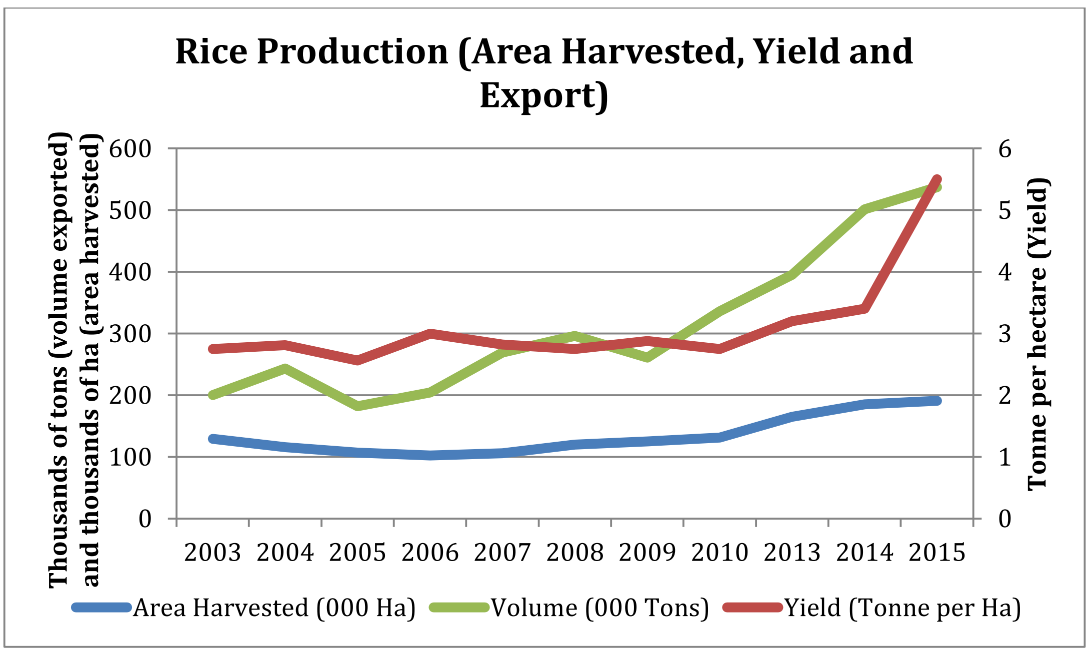


Agriculture generates around fifteen percent (15%) of total national GDP and covers less than two percent (2%) of the country. It also accounts for thirty-three percent (33%) of employment in the country and is predominantly based on small farmers occupying less than fifteen hectares (15 ha) of land (MOA 2013). It is mainly located on the coastal plain and rice and sugar are the main crops.

The information presented in Figure 1.24 does not account for the significant increase in rice yields and exports of the past five (5) years, which likely place the agricultural, forestry and fishing sector close to one-third (1/3) of the GDP.

During the past five (5) years, there has been a significant increase in rice exports, from approximately 300,000 tons in the late 2000s to 537,000 tons in 2015. This growth is explained mostly by increases in yield, but also by an increase in area harvested, which was 131,000 hectares in 2010 and 191,000 hectares in 2015 (see Figure 1.25). It is also worth noting that the forestry sector's contribution to GDP increases to seventeen percent (17%) (with 2010 data) when value-added, such as timber, is included (GLSC, 2013).

Figure 1.25 Rice production (2003-2015). *Source Bureau of Statistics based on Guyana Rice Development Board*

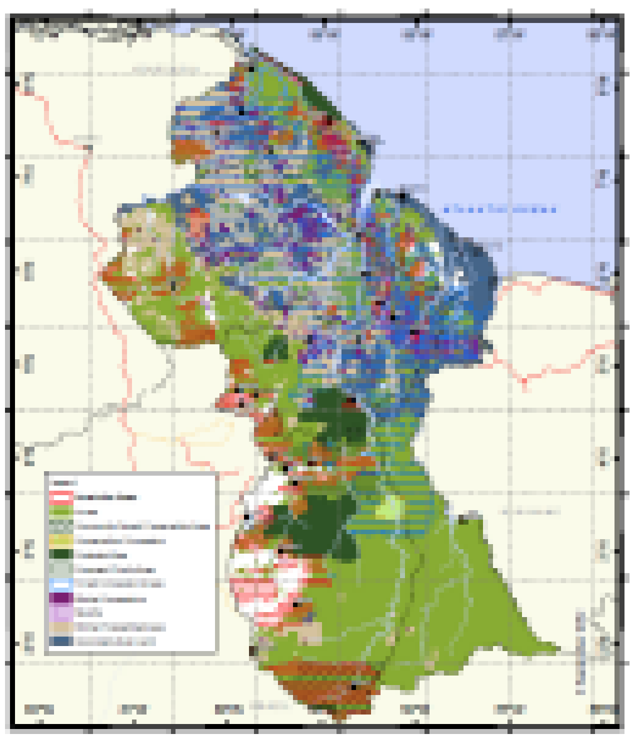


Sugar has been in Guyana for centuries and continues to play an important role in its economy both in terms of GDP and employment. This is despite the recent reduction in production due to weather conditions and difficulties with one of its main markets, the European Union. The sugar industry's prospects depend on established preferences with its markets and a modernization of its production process leading to an improved performance.

As presented in Chapter 2, agriculture production is highly vulnerable to climate change which can influence shortened growing seasons or reduction of yields. In the case of sugar, some regional studies project a potential reduction in yield for sugar in almost thirty percent (30%) (UNEP 2008). The Disaster Risk Management Plan for the Agricultural Sector 2013-2018 states that *"climate change is expected to worsen the Republic's vulnerability, with the greatest impacts projected to affect the coastal zone and the agriculture sector"* (MOA 2013: iii).

Figure 1.26 below describes the areas with more future agricultural potential. Class I and II soils according to FAO (Good to Moderate Agricultural Land) are located on the coastal and inland areas. The use of coastal soils require drainage and fertilization while inland class I and II soils have moderate limitations for agricultural use and with fertiliser can be cultivated expecting to receive high yields (GLSC 2013).

Figure 1.26 Areas with future agricultural potential. Source NLUP PAGE 139



LIVESTOCK

Livestock production takes place along the Coastal Plain and in the Intermediate and Rupununi Savannahs and is largely self-sufficient (GLSC 2013; MOA 2013). Information on livestock is scarce and needs to be updated, however, a 1996 estimation noted 270,000 heads of cattle, 300,000 sheep and 150,000 goats. Information from 2006 for Regions 5 and 6 provide an estimate of 300,000 heads of livestock. Based on these figures, the conclusion is that numbers have grown significantly with poultry and equine being the main contributors. The pig and cattle numbers have also increased significantly (GLSC 2013). However, the existing potential is far larger than what has been developed so far.

In 2010, with the intention of developing the livestock sector for export, the Guyana Livestock Development Authority (GLDA) was established. According to the GLDA, the current livestock enterprises will need to improve pastures and water supply to satisfy export markets. If expanded, it will likely compete with other land uses (GLSC 2013).

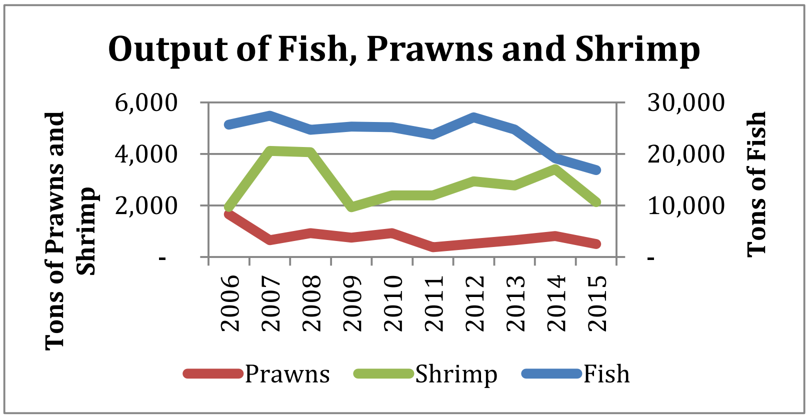
There are also options for conducting livestock operations with forage crops and rotation of agriculture and livestock production. The GLSC (2013) describes systems in Brazil and Colombia that could be replicated in Guyana, particularly in Region 9. Using maximum potential scenarios, which are unlikely due to infrastructure, water and other factors, the potential of the Rupununi savannahs is of 1.36 million heads of cattle. These estimates, together with the potential development of new agricultural alternatives, show that the development of new infrastructure needs to go through careful strategic environmental assessments in order to prepare the country for the increased pressure over natural resources by competing sectors.

FISHERIES

The fisheries sector is an important driver of Guyana´s economy both in terms of exports and jobs. Despite this, Chapter 6 highlights that there is still a significant gap in information on the status of fisheries. Aquaculture, marine and inland fisheries drive the sector, which accounts for approximately two to three percent (2-3%) of GDP as was presented in Figure 1.24 above. The number of jobs supported by the fisheries sector fluctuates between 12,000 and 15,000 (Ministry of the Presidency 2015; MOA 2013). Half of those jobs come from fisheries harvesting and the other half from processing of such harvest. In addition, there are indirect livelihood opportunities related to fishing in areas such as boat building.

Figure 1.27 below shows the evolution of output from the main exports. As can be seen in the Figure, there has been a steady decrease in fish output in the past year and the entire "sub-sector experienced a 7.2 percent decline when compared with a 26.7 percent decline in 2014. The shrimp and fish catch fell by 37.6 per cent and 12.2 per cent, respectively, owing to piracy, smaller fleets, overfishing and the occurrence of Sargassum seaweed in offshore waters " (Bank of Guyana 2015: 11).

Figure 1.27 Outputs of Fish, Prawns and Shrimp. Source: Bank of Guyana based on Ministry of Agriculture and Bureau of Statistics



Fish is also an important source of animal protein in Guyana. The annual estimated consumption of fish is 35.6 kg per capita, which is more than double the world average of 14 kg per capita per year. Though in a growing trend (annual growth of 14% since 1995), aquaculture´s contribution to this consumption is still relatively low and the sector occupies approximately 2000 hectares of land (Ministry of the Presidency 2015; MOA 2013). According to the Guyana's draft Climate Resilience Strategy, *"commercial aquaculture is identified as one of the most promising economic activities with high potential for rapid export and job creation growth. The industry has been experiencing average annual growth of 14% since 1995"* (Ministry of the Presidency 2015: 161).

Environmental degradation is a serious risk for fisheries and the jobs that depend on it. The Sargassum case mentioned above is an example of how environmental degradation places pressure on fisheries. The degradation and destruction of mangroves, which are also vulnerable to climate, represent a direct pressure on fisheries and on fisheries infrastructure. Additionally, it was noted that "*the importance of the fisheries industry in Guyana means that impacts on marine ecosystems and biodiversity will have a significant effect on the productivity and profitability of the industry"* (Ministry of Finance 2015: 146).

ENERGY

In the Strategic Plan (2014 – 2018), Guyana´s Energy Agency (GEA) portrays the current situation in terms of energy sources and describes the potential alternative energy sources for the near future. Guyana currently relies heavily on petroleum imports to cover its energy needs. In 2012, total imports of petroleum-based products were 4.9 million barrels, representing 24% of the country´s GDP. In terms of alternative sources, hydropower has the most potential in terms of production capacity but other sources such as wind, photovoltaic and biofuels are being considered (GEA 2014).

Figure 1.28 below describes the distribution of the consumption of petroleum-based imports in Guyana. Transportation is the top consumer sector, driven mainly for the use by the private vehicle fleet in the country, which has grown significantly during the past ten (10) years (see Figure 1.29 below). The electric power sector (Guyana Power and Light Inc.) accounts for a third (1/3) of total consumption of petroleum imports and generates ninety-six (96%) of electricity in the country.

Figure 1.28 Consumption of Petroleum Based Products (2012). *Source: GEA 2014*

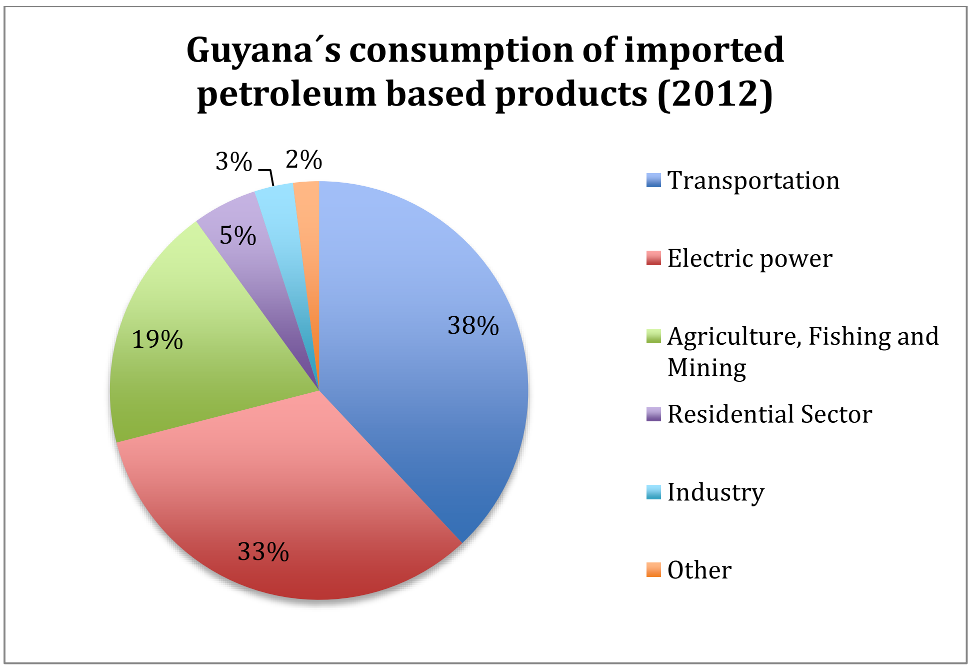
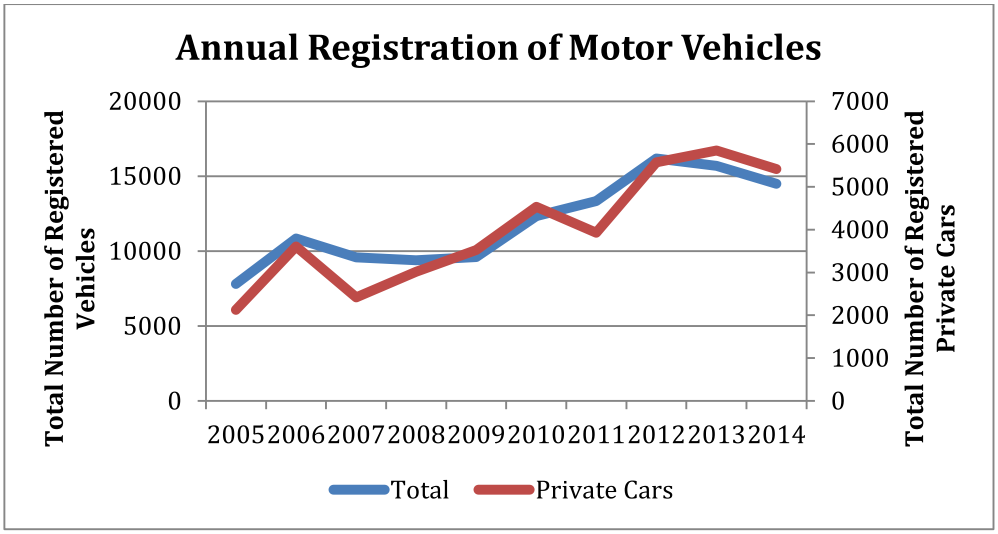


Figure 1.29 Annual Registration of New Motor Vehicles (2005-2014). *Source: Bureau of Statistics based on Licence Revenue Office*



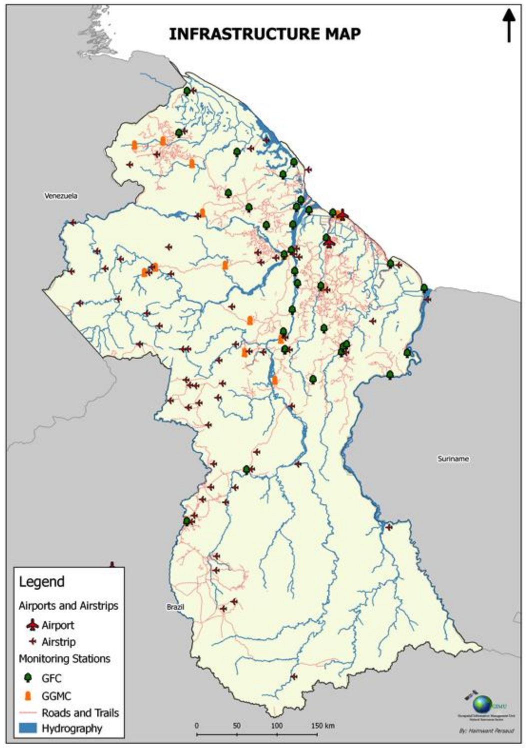
A potential shift from petroleum-based products to alternative energy sources for electric power generation can reduce GHG emissions significantly. According to data for 2004, the energy sector is responsible for approximately fifty percent (50%) of total GHG emissions (Government of Guyana 2012). More information is presented in Section 2.4 of this report. At the same time, this shift can represent a driver for land use change in the country as it is described in Chapter 4. This is particularly the case for hydropower and biofuels, which can result on further pressure on forests.

Biomass represents approximately a quarter of energy supply and comes mainly from the burning of waste crop products. The sugar industry produces bagasse used for co-generation at Skeldon and rice husk is produced by the rice industry for co-generation of heat and electricity (GLSC 2013).

INFRASTRUCTURE

Figure 1.30 shows Guyana´s main current infrastructure. The potential for increasing the country´s exports in agriculture, mining and forest resources is enormous, as highlighted below. This potential has been limited by lack of infrastructure linking Guyana´s hinterland with its main existing port or the potential deep-water port in New Amsterdam. Developing the road and energy infrastructure potential can result in development opportunities for Guyanese and at the same time place significant pressure on Guyana´s natural resources.

Figure 1.30. Infrastructure Map of Guyana. *Source MNR, 2016*



Historically (2001-2012), infrastructure has been responsible for approximately 11 per cent of emissions. This figure includes infrastructure for mining (not the area under exploitation), infrastructure for forestry (not including timber harvesting) and infrastructure in general (Government of Guyana 2015b).

Other infrastructure projects could become drivers of deforestation in the near future, particularly hydropower projects that are an essential part of Guyana´s Low Carbon Development Strategy. There are sixty-seven (67) potential hydropower sites identified by the Guyana Energy Agency, but the Amaila Falls Hydro was being pursued in recent years, which could reduce the country´s energy related emissions by ninety percent (90%), (Government of Guyana 2015b). This project is currently stalled and the government is currently exploring additional potential sites.

In terms of road infrastructure, the Georgetown - Lethem Road Corridor has enormous potential and is considered a key infrastructure project for the future development of Guyana. The estimated emissions projected in Guyana´s reference level document (Government of Guyana 2015b) estimate the contribution of road infrastructure to nine percent (9%) and alternative energy infrastructure to eighteen percent (18%). However, road infrastructure such as the Georgetown - Lethem Corridor will also create indirect pressures on Guyana´s forests and grasslands as it will significantly reduce the time and cost between potential agricultural soils and markets. This situation is considered in the Lethem - Linden

Road Corridor Land Use Plan, where the importance of a Land Use Policy is highlighted.

Box 1.3 – Internalizing Costs of Infrastructure

Infrastructure, particularly for transportation and power generation, is necessary to improve human wellbeing. However, the potential environmental costs of these essential investments are often not factored into their design, construction and operation, leading to sometimes costly and unnecessary consequences (Vieira, Moura, & Manuel Viegas, 2007). This is especially the case in developing countries, like Guyana, where expansion in energy and transportation infrastructure, central to catalysing economic growth, is not associated with sufficient information to make objective trade-off decisions regarding environmental costs and benefits of such investments.

As part of the pre-investment studies for upgrade of the 553-kilometre road linking Georgetown to Lethem on Guyana's border with Brazil, Conservation International Guyana (CI-Guyana) conducted an assessment to quantify potential direct and indirect environmental impacts of the project (CI-Guyana and CI, 2014). The project contains the only unpaved section of road connecting Manaus – Brazil's 11th largest city – and the rest of northwestern Brazil to the Atlantic coast, and has significant importance to both Guyana and Brazil. The study undertook a broad-scale rapid biodiversity and ecosystem services assessment to help identify and manage risks and potential impacts on ecosystem services and biodiversity that can result from the road upgrade (CI-Guyana and CI, 2014). Recommendations for addressing these impacts through application of the mitigation hierarchy – avoidance, minimization (mitigation), rehabilitation and offset were developed, and economic benefit-cost analyses were conducted for better informed decision-making regarding the project.

The study identified a number of key biodiversity features and ecosystem services that require special attention to ensure that the road upgrade does not negatively affect them in irreversible ways. The most significant direct impacts identified were loss of wildlife through road-kill, hunting and trapping, and the clearing of forest and savannahs. The most important indirect impact identified was deforestation and other ecosystem changes that can result from various land uses the upgraded road might induce. The assessment also determined that approximately US$ 12.4 million in annual REDD+ payments could be at risk and other quantifiable values could be lost if the deforestation and other impacts were not addressed (CI-Guyana and CI, 2014). A number of measures to address the potential impacts, particularly deforestation, biodiversity loss, and loss of freshwater quality and quantity were recommended. It was concluded that implementation of the recommended measures is justified given the magnitude of the cost of these impacts.

Rapid broad-based assessment of the potential environmental costs of development projects in their design phase can be of tremendous value to minimising their environmental costs. This is true even in situations of data scarcity, as in the case of Guyana. Studies of this nature can reduce investment costs of projects by better identifying areas where more detailed studies are required. Delimitation of areas of influence of projects using ecosystem services is a good approach to fitting infrastructure more sustainably into landscapes. The quantification and valuing of likely direct and indirect impacts of infrastructure in the design phase also provide an effective means of internalizing and minimising their environmental – and potentially construction – costs.

Other key infrastructure investments are related to the agricultural sector. The main areas are drainage and irrigation in the coastal area and infrastructure to support mechanization in the sugar, rice and corn production (MoA 2013).

ENVIRONMENTAL EDUCATION AND AWARENESS IN GUYANA

Environmental education and awareness (EEA) are critical components of effective environmental management. The implementation of a targeted EEA programme is critical to support national policy behavioural-change initiatives such as litter and Styrofoam ban regulations to drive local-level actions that maintain and improve environmental quality (EPA, 2015). Even though environmental education, largely, is adjunct to institutions and sectors' existing programmes; it requires an integrated approach through inter-sectorial planning (UNEP, 2010). Over the years, Guyana has made significant strides to promote awareness and enhance knowledge and skills in these areas. Most of these efforts were led by Environmental Protection Agency (EPA) in coordination with key institutions and sector agencies.

From the onset, the Environmental Protection Agency has been mandated through legislation to *"provide information and education to the public regarding the need for and methods of protection of the environment, improvement of the environment where altered directly or indirectly by human activity, and the benefits of sustainable use of natural resources".* The EPA thereafter, established the Education, Information and Training Division (EITD) with the responsibility to plan and conduct programmes to prmote environmental literacy in Guyana (EPA, 2016b).

The EPA commenced with a two year Environmental Awareness and Capacity Building Programme in 1998, with support from the UNDP. This programme laid the groundwork for the EITD, and raising environmental awareness of local government, media, and schools (EPA, 2016b). Specifically, ten workshops were conducted to orient local government - Regional Democratic Councils (RDCs) and Neighbourhood Democratic Councils (NDCs) - in the ten administrative regions of the country on EPA's role and issues related to conservation and environment, thereby increasing their level of awareness and understanding of environmental management and protection (EPA, 2016a; EPA, 2016b). Additionally, during that time (1999-2000) environmental management awareness workshops were held in each administrative region, as well as, awareness on coastal zone management held in Region 2,3,4, and 5. The preparation of Guyana's National Biodiversity Action Plan led to consultation workshops, as well as, awareness workshops, which were held in the ten administrative regions (EPA, 2016a).

Specific interventions targeting schools include national teacher environmental education training workshop involving a number of primary school teachers from the ten administrative regions, as well as the development of four environmental education curriculum supplements for primary level (Grade III), one each on Mathematics, Science, English Language and Social Studies.

Figure 1.31 CPCE Trainee Teachers with Certificates. Source EPA 2016

A number of secondary schools over the period participated in two national environmental quiz competitions with representatives from across the country. Over the last six years, the EPA has been undertaking training workshops for teachers where a number of trainee teachers from the Cyril Potter College of Education (CPCE) received training on a number of learning tools to develop lessons and to effectively infuse environmental content into the core subjects (EPA, 2015).

Moreover, in spite of the high cost associated with media advertisements, the EPA undertook to support a number of public service announcements (PSAs) and documentaries since it became operational. The EPA produced and ran three PSAs on littering funded by the UNDP Education and Awareness Project (circa 1999-2002); three PSAs, one each on the Environmental Protection Regulations (2000) for noise, water and air pollution – funded by IDB Environmental Management Programme Phase II; and one video documentary on Mining and Guyana's Environment funded by GENCAPD project (2007). Over the years, the EPA continues to use the media, electronic and print, as a way to reach the general public in its efforts to raise awareness. In this regard, there are a number of on-going media programmes, inclusive of publishing at least one weekly newspaper article on an environmental subject; airing at least one weekly ten minute discussion on television on a topical environmental issue or subject; publishing one half page newspaper feature on the international focus of at least one environmental day, e.g. world environment day; international day of biological diversity, etc.; airing on radio and television a message on at least one environmental day; and airing on television and radio a panel discussion on least two environmental days (EPA, 2016; EPA, 2016b).

Additional outreach activities undertaken by the EPA include organizing and conducting youth seminars, coastal-clean-ups, walks, rides, exhibitions, classroom sessions, and poster competitions. Youth seminars generally involve a cluster of 10-15 schools, each of which is required to deliver a presentation, poster exhibit, or artistic item on the theme of the seminar. It is typical for two seminars to be organized annually, one in observance of Biodiversity Day and the other for International Ozone Day. So far, youth fora were held in Regions 2, 3, 4, 6, 7 & 10. Coastal Clean-up activities are organized annually to mobilize the public to participate in removing debris that ends up on the shores. Initially, organized in Georgetown, Coastal Clean-up has been done in Regions 2, 3, and for many years now has been sustained in Region 6 and Georgetown (EPA, 2016b & EPA 2016a, 2015).

The Green Walk first commenced in 1999 and continued until 2013 and was organized in observance of World Environment Day (WED). WED activities over the years were extended to Regions 6, 10 and 7, inclusive of the Ride-for-the-Environment, with the first one taking place in Region 10. This activity was thereafter extended to Regions 2 and 6. Environmental exhibitions have also been successfully organized from time to time to engage the public on various environmental issues, their impacts and potential solutions. Key materials were prepared to support outreach activities, in general, and specific as an awareness tool. These include preparation of posters, booklets, brochures, activity books, newsletters, etc. and covered best practices in mining; environmental protection regulations; national programme of action and water safety plans; marine litter; litter prevention regulations; protected areas; biosafety; climate change; composting; and impacts on biodiversity (EPA, 2016b; EPA, 2015).

Additionally, capacity building has been a focus of the EPA and over the years a number of exercises were conducted with specific target groups focusing on environmental education, climate change and composting. Capacity building on climate change and its impacts were conducted manly in primary schools. Classroom sessions were held using the EPA's workbook on climate change. The EPA has continued to deliver this activity in schools across several regions of the country including, Regions 2, 3, 4, 5, 6, and 9. Additionally, the EPA has been implementing, annually, climate change workshops targeting women; these are usually organized women's groups, whether religious or social in nature. The EPA has expended its efforts to many hinterland communities by collaborating with various partners, to raise awareness of the need to prevent water pollution and to conserve water in the as a means of addressing the issues associated with climate change. Also through partnership, the EPA has been able to do work with youths in Regions 7 and 10 to enhance understanding of climate change so as to be better prepared for its consequences (EPA, 2016b).

The EPA has also been addressing the issue of solid waste management through the provision of information and creating awareness across the country. The EPA has conducted numerous workshop sessions with communities and schools to bring attention to the Litter Prevention Regulations. For example, in 2015 workshops were held for several schools in New Amsterdam, Region 6. Students from twelve schools were trained in techniques of reusing trash as fashion and presentations were made at a hosted fashion show in 2015 and conducted again in 2016 with participation from ten schools. Specific environmental education programmes for schools were organised in the form of environmental camps.

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CHAPTER 2

Climate Change and Variability

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CLIMATE CHANGE AND VARIABILITY

BACKGROUND

Changes and variability in the Earth's climate system are being observed already and strong evidence suggests such variations are occurring in the Caribbean (ECLAC, 2011). Moreover, the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) concluded with greater certainty that anthropogenic impacts on the climate system are evident and increasing with effects observed around the world (IPCC, 2014). This is as a result of increasing greenhouse gas (GhG) concentrations in the atmosphere (IPCC, 2013). Recent scientific advances have shown that climate change is driving an increase in rainfall extremes[13] and that sea levels are rising at an unprecedented rate[14]. Indeed, recent projections indicate that sea levels could rise by more than two times previous estimates[15]. The AR 5 concluded that risks are expected to be greater the more human activities disrupt the climate and continued emissions of GhG will cause further warming and threshold level changes in all components of the climate system, increasing the likelihood of widespread impacts on the environment and human well-being (IPCC, 2014) and as a consequence, adverse climate change impacts may be more severe than previously anticipated.

The consequences of global climate change will cause more frequent and extreme weather events and rising sea levels, wildfires, alter ecosystems and habitats and threaten human health and society at large. These impacts are already being observed where some countries have experienced longer, more intense droughts that affect crops, wildlife and freshwater supplies and frequent and intense storms and heat waves. The impacts are expected to be significantly greater for susceptible communities, small island developing states and small, vulnerable developing countries like Guyana.

Guyana is intrinsically vulnerable to the impacts of climate change given its socio-economic and geographic characteristics (GoG, 2015a). The effects of extreme weather events, specifically, increased frequency and intensity of precipitation and storm surges coupled with sea level rise will significantly impact the country's coastal zone, leading to frequent flooding where the majority of its population, settlements, main infrastructure and economic centres are located and critical sectors such as agriculture, water, energy and health (GoG, 2012).

The effects of increased temperature and decreased mean annual precipitation will result in drought-like conditions across the country and, especially, impacting the

[13] http://www.nature.com/news/global-warming-already-driving-increases-in-rainfall-extremes-1.19508
[14] https://www.washingtonpost.com/news/energy-environment/wp/2016/02/22/seas-are-now-rising-faster-than-they-have-in-2800-years-scientists-say/
[15] http://www.bbc.com/news/science-environment-35926694

agriculture, health and water sectors. An increase in temperature will contribute to increased forest and savannah fires, saline intrusion and the spread of infectious diseases such as malaria, dengue, chikungunya and zika. Moreover, temperature increase along with decreased precipitation would affect the evapotranspiration processes with resultant water deficits for industrial process and domestic use (GoG, 2012). Over the years, the country has experienced drought-like events over the period 1997-1998, 2009-2010, 2015-2016 (GoG, 2015a).

As a consequence, even though the country is only exposed to seasonal temperature changes, floods and drought-like conditions, the combined impacts of these may be felt across more than one sector simultaneously, thereby magnifying the effects on the country and placing additional pressure on the socio-economic systems and already vulnerable resources. Table 2.1 summarises the climate change impacts affecting Guyana and the derived effects on sectors and territories.

Table 2.1: Summary of climate change impacts affecting Guyana and the derived effects on sectors/territory.
Source: Second National Communication – Table 4.2 pg 174.

Possible climate change impacts affecting Guyana	Derived effects affecting sector/territory
Increase in storm surges, sea-level rise and/or increased rainfall leading to flooding.	Coastal protection infrastructure affected (causing impacts on all the systems in the coastal plain)
	Houses in settlements damaged by soil erosion
	Pollution of freshwater systems
	Change in patterns of agriculture yields due to agricultural soil erosion
	Saline intrusion affecting surface and ground water sources
More intense and frequent ENSO events, change in rainfall and temperature patterns leading to droughts.	Migration from the hinterland to the coastal areas and thus increasing the pressure on the coastal zone
	Increase in pests and diseases
	Increase in infectious vector-transmitted diseases due to temperature rise
	Reduction in productivity of crops, especially sugar-cane and rice leading to effects on exports
	Risk to future energy security due to water deficit for hydropower stations
	Increase of forest and savannah fires due to temperature rise

INTERNATIONAL RESPONSE TO GLOBAL CLIMATE CHANGE[16]

International efforts to address a pervasive and global issue like climate change commenced over twenty-five (25) years ago and an overview of some of key events are provided.

Discussions on the science of climate change commenced since the 1970's led by the World Meteorological Organisation (WMO). It was recognised that this issue and its effects were not restricted to borders and a global effort is necessary. This led to a call to establish a scientific body and the United Nations Environment Programme (UNEP) and WMO established the Intergovernmental Panel on Climate Change (IPCC) in November 1988, with a mandate to investigate and publish reports and provide clear and updated scientific evidence relating to climate change and possible international responses.

The United Nations Framework Convention on Climate Change (UNFCCC) was agreed by Parties and entered into force in 1994. A number of objectives were outlined in the Convention, specifically, to stabilise the climate to prevent *"dangerous anthropogenic interference with the climate system"* in a timeframe to allow the natural systems to adapt without major damage to food systems and economic development

The Kyoto Protocol was adopted in December, 1997, as the operationalization mechanism for the Convention. This legally binding agreement came into force in 2005, and secured one hundred and ninety-two (192) signatories. The Protocol sets out binding emissions reduction targets for developed countries with a goal to reduce emissions of six (6) GhG gases by 5.2% below 1990 levels between 2008 and 2012 (known as the first commitment period). Moreover, the Protocol established three (3) main mechanisms for Parties, in particular, developed country Parties, to achieve emissions reduction and these were through (i) an emissions trading scheme (ETS); Clean Development Mechanism (CDM); and Joint Implementation (JI). In December, 2012, Parties negotiated and adopted the Doha Amendment to the Kyoto Protocol thereby launching the second commitment period (January 2013 to December 2020).

Progress towards Paris & the Paris Agreement 2015

In 2005, a number of Parties to the Convention introduced the agenda item on *"Reducing emissions from deforestation in developing countries and approaches to stimulate action"* which received wide support. The IPCC's Fourth Assessment Report (4AR) estimated emissions from deforestation in the 1990s to be 5.8GtCO2/year. The 4AR further concluded that reducing or preventing deforestation and the release of carbon dioxide into the atmosphere is the most

[16] http://unfccc.int/timeline/

impacting mitigation option in the short term (per hectare per year globally) (UNFCCC REDD Landing Page[17]).

The 4AR provided strong evidence of a changing climate and its conclusions fed into the preparation of the Bali Road Map and Action Plan. The Bali Road Map provided direction to Parties to negotiate a post-2012 outcome in two work streams, the Ad Hoc Working Group on the Kyoto Protocol (AWG-KP) and the Ad-Hoc Working Group on Long-Term Cooperative Action (AWG-LCA) under five (5) key categories – shared-vision, mitigation, adaptation, technology and finance.

In 2008, two (2) important steps in the process were launched for developing countries, specifically, the Adaptation Fund under the KP and the Strategic Programme on Technology Transfer, and in 2009, the Copenhagen Accord was produced to allow counties to voluntarily submit mitigation actions or emission reduction pledges. At the same time, developed countries pledged up to USD 30B in fast-start finance for the period 2010- 2012. In 2010, Parties agreed to a comprehensive Cancun Agreement, inclusive of the establishment of the Green Climate Fund, Technology Mechanism and the Cancun Adaptation Framework to aid developing countries to address issues associated with climate change. Parties in 2011, committed to the negotiation of a new universal climate change agreement by 2015, for the period beyond 2020. Parties also agreed to submit their Intended Nationally Determined contributions (INDC) prior to COP 21. Thereafter, Parties in 2013, agreed on the Warsaw Outcomes including the operationalization of the Green Climate Fund, the Warsaw framework for REDD+ and the Warsaw International Mechanism for Loss and Damage.

The Paris Agreement is the result of a culmination of four (4) years of rigorous targeted negotiations building on the foregoing. The Agreement was adopted by Parties in 2015, and outlines a common framework for countries to address issues associated with climate change, in particular, requiring all Parties to report on emissions reduction and implementation efforts, and undergo international review. Specifically, the Agreement reaffirms the goal of limiting global temperature increase well below 2 degrees Celsius, but also urges Parties to make efforts to limit the increase to 1.5 degrees (CCES, 2015).

The Paris Agreement was opened for signature by States and regional economic integration organisations that are Parties to the UNFCCC, on April 22, 2016, and will remain open until April 21, 2017. The Agreement will enter into force thirty (30) days after the date on which at least fifty-five (55) Parties to the Convention - accounting in total, for at least an estimated fifty-five percent (55%) of total global GhGs - have deposited their instrument of ratification, acceptance or approval for accession. At the time of revising this Report (October 05, 2016), there were one hundred and ninety-one (191) signatories to the Paris Agreement of which seventy-four (74) States have deposited their instruments of ratification,

[17] http://unfccc.int/land_use_and_climate_change/redd/items/7377.php

acceptance or approval, accounting in total, for 56.87% of the total global greenhouse gas emissions (United Nations Treaty Collection[18]). The Paris Agreement is expected to enter into force before the end of 2016.

NATIONAL RESPONSE TO GLOBAL CLIMATE CHANGE

Guyana has demonstrated its commitment to sustainable development and by extension addressing the issues associated with climate change well in advance of the UNFCCC. Guyana was the first country to establish a protected area in Amazonia – the Kaieteur National Park, established in 1929 and in 1989 offered the world to share the management of a million-acre Iwokrama Rainforest "*in a manner that will lead to lasting ecological, economic and social benefits to the people of Guyana and the world in general*" (GoG, 2015b). While climate change was not a perilous issue at that time, this foresight and vision to demarcate pristine areas of forest for conservation now has significant potential to contribute to the global fight against climate change.

Guyana became a Party to the Climate Convention in 1992 (ratified in 1994) and the subsequent Paris Agreement in 2016, and acceded to the Kyoto Protocol of the Convention in 2003. Further, Guyana tabled its instrument of ratification to the Paris Agreement on May 20, 2016. Additionally, the country is a Party to a number of other key international agreements on environment, recognizing the need to balance economic development with environmental management while safeguarding and providing for the people of Guyana. These include the Vienna Convention for the Protection of the Ozone Layer; Montreal Protocol on Substances that deplete the Ozone Layer; UN Convention to Combat Desertification; UN Convention on Biological Diversity and its Cartagena Protocol on Biosafety; Stockholm Convention on Persistent Organic Pollutants; and Convention on International Trade in Endangered Species of Wild Flora and Fauna.

Guyana's national environment and climate policy direction is shaped by its level of ambition committed and contained in its revised Intended Nationally Determined Contributions (INDC) as tendered under the Paris Agreement (Thomas, 2016b) and anchored in its pursuit of a Green Economy. Efforts to achieve a Green Economy through a resilient, low emission economic development pathway have commenced where the Government of Guyana (GoG) has expressed its commitment to *"continue the transition of our economy to realize improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcity"* (GoG, 2015b). Guyana's approach to a Green Economy is grounded in Article 36 of the Constitution of Guyana, that is, to ensure we develop sustainably through the utilization of our natural resources for the benefit of current and future generations (Thomas, 2016b). Developing Guyana as a Green Economy, according to Thomas (2016b), requires the maintenance of macro-economic stability, while at the same time, being able to anticipate shocks and disruptions to economic processes and to

[18] https://treaties.un.org/ (Chapter XXVII Environment; 7.d. Paris Agreement)

be able to offset those through the establishment of a financial mechanism such as the Sovereign Wealth Fund.

The Green Economy (GE) builds on the experiences and lessons from the implementation of the Low Carbon Development Strategy (LCDS) with the intention to develop a more inclusive and comprehensive path (GoG, 2015b) to a low emission, low deforestation, and climate resilient development plan. The GoG has indicated that the Green Economy Plan rests on six (6) pillars: (i) the protection of our biodiversity and wildlife; (ii) the provision of educational, environmental services and ecotourism; (iii) the generation of sustainable energy; (iv) the mitigation of the adverse effects of climate change; (v) management of our coastal zone, rivers, wetlands and protected areas; and (vi) the management of waste and sanitation services (GoG, 2016). In particular, the immediate activities of the GE plan will focus on (Thomas, 2016b; GoG, 2015b)(i) reforestation in mined out areas in Regions 1, 7, and 9; (ii) widen the mix of renewable energy projects through wind, solar, biomass and hydropower to supply the demand to the national grid through grid connected systems and off-grid systems for the hinterland regions and the launching of Bartica as a GE model town; (iii) development of the coastal zone and in particular the management of GhG emissions on the coast; and (iv) examining climate variability impacts across the country, recognizing that impacts by type and intensity would be peculiar across the geographical and administrative regions.

Specific implementation of activities towards a GE commenced in two (2) critical sectors, forest and energy as identified in the INDC with the focus on reducing carbon emissions, recognizing that this is the leading source of GhGs. Guyana's Second National Communication (SNC) identified the energy sector, in particular, the power generating sub-sector, as contributing the largest share of GhG emissions historically and while carbon emissions exist in the forest sector as a result of infrastructural development and land use change, the sector has the largest potential for carbon dioxide removals.

As such, in the fight against climate change Guyana has pledged to avoid deforestation and carbon emissions in the amount of 48.7MtCO_2e annually (GoG, 2015b) through the implementation of an Emissions Reduction Programme (ERP). The ERP for forest include (i) Reduce Impact Logging in the timber industry, (ii) Improved Monitoring, Reporting, and Verification System (MRVS) for assessing levels of forest degradation and deforestation; and (iii) Improved Forest Governance and Institutional Capacity Upgrading (IFG & ICU) (Thomas, 2016a). This programme, once implemented, will see reforms in the mining and forest sectors, conservation of an additional two (2) million hectares of forest through the national protected areas system and sustainable management of commercial state forest estate through RIL. The strengthening and implementation of RIL techniques in the timber industry will result in annual emissions reductions from 3.5 MtCO_2e to 2.3 MtCO_2e, that is, eleven percent (11%) reduction in the overall historic emissions level.

The second commitment outlined in the INDC and is being pursued within the GE framework is to increase the share of renewable energy by 100% by 2025 (Thomas, 2016b; GoG, 2015b). Guyana has committed to develop an energy mix comprising of wind, solar, biomass and hydropower to supply grid connected and off-grid (hinterland regions) connected systems. It intends to pursue small hydropower systems at specific locations across the country and, in particular, establish six (6) new towns powered by renewable energy sources (GoG, 2015b), commencing with the town of Bartica, Region 7. The GoG further plans to ensure all government buildings are powered by renewable energy within the next four (4) years.

In addition to the foregoing, over the years Guyana has implemented various initiatives and actions to address the issues associated with climate change. Key among these are the development of the LCDS and the implementation of the Mangrove Restoration Project. The LCDS was launched in 2009 as a workable national scale model with global reach in the absence of an international community agreement on a REDD+ framework. The Strategy aimed to pursue a low carbon development path while transforming the economy. It sets out one approach to achieve this by deploying the forest to mitigate climate change and receive payments in return for its forest carbon service. It proposes to utilise the revenue earned to invest in low carbon projects across a number of sectors. The Government of Norway expressed interest to partner with Guyana to realize this aspect of the LCDS and in 2009, both governments joined in partnership, Box 2.1 provides additional information on the LCDS and the Guyana Norway Agreement (GNA).

Box 2.1: The Guyana Norway Initiative

The Low Carbon Development Strategy (LCDS) launched in 2009, aims "*to transform Guyana's economy to deliver greater economic and social development along a low carbon path while addressing climate change"* (GoG, 2009). The Strategy is founded on three pillars: (i) investment in low carbon economic infrastructure; (ii) investment and employment in low carbon economic sectors; and (ii) investment in communities and human capital. The LCDS further sets out the framework for Guyana to deploy its forests to mitigate global climate change and to receive payments in return for the carbon service recognizing the significant potential for GhGs reductions from avoided deforestation. The LCDS outlines that this could be done without compromising forest sovereignty or affect the development prospects of the people of Guyana through low carbon, low deforestation, and climate resilient development. This approach is currently framed in the context of a Green Economy whereby low carbon, climate resilient development are components.

The Strategy outlined a number of priority areas whereby the earnings from forest climate services will be channelled inclusive of strategic low carbon investments and protection for people and productive land from changing weather patterns.

While the international community negotiated a REDD+ agreement, forest countries articulated the urgent need for interim financing in the period before 2020. The Government of Norway recognised this need and filled the gap through national-scale forest climate services agreement with three forest counties, including of Guyana.

The Governments of Guyana and Norway signed a Memorandum of Understanding (MOU) on November 09, 2009, agreeing that Norway would provide Guyana with result-based payments for forest climate services of up to US$250 million by 2015. This payment is dependent on Guyana's delivery of results as measures against two (2) sets of indicators: Indicators of Enabling Activities and REDD+ Performance Indicators. These indicators were established by both Parties and set out in the Joint Concept Note (JCN) that operationalizes the MOU and at the same time both countries agreed to work together to address the issues associated with climate change, the protection of biodiversity and the enhancement of sustainable development (JCN, 2009).

Since 2009, Guyana has made significant progress in the areas of forest management through sustainable forest management and avoided deforestation to maintain a low deforestation rate. It is worthy to note, that Guyana's forest conservation efforts are embedded in the wise use of the land by the original forest stewards, successive government's efforts, along with contributions from key stakeholders and conservation institutions, to sustainably manage the forests resource (GoG, 2015b) allowing for an estimated 18.48 million hectares of intact forest cover (GFC *et al*. 2015) for assessments conducted up to December 2014. The country has maintained its deforestation rate below one (1) per cent and recorded a deforestation rate of 0.065% in 2014. A robust national-scale Monitoring, Reporting and Verification System (MRVS), the performance-based system established to implement a national scale REDD+ mechanism and the Guyana Norway Agreement allows for annual reporting on deforestation and degradation since the onset of the partnership. Guyana has received four (4) payments for forest climate services through this partnership, a total of US$ 150 million to date, making it the second largest interim REDD+ arrangement in the world. A Guyana REDD+ Investment Fund (GRIF) was established as a multi-partner financial mechanism to channel the funds received from the Government of Norway to Guyana to support a number of on-going projects in areas of renewable energy, Amerindian development and adaptation among others.

The Guyana Mangrove Restoration Project (GMRP) started in 2010, and was co-funded by the Government of Guyana (GoG) and the European Union (EU) under the Global Climate Change Alliance with the National Agriculture Research and Extension Institute (NAREI) as the implementing Agency, Box 2.2 provides additional information on the restoration of mangroves along the coast (see also Figure 2.1 & 2.2).

Figure 2.1: Restored mangrove forest along East Coast Demerara (Chateau Margot & Felicity). *Source: NAREI, 2016*

Box 2-2: Restoring Mangroves along Guyana's Coast

Guyana's mangrove cover declined significantly from an estimated 80,000ha in 1992 to 22,632ha in the year 2011 (Persaud 2011). Some of the major factors which lead to the decline include: removal of mangroves for domestic uses; agriculture development; coastal aquaculture; fuel source to make bricks for construction; national infrastructure projects; housing and tourism development; clearance of mangroves to remove or reduce the nuisance of mosquitoes; and encroachment and squatting in mangrove areas (Bovell 2010; GMRP2013).

Recognizing the risk to the coastline and the population, the Government of Guyana (GoG) with support from the European Union (EU) started a project to restore, protect and manage the country's coastal mangrove resources. The Guyana Mangrove Restoration Project (GMRP) commenced in 2010 and was implemented by the National Agriculture Research and Extension Institute (NAREI,) with support from a multi-agency oversight committee known as the Mangrove Action Committee (MAC).

The project activities were focused on implementation of Guyana's National Mangrove Management Action Plan (NMMAP), specifically, components which include rehabilitation, protection and sustainable use of mangroves, monitoring and the enforcement of forest legislation, formulation of a Code of Practice for mangrove management, public awareness and education among others (GMRP 2010).

A multidisciplinary approach was applied for mangrove restoration, protection and management and Village Mangrove Action Committees (VMAC) were established where members were trained in mangrove ecology, restoration and management, seedling propagation and mangrove monitoring. VMAC provided the mangrove seedlings for restoration and supported with the monitoring, awareness and nursery components of the project (GMRP 2012).

The project also sought options for alternative livelihoods that would encourage communities to manage and protect their coastal mangroves while earning an income. Villagers were trained in apiculture and provided with technical assistance, equipment and marketing and packaging. The alternative livelihood beekeeping sub-project resulted in the establishment of a vibrant cooperative that markets honey under a *"mangrove reserve products label"* (NAREI 2014).

Figure 2-2: Restored mangrove forest along West Cost Berbice (Village 6 – 8).
Source: NAREI, 2016.

Results

The restoration resulted in production of 496,771 mangrove seedlings, primarily *Avicennia germinans,* planted at fifteen locations north of the existing sea defence structure. Initial efforts of restoration were less successful due to limited local expertise in restoration. The success rate increased during the second year of project implementation following the fielding of technical experts and training of local project team. Based on survival rate of planted seedlings and extensive natural regeneration, the project has successfully restored 142 ha of coastal mangrove forest. Field monitoring of planted restoration sites facilitated a comprehensive statistical analysis for survival and growth rates. Assessments completed (Machin and Lewis III 2013; Adams 2014) indicated that survival rates and growth varied among restoration sites and can be grouped into three scenarios:

1. Fast growing and high survival: Evident at Wellington Park, Village #6-8, Chateau Margot, Success, Lima). Mud elevation 2.13 – 2.49cm above CD

2. Slower growing and high survival: Evident at Greenfield, Hope Beach, Le Ressouvenir & Felicity. Mud elevation 1.61 – 2.37cm above CD

3. Low or no survival: Evident at Hope, Greenfield, Victoria, Section C Enterprise, Mon Repos, LBI/Triumph, Buxton, NootenZuil, Lusignan. Mud elevation 1.9 to 2.4m above CD

Challenges

The lack of baseline data on the impact of anthropogenic activities at each project site prior to application of interventions (e.g. extent of livestock grazing, illegal harvesting) made it difficult to quantitatively estimate the reduction in threats after the intervention.

The importance of mud bank movement along the coast of Guyana and its influence on mangrove management and restoration has been recognized and documented (Gratiot 2010; Welage 2005). However due to limited research on the movement and mapping of mud banks along coastal Guyana, the project continues to be challenged to effectively plan restoration activities based on definitive data on the current and future location of mud banks.

Following the completion of the project phase, the Mangrove Department was challenged to motivate community members at some of the intervention sites to continue to actively participate in mangrove protection and awareness and to become involved in the monitoring of their coastal resources. The will to change old habits such as garbage dumping and illegal grazing continues to threaten restoration.

While the public awareness and education campaign has resulted in significant reduction on mangrove destruction, there continues to be conflict with regards to land tenure and the protection of mangroves on private lands. Mangrove destruction for the production of burnt bricks used in the road construction industry continues to be a problem, though apparently restricted to the Abary area. The laws protecting mangroves are vested in other sector agencies and continue to prove challenging to enforce (NAREI 2016).

Moreover, a number of specific actions and projects were implemented over the years and principal among them were (GoG, 2012 & 2007):

- The appointment of a UNFCCC focal point;
- Reactivation of the National Disaster Risk Reduction Coordination Platform;
- The establishment of an Office for Climate Change in 2009 to coordinate and implement climate change initiatives and the REDD Secretariat to oversee Guyana's REDD+ initiatives and manage the MRVS;
- Preparation of a Climate Resilience Strategy and Action Plan for Guyana;
- Preparation of a Disaster Risk Management Policy and Disaster Risk Management Plan;
- The Guyana Energy Agency strategic direction to expand the share of renewable energy and reduce dependence on imported fossil fuel and preparation of a number of energy studies including energy audits;
- Preparation and submission of the Initial and Second National Communications to the UNFCCC;

- Implementation of measures to adapt and mitigate human-induced climate change, as best as, resources can permit, in light of other pressing socio-economic activities;
- Implementation of projects such as the Caribbean Planning for Adaptation to Climate Change (CPACC) and Mainstreaming Adaptation to Climate Change in the Caribbean (MACC);
- Institutional capacity building activities with sector agencies such as the Sea and River Defence Board in areas of climate monitoring and evaluation with emphasis on sea level rise and wave intensity on the coast;
- Mitigation projects, for example, the Environmental Protection Agency in collaboration with CIDA and SENES carried out a project which resulted in recommendations to the rice and wood sectors on technological changes to reduce GhG emissions into the atmosphere;
- Production of biofuels by the Institute of Applied Science and Technology;
- Initiatives to integrate climate change into national development plans and programmes such as the National Capacity Self-Assessment Project;
- Implementation of training and public awareness activities on climate change and its associated impacts by a number of institutions including the Office of Climate Change, Guyana Energy Agency, National Agriculture Research and Extension Institute (NAREI), Environmental Protection Agency, and School of Earth and Environmental Sciences of the University of Guyana.

GUYANA'S CLIMATE PROFILE

Guyana's weather and climate are influenced by seasonal shifts in the Equatorial Trough (ET) which brings heavy rain to the Amazonian Basin (GoG, 2012; Bovolo *et al*, 2009) and the Inter-Tropical Convergence Zone (ITCZ) (GoG, 2012). As a result, Guyana experiences typically warm and wet tropical climate (McSweeney *et al*, 2008 and McGregor and Nieuwolt, 1998).

It is worth noting, according to Bovolo *et al*, (2009), that from a climate perspective, the Guianas and Amazonian rainforests are interconnected and, thus, have a role in regulating and/or influencing the weather of the region[19]. In particular, the Amazon creates about fifty to eighty percent (50-80%) of its precipitation through evapotranspiration (Butler, 2012) and several model studies and field experiments have confirmed about fifty percent (50%) of the rainfall in the region originates from water recycled in the forest (IPCC, 2001). It was found that even small changes in the evapotranspiration process can affect the water vapour fluxes. Deforestation, therefore, can reduce precipitation as a result of a decrease in evapotranspiration

[19] However, Bovolo *et al*, (2009) further notes that additional research is needed to understand how the rainforests generate and buffer climate.

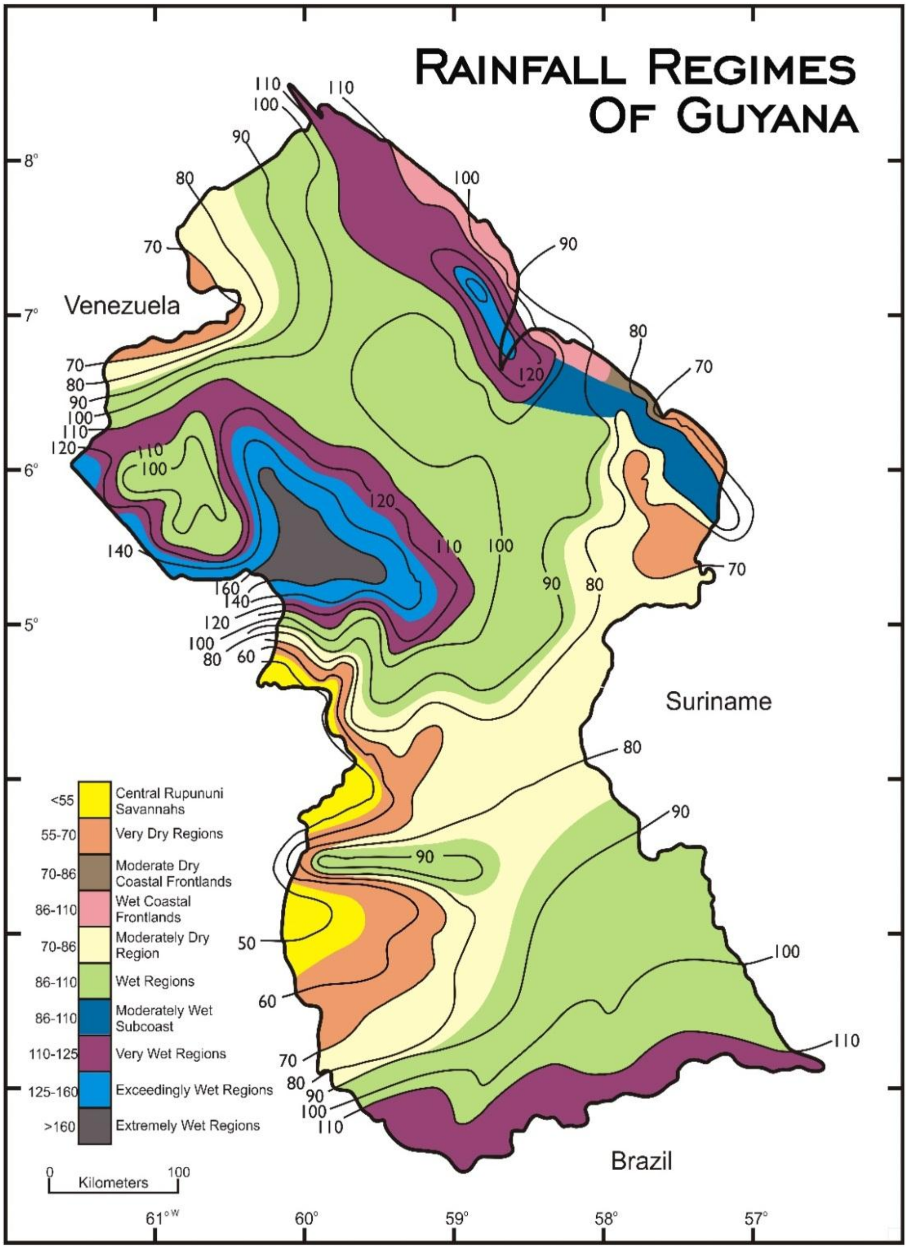
and a reduction in rainfall would affect activities, in particular, agriculture not only in Amazonia but also the Guianas (IPCC, 2001).

PRECIPITATION

According to the Second National Communication (2012), annual average rainfall totals range between 1,600mm to 3,000mm (GoG, 2012). Bovolo *et al*, (2009) concluded that precipitation in the country is spatially and temporally variable with influences from the ET and El Niño Southern Oscillation (ENSO). Geographical influences such as mountains and ocean contribute to spatial variability of rainfall in Guyana resulting in three major climate types (GoG, 2012). Persaud and Persaud (1995) identified three main rainfall regimes in Guyana, and then divided these types into different subcategories in order to define different rainfall regions.

Figure 2.3 illustrates these different rainfall regimes and research shows that the highest annual rainfall is found in the mountainous area of Guyana and the lowest annual rainfall in the savannahs.

Figure 2.3: Average annual distribution of rainfall (in inches) in Guyana.
Source: Persaud and Persaud (1995), as provided by Hydromet, 2016.



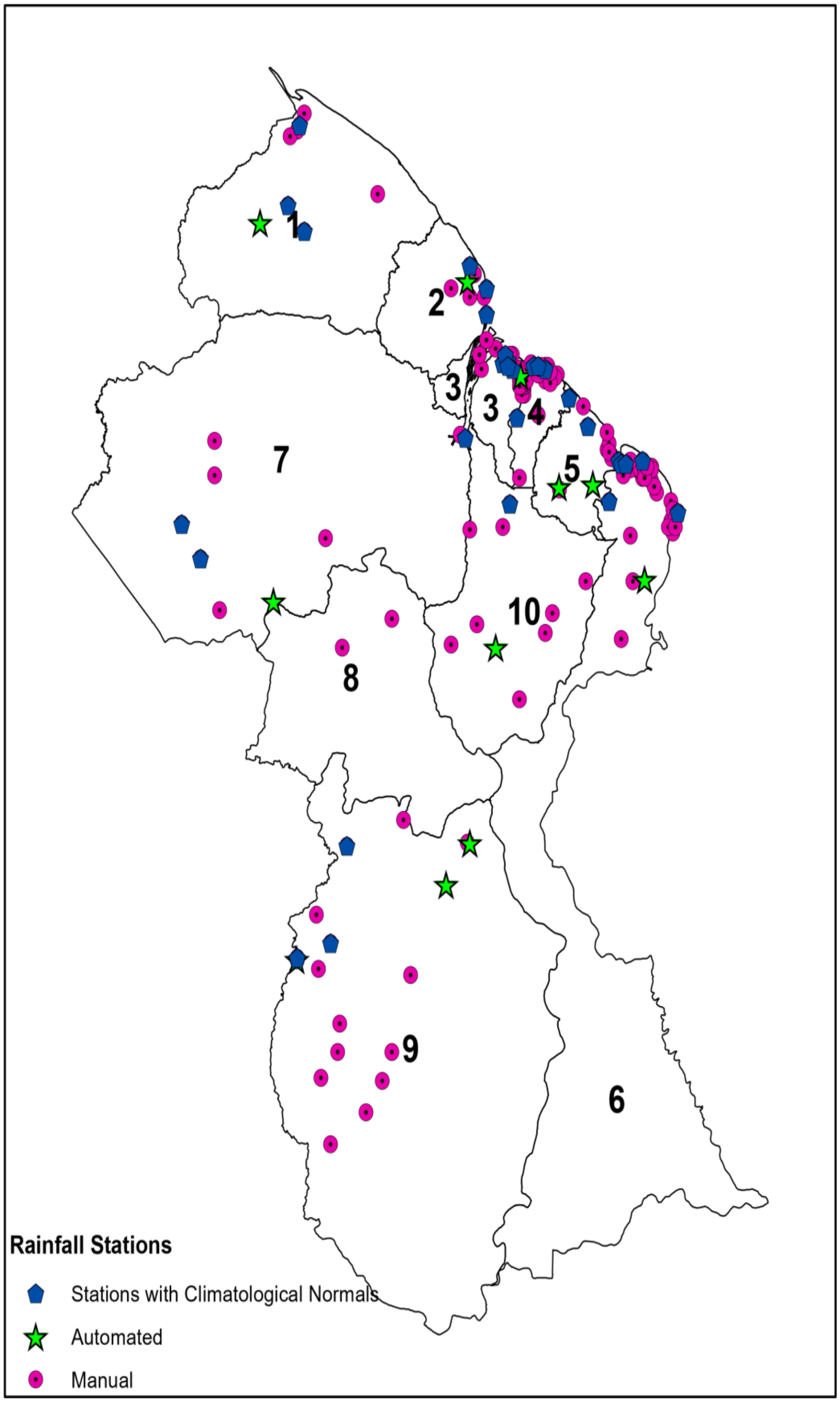
The three major rainfall regimes are referred to as (GoG, 2012):

- Tropical savannahs or very dry regions - Areas with annual rainfall less than 1788 mm. Such areas are located in the Rupununi Savannahs, the Intermediate Savannah (south of Guyana), the Upper Cuyuni (north west of Guyana) and the Corentyne Coast. The Corentyne coast is found to be much drier than places further inland.

- Very wet tropical rainforest climate (very wet regions) - These are areas with annual rainfall exceeding 2728mm. These regions are found in the Pakaraima Mountains, the upper Akarai Mountains and the sub coast.
- Wet/dry tropical rainforest (wet/dry regions) - The remainder of country experiences this type of climate. These are areas with annual rainfall between 1778 mm and 2800 mm.

The distribution of rainfall stations across Guyana is shown in Figure 2.4 below where the icons in the legend depict the type of stations and those used for climatological analyses.

Figure 2.4: Map showing types of rainfall stations across Guyana.
Source: Hydromet, 2016



According to the Second National Communication (2012), mean annual rainfall across Guyana (coast) increased at an average rate of 4.8mm per month or 2.7% per decade since 1960 (GoG, 2012 & McSweeney *et al*, 2008). The SNC concluded, as referenced by McSweeney *et al*, (2008) with 95% confidence, that the trends in both annual and seasonal rainfall are minimal and not statistically different (GoG, 2012).

Bovolo et al, (2009) concluded that high precipitation occurs in June and December along Guyana's coastal areas, in particular, over Regions 1-6. Precipitation across these Regions was found to vary based on their monthly averages for the months of September and October. Coastal Regions in the southeast were receiving less rainfall than in the north during those times (Bovolo et al, 2009). Bovolo et al, (2009) found similar patterns in Regions 7 and 10 and concluded the similarity is based on proximity to the coast - even though these are inland Regions they run parallel to the coast. It was found that Region 8, north of Iwokrama receives the highest rainfall in Guyana whilst Region 9 receives the least rainfall[20] (Bovolo et al, 2009).

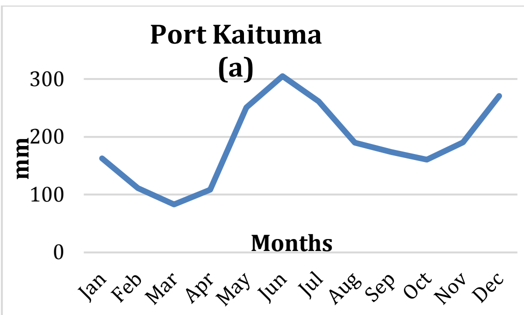
Specific trend lines for rainfall, provided by the Hydrometeorological Department (2016), show monthly variation of rainfall across the Administrative Regions which supported the conclusions made by Bovolo et al, (2009). These monthly values were considered as the Climatological Normal, which is the monthly total average for the period of thirty (30) years. Due to incomplete datasets, some of the Climatological Normal were calculated for less than thirty (30) years. Further, annual rainfall accumulated across the country's' four (4) natural regions for the thirty-year period is also presented.

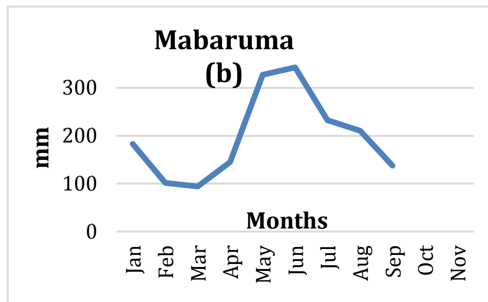
[20] This is as a result of the Savannah region in Region 9 experiences only one dry season and one wet season (Bovolo *et al*, 2009).

Region 1

Rainfall Observational Stations in Region 1, as illustrated in Figure 2.5 (a) & (b), Port Kaituma and Mabaruma respectively, show similar rainfall trends throughout the year with rainfall peaking for the month of June. However, as a result of incomplete dataset, trends for October-December for Mabaruma cannot be shown.

Figure 2.5 Climatological rainfall trends for Port Kaituma and Mabaruma. *Source: Hydromet, 2016*.

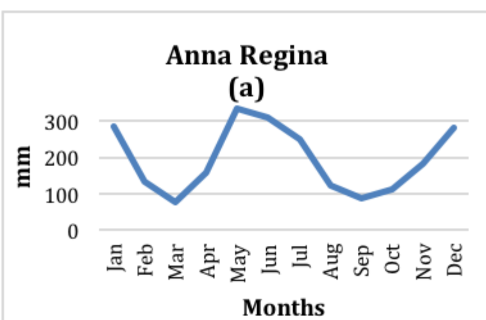


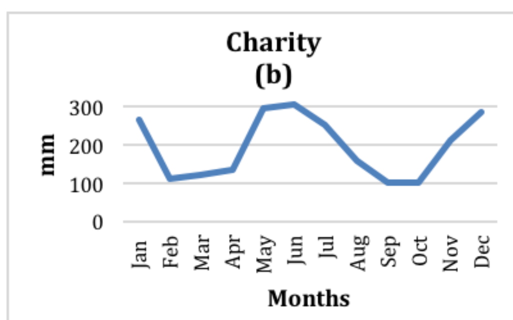


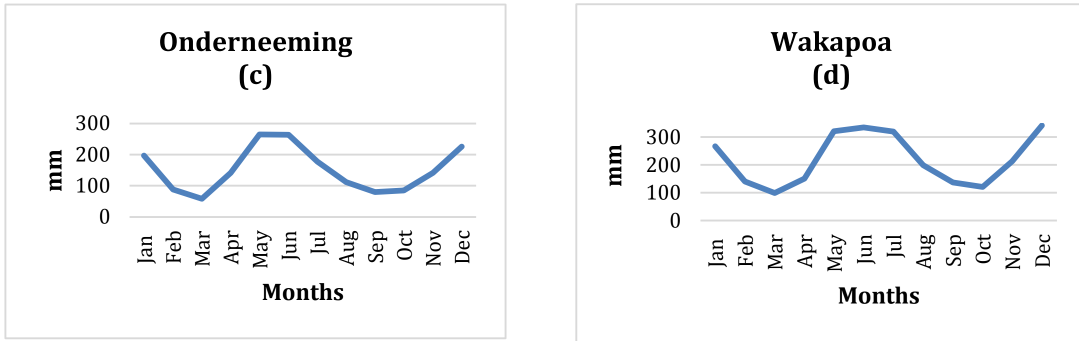
Region 2

Rainfall Observational Stations in Region 2 as shown in Figure 2.6 (a), (b), (c), (d) Anna Regina, Charity, Onderneeming and Wakapoa show similar rainfall trends across two (2) rainfall seasons, the primary season occurring mid-April to Mid-June with rainfall peaking for the months of June and December.

Figure 2.6 Climatological rainfall trends for stations in Region 2. *Source: Hydromet, 2016.*



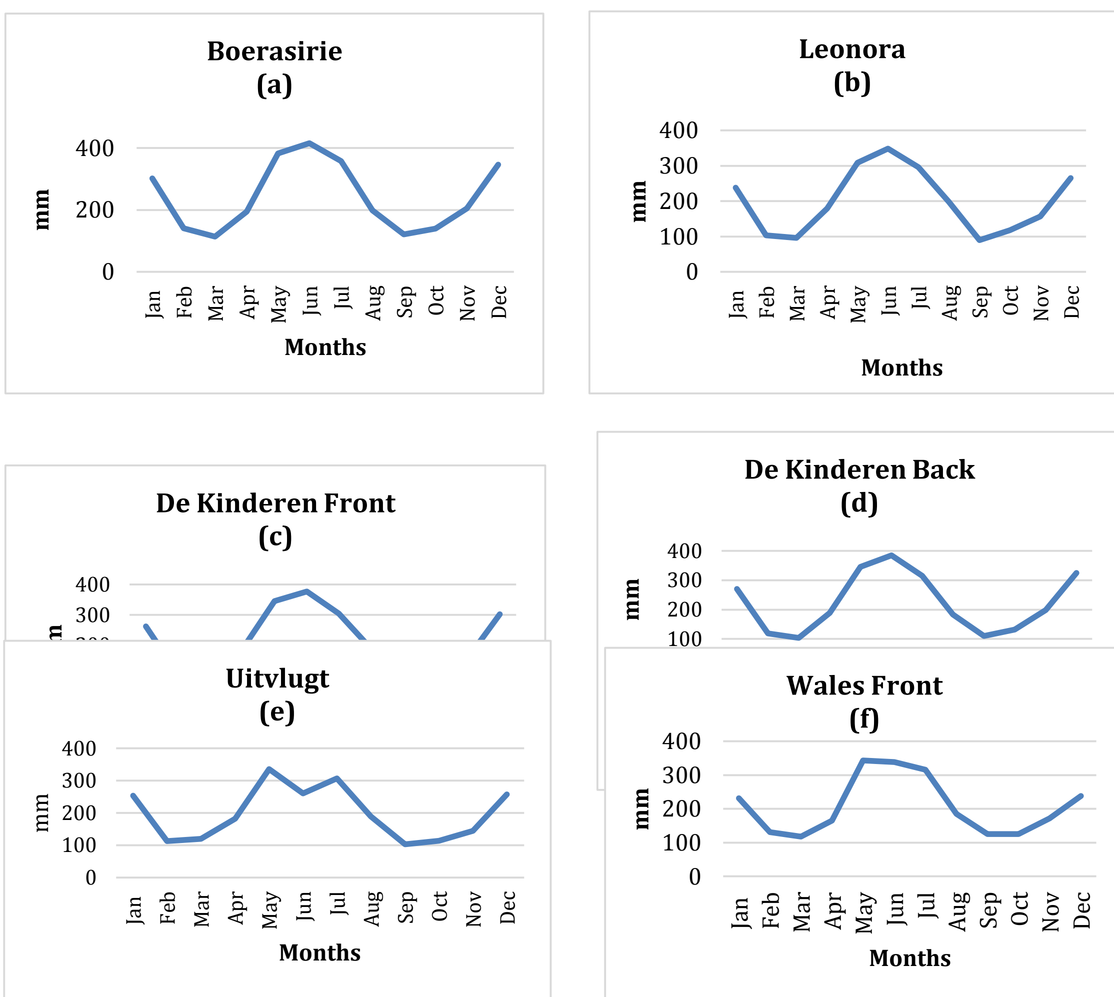




Region 3

Rainfall Observational Stations in Region 3 as illustrated in Figure 2.7 (a) – (f) show similar climatological rainfall trends as observed for Region 2. However during the month of June, the peak rainfall in Region 3 is higher than that of Region 2 with the Boerasirie station (East Bank Essequibo) recording the highest for the Region.

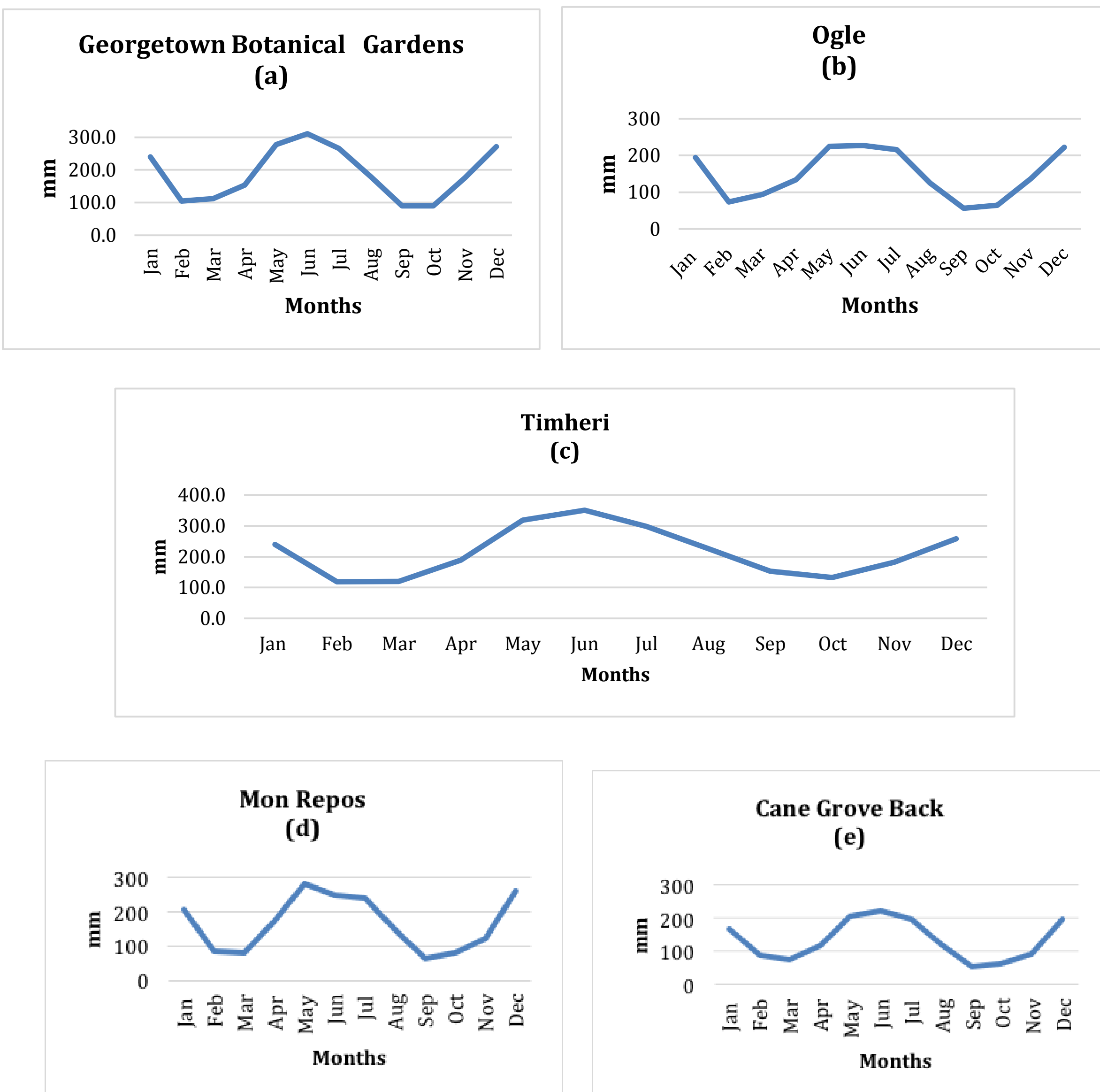
Figure 2.7 (a) & (f) Climatological rainfall trends for stations within Region 3. *Source: Hydromet 2016*



Region 4

Rainfall Observational Stations illustrated in Figure 2.8 (a) – (e) show climatological rainfall trends in Region 4. Figure 2.8 (b) shows an approximate 90mm less rainfall as compared to the Georgetown rainfall station located at the Botanical Gardens Figure 2.8 (a) despite a distance of less than 10km between these stations. Figure 2.8 (c) shows a longer primary rainfall season at the Timehri station and this is mainly due to higher elevation with reference to Mean Sea Level and the station located within the Hilly Sand and Clay Region.

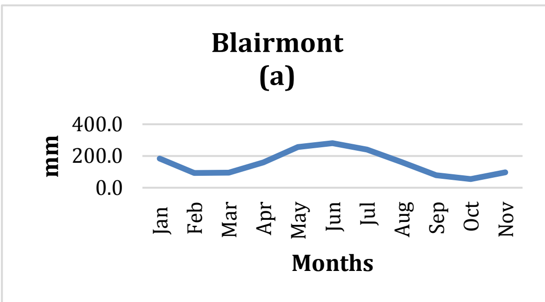
Figure 2.8 Climatological rainfall trends for stations within Region 4. *Source: Hydromet, 2016.*



Regions 5 and 6

Rainfall Observational stations within Regions 5 and 6 as shown in Figure 2.9 (a), (b) & Figure 2.10 (a) – (d), respectively, also experience two (2) rainfall seasons. In general, they have similar climatological rainfall trends as the rest of the stations on the Low Coastal Plain.

Figure 2.9 Climatological rainfall trends for stations within Region 5. *Source: Hydromet, 2016.*



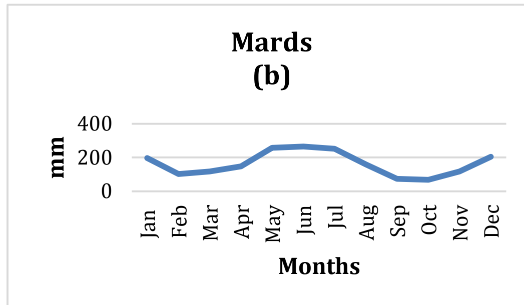
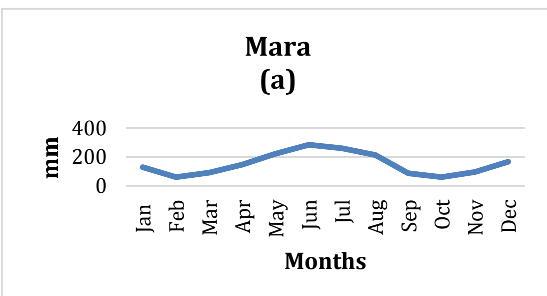
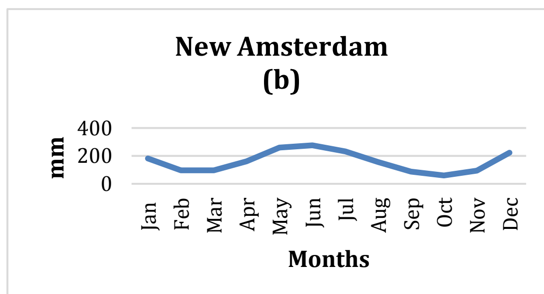
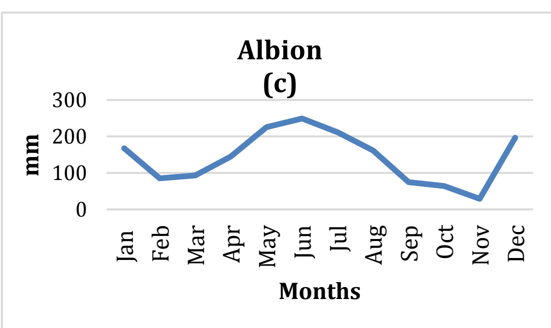
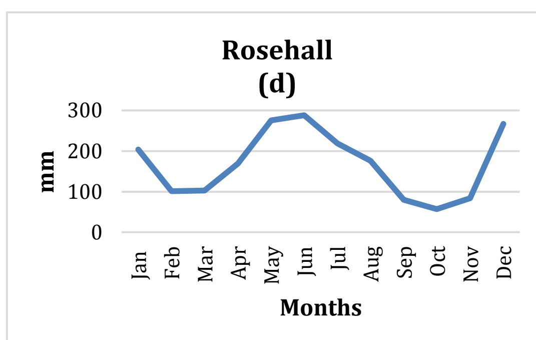


Figure 2.10 Climatological rainfall trends for stations within Region 5. *Source: Hydromet, 2016.*





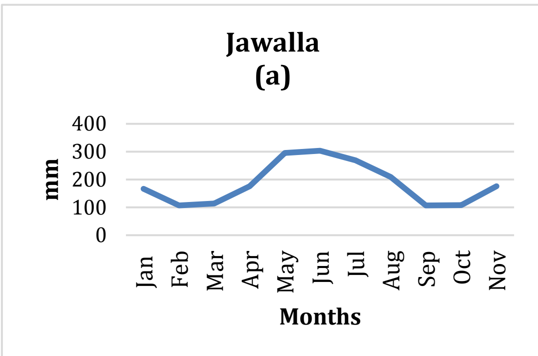


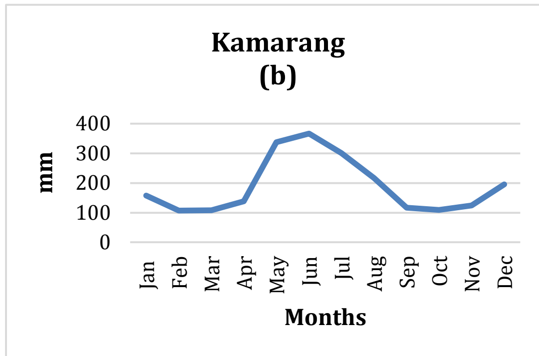


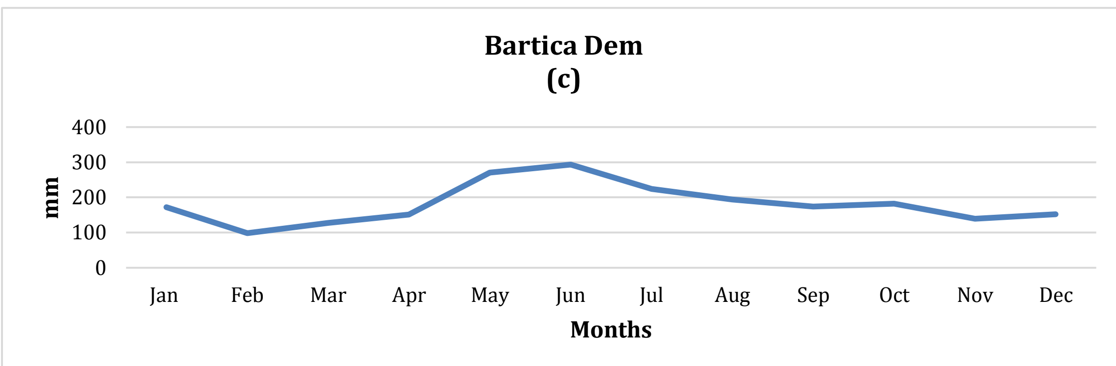
Region 7

Figure 2.11 (a) – (c) shows climatological trends for two (2) rainfall seasons, however, the primary rainfall season is much more intense than the secondary rainfall season as compared to stations on the Coastal Plain. Additionally, Bartica DEM shows higher rainfall for October as compared to most of the stations across Guyana.

Figure 2.11: Climatological rainfall trends for stations within Region 7. *Source: Hydromet, 2016.*



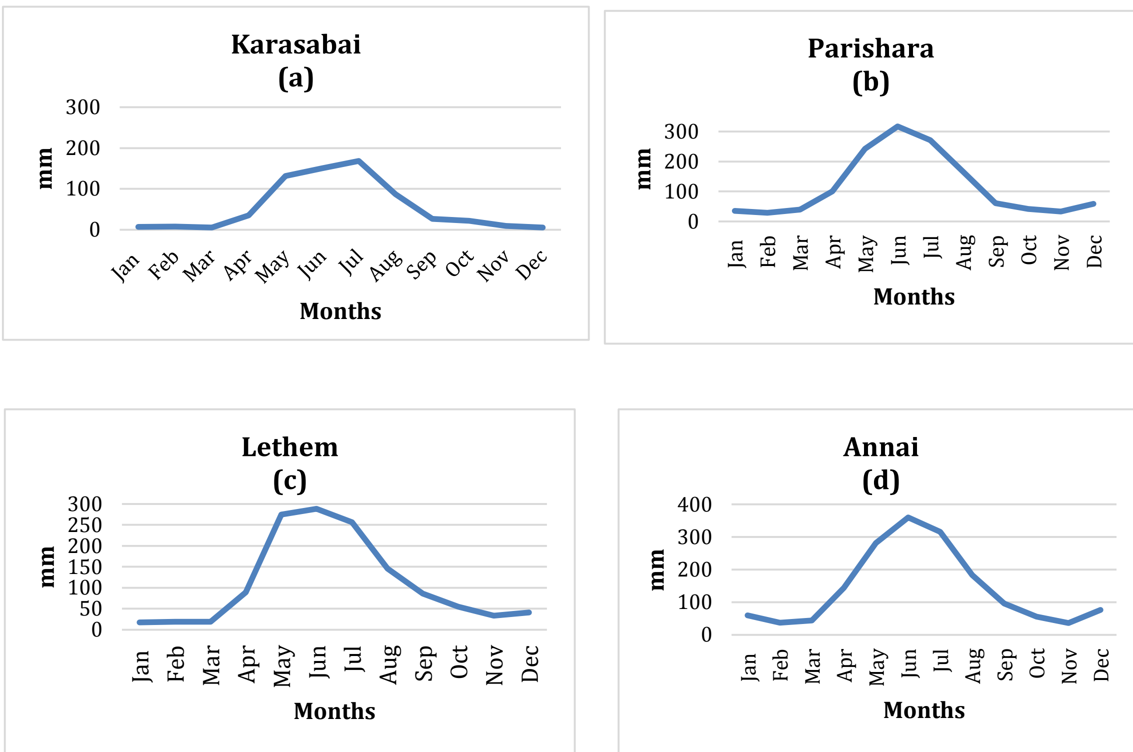




Region 9

Figure 2.12 (a) – (d) illustrates climatological trends for rainfall stations in Region 9 showing one (1) rainfall season, specifically, mid-April to mid-August with monthly rainfall peaks in June. Karasabai recorded the lowest rainfall and Parishara the highest.

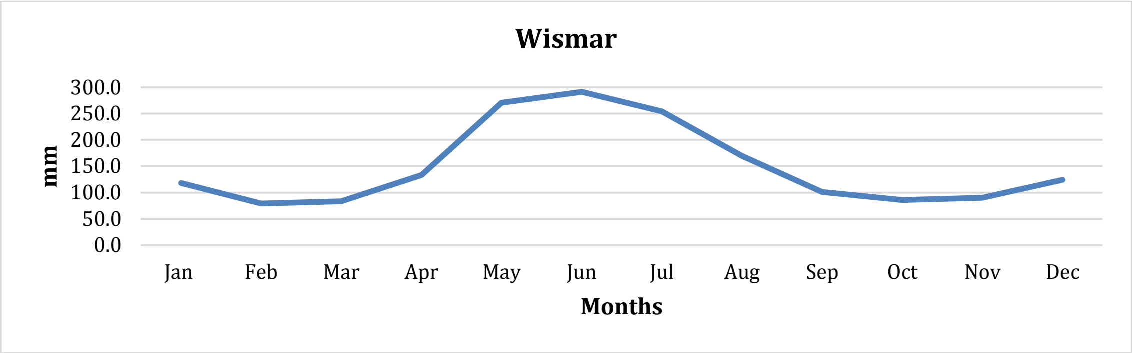
Figure 2.12: Climatological rainfall trends for stations within Region 9. *Source: Hydromet, 2016.*



Region 10

Figure 2.13 illustrates climatological trends for the Wismar rainfall station in Region 10. This Region usually experiences two (2) rainfall seasons similar to the coast. However, the primary rainfall season for this Region is much longer than those Regions on the Coastal Plain.

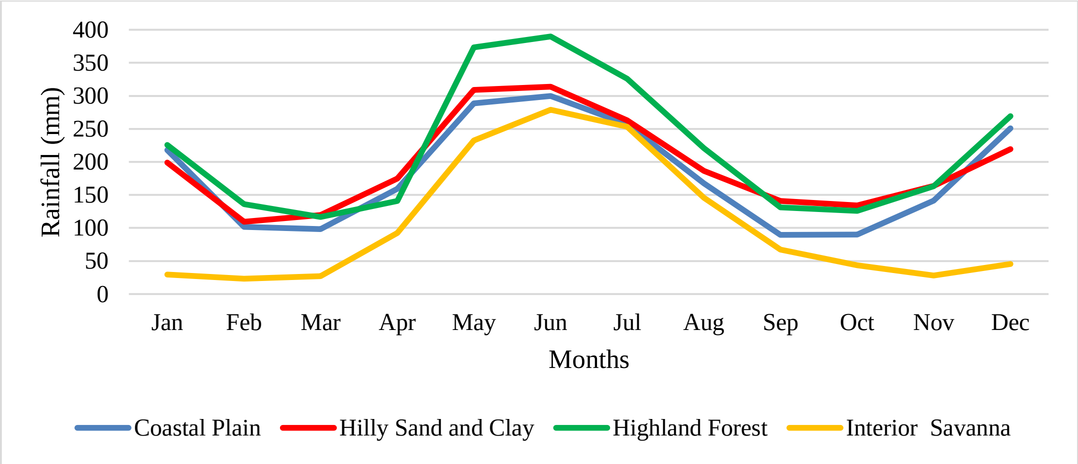
Figure 2.13 Climatological rainfall trends for Wismar, Region 10. *Source: Hydromet, 2016.*



Accumulated rainfall across the Four (4) Natural Regions

Elevation, vegetation, topography and ocean are some of the factors that have great influence on rainfall. The orography of Guyana serves as a typical example to demonstrate these influential factors and such results can be illustrated in Figure 2.14 – a comparison of rainfall for the four Natural Regions of Guyana. Trends show the highest rainfall is being observed in the Highland Forests with a long-term annual accumulated rainfall of 2618.7 mm for the thirty year (30 yr) period followed by Hilly Sand and Clay and Coastal Plain with 2334 mm and 2161.7 mm, respectively, and the lowest at the Interior Savannahs with 1266 mm. It can be observed also, that the Interior Savannahs experience one rainfall and dry season while the other three natural regions experience two rainfall and dry seasons.

Figure 2.14: Long-term annual accumulated rainfall across Guyana's four (4) Natural Regions over a thirty (30) year period. *Source: Hydromet, 2016.*



TEMPERATURE AND HUMIDITY

According to the SNC, air temperature in Guyana ranges between 16 °C and 34 °C with lower temperatures in regions of higher elevation (GoG, 2012). McSweeney *et al*, (2008) concluded mean air temperature is 25 °C to 27.5 °C throughout the year across most of the Administrative Regions with the exception of the highlands in the west of the country. Mean temperature in this region was found to be cooler at 20 °C to 23 °C. Temperatures on the coast range between 22 °C and 31 °C due to the stabilizing effect of the sea and the North Eastern Trade Winds (GoG, 2012).

Guyana has recorded an increase of 0.3°C since 1960, in its mean annual temperature or an average rate increase by 0.07°C per decade (GoG, 2012 & McSweeney *et al*, 2008) with the highest recorded change occurring during August – September dry season (GoG, 2012). According to McSweeney *et al*, (2008), the rate of increase was found to be less rapid (moderate in Guyana) than the global average, however, the increased frequency of hot days and nights[21] was observed to be increasing significantly since 1960 across the seasons[22]. It was concluded that the average number of 'hot' days per year have increased by 93 between 1960 and 2003 – an increase by twenty-five percent (25%) of hot days in Guyana [23] (McSweeney *et al*, 2008). This increase was most evident in the months of June, July and August where it was found that the average number of hot days increased by nine (9) days per month for the period. McSweeney *et al*, (2008) further observed an increase in the number of 'hot' nights by 87 – an increase of twenty-four percent (24%) of hot nights for the period (1960-2003); an average increase of ten(10) days per month most strongly observed in the months of March, April and May.

Accumulated temperature across the Four (4) Natural Regions

Specific trend lines, based on available data for a twenty-five (25) year period provided by the Hydrometeorological Department (2016) show very little variance in temperature across Guyana's four (4) natural regions. It can be observed that the Interior Savannahs experience the highest temperatures while all other natural regions experience similar temperatures and trends throughout the year, refer to Figure 2.15**.** October is observed to be the hottest month of the year. Further, the Interior Savannahs, the Region with the least vegetation and thus, moisture conveyance, has greater exposure to direct sunlight causing the absorption of more solar radiation with the resultant higher observed temperatures.

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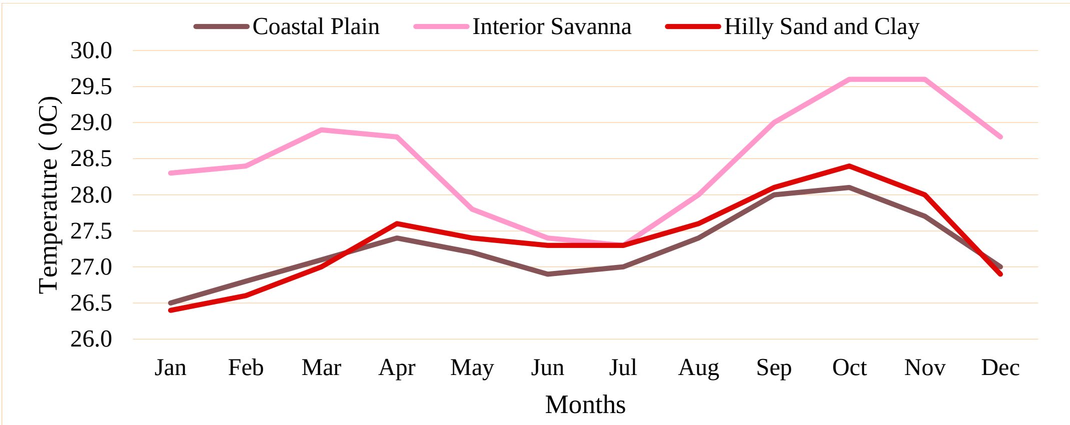
[21] McSweeney *et al*, (2008), defines a hot day or hot night by the temperature exceeded on 10% of days or nights in current climate of the region and season.
[22] This observation was made based on where data is available.
[23] This increase in frequency was undertaken for a 43-year period (1960-2003) and was estimated based on the decadal trend.

Figure 2.15: Mean annual temperature across three (4) Natural Regions over a twenty-five (25) year period. *Source: Hydromet, 2016.*

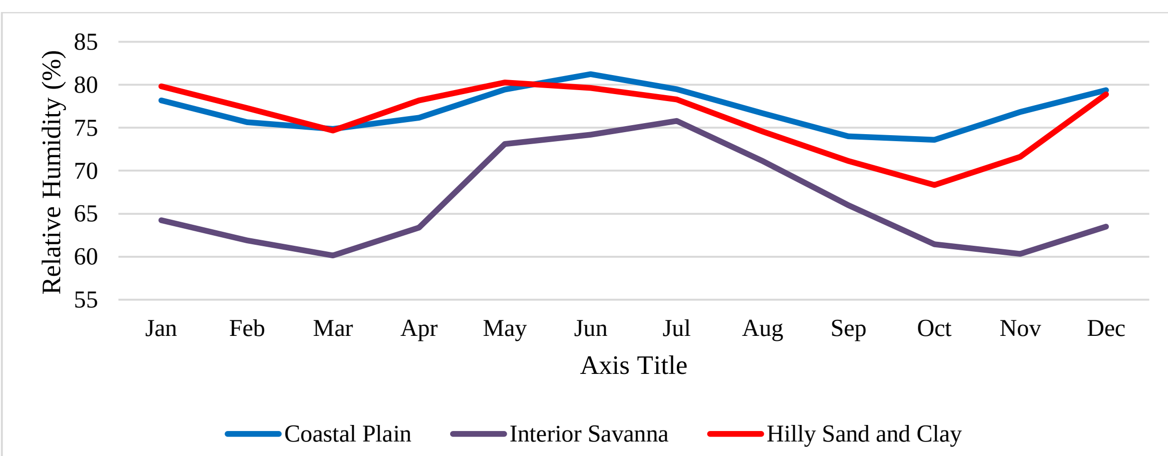


Relative humidity is high, averaging eighty percent (80%) or more on the coast and approximately seventy percent (70%) in the savannah regions. However, humidity can reach one hundred percent (100%) in the rainforest regions especially in the morning hours (GoG, 2012).

Accumulated humidity across the Four (4) Natural Regions

Relative humidity is one of the parameters that highly correlate with temperature and rainfall. The absence or minimum rainfall means lower relative humidity and vice versa and this can be observed if Figure 2.16 is superimposed with Figure 2.15. The lowest relative humidity is observed across the Interior Savannahs with a long-term annual mean of 66.3% while the highest is observed across the Coastal Plain with an annual long-term mean of 77.1%.

Figure 2.16: Long-term annual mean relative humidity across three (3) natural regions over an eighteen (18) year period. *Source: Hydromet, 2016.*



OVERVIEW

Over the last half-century, Guyana has experienced changes and variability in its climate system. Since the 1960s, mean annual temperatures have increased by more than 1°C and frequently occurring extreme rainfall events have triggered intense periods of flooding and drought. Moreover, Guyana's sea levels have risen at a rate that exceeds global trends. Projections demonstrate that these trends will continue and exacerbate by the end of this century. Guyana will face serious challenges from higher temperatures; refer to Figure 2.17, sea level rise and extreme weather events. Temperatures may increase by up to 4°C by the 2090s with the southern parts of country experiencing greater warming. Total rainfall is projected to decrease and by 2050 however, precipitation that falls in heavy events may increase[24], refer to Figure 2.18.

Figure 2.17: Mean annual temperature projections[25]

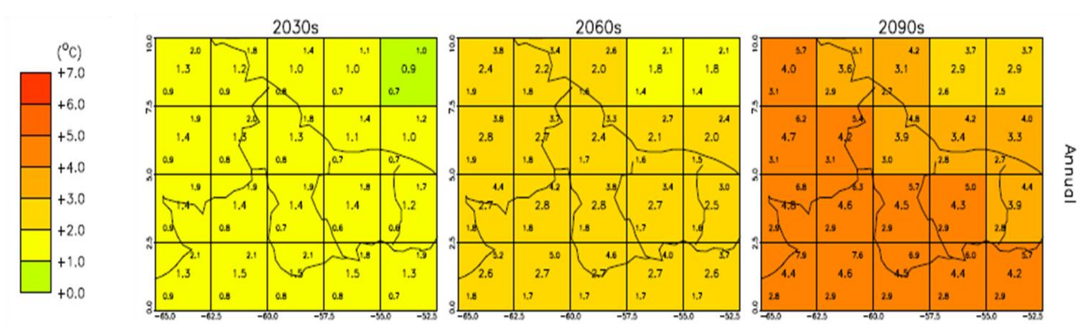
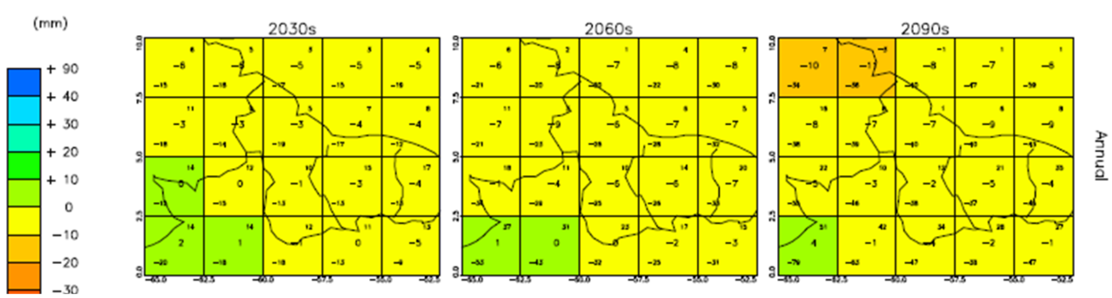


Figure 2.18: Mean annual precipitation projections[26]



[24] GoG 2012

[25] McSweeney, C., New, M. and Lizcano, G. (2010). UNDP Climate Change Country Profiles: Guyana. Available at: http://country-profiles.geog.ox.ac.uk

[26] McSweeney, C., New, M. and Lizcano, G. (2010). UNDP Climate Change Country Profiles: Guyana. Available at: http://country-profiles.geog.ox.ac.uk

Sea level is projected to rise by 40cm – 60cm by the end of the 21st century. In the SNC to the UNFCCC, an impact analysis of the coastal zone was conducted by estimating how many hectares would be inundated due to sea level rise using two climate models (HadCM3 and CGCM2). The most affected areas are lands for residential settlements and lands used for rice cultivation. See Table 2.2 for further the full projections.

Table 2-2: Coastal lands projected to be inundated under three scenarios[27]

	Scenario A: SLR only (hectares inundated)		Scenario B: SLR + 2 meters storm surge (hectares inundated)		Scenario C: SLR + 5 meters storm surge (hectares inundated)	
Model	HadCM3	CGCM2	HadCM3	CGCM2	HadCM3	CGCM2
2031	1961	2901	75,578	79,851	139,123	140,245
2051	2563	3764	78,038	82,881	139,784	140,986
2071	2901	5645	79,483	88,591	140,152	142,480

SECTORAL CONTEXT

A climate uncertain future will be challenging for Guyana particularly for the climate sensitive sectors. Sea level rise and saline intrusion could affect crop and livestock production in the agriculture sector, contaminate fresh-water supplies, exert additional stress on sea defences, and cause damage to residential and government building among others. In addition to adversely impacting productive sectors (like agriculture, forestry and mining) variability and extremes in rainfall that causes flooding will drive public health concerns by increasing the potential for incidence of water and vector borne diseases such as malaria, dengue and leptospirosis.

Temperature increases are likely to significantly impact human systems and could also impact ecosystems and biodiversity. Undoubtedly, Guyana faces a significant challenge in planning a climate resilient future: draining capacity must be increased while simultaneously ensuring that water storage capacities also increase; shoreline management interventions must be scaled-up to prevent salt water intrusion; and necessary measures will be required to ensure that the human and agricultural systems, in particular, can cope with increasing temperatures.

Climate change impacts in conjunction with Guyana's unique biophysical and socio-economic circumstances make the country particularly vulnerable. In general, vulnerability to climate change is the propensity to be adversely affected

[27] Table reproduced from the SNC, Table 4.10, pg202

and is determined by Guyana's exposure and sensitivity to climate risks, and adaptive capacity.

According to the IPCC, exposure refers to the presence of people, ecosystems, infrastructure and assets in areas that could be significantly affected by climate change. The concentration of activity on the Low Coastal Plain which lies at or below Mean Sea Level is a clear example of exposure to climate risks. The coastal plain is Guyana's socio-economic and political centre. Approximately ninety percent (90%) of the population resides on the Coastal Plain, including the three most populous administrative regions, and the country's capital (Georgetown). Even in the absence of climate stressors, the coastal plain requires protection through a system of engineered and natural structures (for example, seawalls, rip-raps, kokers, mangroves) for sea defences and drainage. The alluvial clay soils found on the coast have made it the locus for agricultural production but they have low levels of permeability and consequently, drain slowly. In January 2005, the coastal plain experienced the worst flooding event in Guyana's history resulting in thirty-four (34) deaths and an estimated losses and damage totalling sixty percent (60%) of the Gross Domestic Product (GDP), refer to Box 2.3 for additional details pertaining to flooding in Guyana.

Box 2.3: Overview of major flood events in Guyana

Guyana's coastal plain, as well as, certain parts of Guyana's hinterland, most notably the Rupununni Savannahs have long been plagued by flooding. Flooding on the coast has a long history dating back as early as 1804, where there were reports of widespread damage. Most notably, the areas once known as Sandy Point and Kierfield which were north of where the current Kitty seawall is located, was completely washed away by the high tide. There was also the "Great Kingston Flood" in 1855, causing considerable damage in that district. One of the most notable events of that flood was the washing away of "Camp House", which was the residence of the Governor of Guyana at that time (Kandasammy , 2006).

Prior to the 1855 flood, the country experienced an earlier flood event, caused by a breach in the conservancy dams at Plaisance that cost the State GBP$29,784 (which translates to GBP$2,975,422 or GYD$874,095,605 in 2016). Subsequently, the occurrence of an extreme rainfall event in late 1886, lasted until early 1887, and was reported by residents to be the worse within the last forty (40) years in that century (Kandasammy , 2006).

In recent years, two (2) of the most intense flood events occurred in 2005, that caused significant damage to property, infrastructure and the economy, in particular, the agricultural industry, one of the main income earners for Guyana. (Figure 2.19) Damage was estimated at USD$54.5 million (17.56% of the total GDP) (ECLAC, 2005). The total damages caused by the 2005 flood were estimated at

USD$445 million (GoG & UN, 2012). The following year, (2006), the country experienced another major flood event costing USD$30.1 million in damages and further set back the agriculture industry which was still recovering from the 2005 flooding (Green, 2013).

Figure 2.19: A resident paddling through the flooded streets in Georgetown on a makeshift raft.

The most recent flooding event occurred in 2015, (Figure 2.20) after receiving more than 100mm of rain in 24 hours (Guyana Hydromet Office, 2015). This heavy rainfall event resulted in flooding of parts of Guyana's coast affecting areas along the East Berbice-Corentyne (Region 6), Demerara-Mahaica (Region 4), including Georgetown, and some areas of Mahaica-Berbice (Region 5) (Kaieteur News, 2015).

Figure 2.20: flooded street in Georgetown in 2015. *Source: Davis, 2015*

These flood events have long been managed by a system of drainage canals that were originally constructed by the Dutch. The system channels water into the Atlantic Ocean through a series of gravity drained canals and over the years has undergone minor modifications.

Despite all the measures in place, mostly every year with every rainy season sections of the coast are inundated. The Government of Guyana recently contracted the original designers of the drainage and irrigation system for their input and assessment of the situation. After careful analysis, it was concluded that the main reasons for frequent flooding were *"an increase in impervious areas; infilling of drains; reduction of maintenance; use of drains for refuse disposal; establishment of illegal housing on drainage reserves; relative rise in sea levels; and inadequacy of secondary and roadside drainage systems"* (Kaieteur News, 2015).

Although events of similar magnitude have not since occurred, it is a matter of increasing concern that extreme rainfall events have occurred frequently in 2005, 2006, 2008, 2010, 2011, 2013, 2014 and 2015 (GoG, 2015a). Importantly, the resultant flooding from several of these intense precipitation events were not limited to Georgetown and the Coastal Plain but were also felt in in the hinterland regions. In June 2011, continuous heavy rainfall in Region 9 resulted in the worst flooding event since 1973. The two of the most populous areas were the most significantly affected and critical infrastructure such as roads, bridges and electricity plants were damaged. Emergency supplies like food and water were flown to Region 9 from Georgetown.

Sensitivity to climate risks refers to the degree to which impacts are felt. For example, following an extended period of dry weather in Guyana, particularly, the hinterland communities, faced drought conditions in late 2015 to early 2016. Impacts were felt across the country with the most severe impacts occurring in weather sensitive sectors like agriculture and water. In January 2016, wells in the Rupununi began to run dry and potable water became increasingly scarce prompting the Government to implement measures that would bring relief. Water for agricultural purposes was also scarce resulting in loss of crops and livestock. Public health issues were brought to the fore as concerns regarding a potential increase in vector and water-borne diseases were raised[28]. On the coast, the drought caused significant loss and damages on rice cultivation with 16,026 of 71,926 hectares being affected, approximately 22% of the land area sown[29]. The drought has been linked to the El Niño weather phenomenon, which may worsen the impacts of climate change. The drought has also impacted biodiversity and further details are available in Box 2.4: Droughts in Guyana.

Box 2.4: Droughts in Guyana

Serious drought-like events were documented in Guyana as far as September 1877 to April 1878 (Berlage, 1966). In 1997 to 1998, as a result of a prolonged El Nino effect, Guyana experienced a severe drought that affected various sectors across the country. The damages estimated for the 1997/1998 drought amounted to USD$29,000,000 due to decreased outputs in the agriculture (rice 37% and sugar 7%) industry, including livestock and other crops. Losses were also felt in the mining sector due to an estimated 40% decline in production as a result of unavailable or limited sources of water, given the sectors' high dependence on this resource (Wahlström & Weber, 1998). From May 2009 to February 2010, Guyana experienced drought-like conditions that caused great concern especially when the East Demerara Water Conservancy levels dropped below normal (dead storage level) (< 53.5 GD) (Farrel, Trotman, & Cox, 2010). September 2012 to January 2013 the country again experienced a dry spell although not as lengthy as earlier years. However, this was still severe to cause water stress in some agricultural areas (Seulall, 2013).

[28] http://demerarawaves.com/2016/01/28/drought-affecting-agri-sector/
[29] Ibid

Figure 2.21: Cassava crops Moco Moco, Rupununi Savannahs. *Source: Hamer, 2015*

The most recent drought in Guyana started early 2015 and has extended into 2016. The Upper Essequibo – Upper Takatu (Region 9) was most affected. Farmers in Kumu, Moco Moco and other villages have reported significant losses, especially their main staple – cassava (*Manihot esculenta*) (Figure 2.21 & 2.22) and livestock. Rivers and wells have dried and potable water was scarce. Even though, naturally, the area is a wetland, during the dry period there were increased occurrences of savannah and forest fires. Fires were also observed on the Kanuku Mountains (Johnson, 2015; Andrews, 2015). On the coast, the level of major water conservancies fell below the dead storage level. This includes the East Demerara Water Conservancy, Mahaica, Mahaicony, Abary Water Project and the West Demerara Water Conservancy (Regions 4, 5 and 3 respectively). In Region 2, the Manikuru (Main Canal) and Tapakuma, Golden Fleece, Ituribisi, and Mainstay Water Conservancies all fell below the dead storage level resulting in severe water stress for irrigation in the agricultural areas. Similar conditions also existed in West Watooka, Region 10 (Browne, 2016; Kaieteur News, 2016).

Figure 2.22: Drying Kumu Creek, Kumu Village, Rupununi Savannahs. *Source: Hamer, 2015*

Moreover, a school of approximately twenty five (25) Arapaimas (*Arapaima gigas*) were stranded in a drying pool and a rescue team from the villages of Rupertee and Rewa; and representatives from key institutions (Iwokrama and Bina Hill Educational Institute) were organised. The fishes were captured, removed from the pond and transported to the Rewa River through the forest (Guyana Chronicle, 2016). (Figure 2.23)

Figure 2.23: Members of the rescue team removing Arapaimas. *Source: Kaieteur News, 2016*

Droughts can cause both water and food shortages for wildlife that result in migration of large animals to other areas to meet their basic needs.

One such example is the jaguar. Jaguars were frequently sighted in communities on the coast and unfortunately in the communities of Mashabo Village in Region Two (Pomeroon-Supenaam) and New Amsterdam, Berbice the jaguars were killed. However, in other communities, for example, Lima Sands, Tapakuma, Capoey, Mainstay – Whyaka and Heathburn Village, Berbice the jaguars were captured alive and relocated. The Government of Guyana has since planned a number of interventions in an effort to reduce the impact of the prolonged drought.

ADAPTIVE CAPACITY

Guyana's vulnerability is also influenced by its capacity to adapt to climate change impacts or to respond to its consequences. Adaptive capacity is influenced by several criteria. The draft Climate Resilience Strategy and Action Plan (CRSAP) examined adaptive capacity in the context of five broad criteria: informational, human, institutional, financial and policy/regulatory environment. Financial capacity was considered one of the most important determinants of adaptive capacity and a deciding factor in the deployment and scale of adaptation actions. For example, Guyana's Intended Nationally Determined Contribution (INDC) indicated that significant financial resources – US$1.6 billion in the period to 2025 – will be required to build resilience. As a lower-middle income country, unilaterally mobilizing adaptation financing at such a scale will be a difficult, if not impossible, task. The INDC states that Guyana requires external support for implementation of mitigation and adaptation actions.

With respect to the other adaptive capacity criteria, the draft CRSAP determined that Guyana has made progress in building its institutional capacity and Government agencies like the Office of Climate Change (OCC), the Project Management Office (PMO) and the REDD Secretariat have official mandates related to climate change. It was recognised that organisations also have climate related mandates but this may not be their primary function. Additional efforts are also required to strengthen informational capacity through enhancing the availability of climate data and information; vulnerability, impact and risk assessment, and information on the costs and benefits of adaptation options. Building human capacity should include efforts to undertake climate change projections, conduct research on sectorial vulnerability, and develop and maintain technologies crucial to successful adaptation. Finally, the policy/regulatory environment should promote the mainstreaming of climate change into national and sectorial policies and plans.

Guyana's vulnerability has been confirmed by third party qualitative and quantitative indices including the Global Adaptation Index (GAIN) on which Guyana is ranked 114 out of 177 countries[30] and the Climate Vulnerability Monitor (CVM) which classified Guyana as 'acutely vulnerable'[31]. In the Human Development Index (HDI), which has been considered to represent social vulnerability to climate change, Guyana is ranked 121 out of 187 countries and classified as having 'medium human development'[32].

Guyana is recognised as a net carbon sink with eighty-five percent (85%) of the country covered by forest (GFC *et.al*, 2015). Its historical GhG emissions are considered minimal when compared with its potential to sequester carbon dioxide and, compared with the rest of CARICOM contributes, less than one percent (1%) to global GhG emissions, approximately 0.33% (WRI, 2008[33]).

The inventory covered the Energy, Industrial Processes, Agriculture, Land-Use Change and Forestry and Waste sectors[34] (GoG, 2012) and the information presented in this section of the State of Environment (SOE) report takes the same categorisation. The year 2000 was considered the Reference Year.

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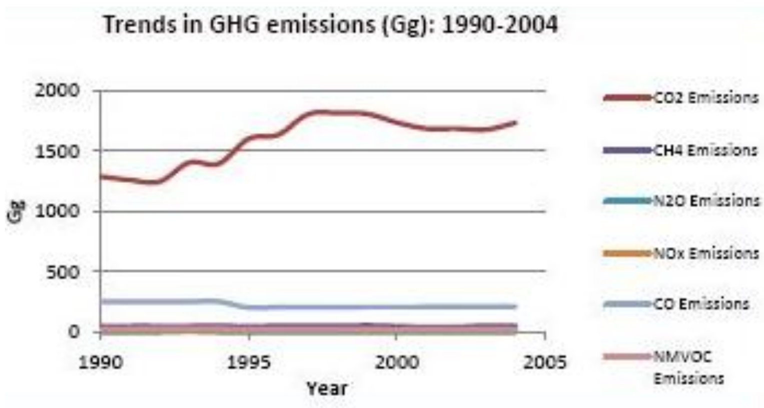
[30] http://index.gain.org/
[31] http://download.daraint.org/CVM2-Low.pdf
[32] http://hdr.undp.org/en/content/human-development-index-hdi
[33] As cited by ECLAC (2011) in the report *"An Assessment of the Economic Impact of Climate Change on the Agriculture, Coastal and Human Settlements and Health Sectors in Guyana".*
[34] International bunkers and biomass were not included in the national totals but reported separately in the inventory.

TRENDS IN GREENHOUSE GAS EMISSIONS AND REMOVALS

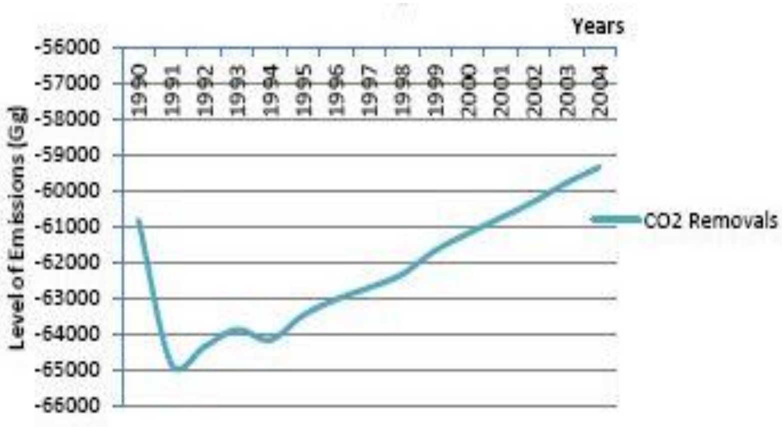
Overall, it was concluded for the period examined (1990-2004) that there were no major trends in GhG emissions even though an apparent minor upward shift was observed for carbon dioxide, Figure 2.24, that later, tapered with a slight indication of moving upward in 2004.

Figure 2.24: Trends in historical GhG emissions (Gg). *Source: SNC(2012) Pg 89*



Historical carbon dioxide emissions ranged between 1,246Gg in 1992, and 1,813Gg in 1998 (GoG, 2012). The other GhG gases emissions (non-carbon dioxide) were found to be notably stable across this fifteen (15) year period with slight variations in methane emissions between 44Gg (2002) and 56Gg (2001) and carbon monoxide ranging from 149Gg (1999) to 254Gg (1990-1994). Nitrous oxide remained stable across the years and non-methane volatile organic compounds ranged between 24Gg (2000) and 30 Gg (1992-1994) (GoG, 2012). The SNC concluded that GhG removals varied between -65,318Gg (1990) and -59,333 Gg (2004), Figure 2.25.

Figure 2.25: Trends in GhG removals for the period 1990-2004. *Source: SNC (2012) Pg 89.*



SECTOR ASSESSMENT

ENERGY[35]

The results of the GhG inventory showed that historical CO_2 emissions were derived mainly from the Energy Sector where the main contributing sub-sectors were energy generation, agriculture, forestry, fishing and transport[36]. Historical emissions were produced from the combustion of secondary fuels (petroleum-based imports) for energy in the power-generating utilities, transport, agriculture, mining and fishing, manufacturing, commercial, residential and international aviation and marine sectors. Fossil and biomass fuel combustion were identified as the two (2) main sources of historical carbon dioxide emissions for the energy sector.

The electrical energy-generating sub-sector contributed the greatest share of CO_2 emissions over the period 1990 to 2004 (10,584Gg) followed by the agriculture, forestry, fishing sub-sector with 5,363Gg and transport with 4,043Gg. The highest emissions from these sub-sectors occurred in 2001 where the electrical energy-generating sub-sector contributed 56.9% of the total CO_2 emissions for that year followed by transport at 15.6% and agriculture, forestry, fishing sub-sector at 14.8%. These sub-sectors remained at a stable rate of CO_2 emissions across 2002 –

[35] Carbon dioxide emissions from international bunkers were not included here. It was concluded that these emissions were minimal because vessels engaged in international air and marine transport purchased fuel outside of Guyana (GoG, 2012).

[36] The Energy Sector is further categorized into six (6) sub-sectors – energy industries; manufacturing and construction; transport; commercial/institutional; residential; and agriculture, forestry, fishing.

2004; the electrical energy-generating sub-sector remained at 44.7%, followed by agriculture, forestry and fishery at 19.86% and transport at 18.9% (GoG, 2012).

As a result of lack of data for some years over the period 1990 – 2004, emissions from biomass were estimated at 1,487 Gg prior to 1994 and about 716 Gg after 1998 with peaking of 1,571Gg in 1997 (GoG, 2012). Sources of biomass for fuel consumption were firewood, charcoal, rice husk and bagasse. It was found that bagasse accounted for over 90% of the total share of CO_2 emissions for all the years except 1998 (GoG, 2012).

MANUFACTURING/INDUSTRIAL

As a result of a small manufacturing/industrial sector, the emissions for the period were found to be minimal. Road paving (Asphalt), alcoholic beverage manufacturing and food production are the main contributors of GhG emissions. However, this sector's share of the total emissions contribution was less than 0.2% for the reporting period and limited to non-methane volatile organic compounds. Emissions ranged from 13.78Gg (1990) to 15.91Gg (2002) (GoG, 2012).

AGRICULTURE

Carbon monoxide (CO) and nitrogen oxides (NOx) were the main emissions assessed for this sector recognising that these are derived primarily from the burning of agricultural residues in the field (rice and sugarcane) and to lesser degree the burning of savannahs[37]. Nitrous oxides (N_2O) emissions were also assessed recognising that emissions resulted from a number of sources such as manure management, enteric fermentation, burning of agricultural residues and soil processes such as the application of nitrogenous fertilizers to agricultural fields.

CO emissions from the burning of savannahs were estimated at 17Gg for all the years for the reporting period while emissions from field burning (rice and sugarcane) were recorded at 92Gg for the period. NOx emissions from savannah burning were recorded at 0.3Gg for the period 1990-2004 while emissions from burning of agricultural residue were stable for the period (4.7Gg). It was concluded that direct N_2O emissions from grazing animals were insignificant and considered as zero (GoG, 2012).

[37] Data on total savannah area burnt annually were not available and this resulted in the use of default values – using total savannah area and a fraction of what is burnt annually to estimate the GhG emissions (GoG, 2012).

Methane emissions for this sector were derived mainly from rice cultivation under flooded conditions and ranged from 14.4Gg (2002) to 29.4 Gg (1999) for the reporting period. Enteric fermentation from domestic animals was another source of methane in this sector and ranged from 8 Gg (1990) to 16Gg (2004). It was found that the contribution to methane emissions from manure management was negligible and emissions resulting from field burning of sugarcane and rice residues ranged from 4.38 Gg (1990-1998) to 4.73Gg (1999) while savannahs remained at 0.65Gg across the reporting period (GoG, 2012).

LAND USE CHANGE AND FORESTRY

The GhG inventory for this sector assessed both CO_2 emissions and removals and concluded that GhG emissions were derived mainly from forest and grassland conversion and forest soils while removals were derived mainly from changes in forest and biomass stocks. The SNC further concluded that forest and grassland conversions resulted in CO_2 emissions ranging from 1,025Gg (2001) to 2,319Gg (1990-1997 and 2002-2004) while CO_2 emissions from forest soils were estimated at a constant value of 2,180Gg (using default data). Therefore, the total CO_2 emissions from this sector ranged from 2,575Gg (1999) to 4,499 Gg (1990-1998 and 2002 – 2004) (GoG, 2012). These assessments were done considering an estimated total forest area impacted by anthropogenic activities as 2.3million hectares, approximately 14% of the total forested area.

Total CO_2 removals, as a result of changes in forest and biomass stocks, ranged between -65,318Gg in 1990 to -59,333Gg in 2004 (GoG, 2012). These calculations for the inventory were made with total forested area estimated at 16.45 million hectares (GoG, 2012).

WASTE

Methane (CH_4) and Nitrous Oxide (N_2O) are the main emissions from the Waste Sector. From 1990 to 1998, no data was available for CH_4 emissions, however, from 1999 to 2004, emissions ranged from 2.05Gg (1999) to 2.78Gg (2004). Emissions due to human waste in the form of N_2O remained constant at 0.05Gg for the reporting period (GoG, 2012).

DEVELOPING TRENDS POST 2004

ENERGY

Guyana has a high dependence on imported petroleum-based fuels as its primary source of energy (GEA, 2014). In the absence of primary or secondary fossil fuel production, the country utilises imported secondary fuels such as diesel (gas oil), fuel oil, gasoline (mogas), avjet, avgas, kerosene and liquefied petroleum gas (LPG) to service its energy needs (GEA, 2014b; GoG, 2012).

Table 2-3: Volume of petroleum-based products imported over the period 1994-2015with associated costs. *Source: GEA, 2015.*

Years	Volume		CIF Value
	BBLS	LTRS	US$
1994	3,095,728	492,181436	72,067,912
1995	3,624,053	576,178,402	85,161,130
1996	3,711,893	590,143,846	100,696,609
1997	4,093,677	650,842,653	107,727,233
1998	4,125,765	655,944,238	78,539,499
1999	4,137,266	657,772,751	99,704,391
2000	3,924,614	623,963,783	143,277,974
2001	3,834,651	609,660,809	123,373,521
2002	3865505	614566203	122,643,684
2003	3980199	632801092	153,193,966
2004	3,901,760	620,330,288	185,702,255
2005	3,546,069	563,779,936	240,663,147
2006	3,179,925	505,567,690	251,594,083
2007	3,910,234	621,677,546	319,122,554
2008	3,660,583	581,986,208	405,960,936
2009	3,924,723	623,981,072	282,909,993
2010	4,137,931	657,878,518	375,951,700
2011	4,341,345	690,218,765	534,982,446
2012	4,867,748	773,910,151	604,000,602
2013 (revised)	4,726,150	751,397,875	582,281,795
2014	4,938,855	785,215,261	561,633,697
2015	5,001,497	795,174,539	355,201,732
Total	88,530,172	14,075,173,061	5,786,390,859

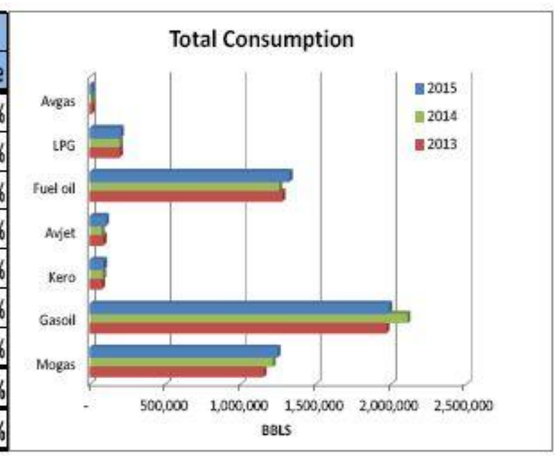
In the last twenty-two (22) years, the country imported a total of 88,530,172 barrels of oil, refer to Table 2.3 above, with the largest share imported in 2015 (5,001,497) followed by 2014 (4,938,855) and 2012 (4,867,748) (GEA, 2015). This represented an average of 13,703 barrels per day (bpd) in 2015, 13,520 bpd in 2014 and 13,320 bpd in 2012 (GEA, 2015; 2014a; 2012). Petroleum imports for these years were acquired at a cost, insurance and freight (CIF) value of US$355,201,732; US$561,633,697 and US$604,000,602 respectively. The 2015 cost represented a decrease of 36.76% from 2014 as a result of the decline in oil prices since mid-2014. This decline was due to contraction in demand along with growth in non-OPEC supply (GEA, 2015). It is posited by the International Energy Agency (IEA) that import prices could remain under US$80 per barrel for the next five (5) years (GEA, 2015) thus, allowing for greater consumption at the end user.

In 2015, the total petroleum imports increased by 1.27% compared with 2014, with increased imports of gasoline (Mogas), jet fuel (Avjet) and fuel oil while imports of diesel (Gasoil), Kerosene, LPG and Avgas decreased over this period.

A total of 4,955,013 barrels of petroleum-based products were consumed in 2015 with an average of 13,575 bpd at a 0.02% increase compared with 2014 (GEA, 2015). Guyana Energy Agency (GEA) reported an increased consumption[38] of all petroleum-based products for 2015, Figure 2.26, with the exception of diesel and avgas. Increased consumption of gasoline (Mogas) was observed across all the years with significant increases in 2012 (GEA, 2015, 2014a, 2013, 2012). While diesel consumption increased in 2014, there was a considerable decrease in 2015. GEA concluded that the increase in 2014, could have resulted from use by larger consumers such as Guyana Power & Light (GPL), Bauxite Company of Guyana Inc. (BCGI) and increased use in the rice industry due to growth of the industry. GEA attributed this decline in energy consumption in 2015, to contraction of the mining, bauxite and forestry sectors (GEA, 2015; 2014a).

Figure 2.26: Total consumption by products for the period 2013-2015. *Source: GEA, 2015*

TOTAL CONSUMPTION (BBLS)					
		2013	2014	2015	% change
January - December	Mogas	1,150,201	1,214,868	1,244,943	2.48%
	Gasoil	1,968,022	2,110,143	1,986,647	-5.85%
	Kero	75,601	86,023	88,031	2.33%
	Avjet	85,302	77,309	102,498	32.58%
	Fuel oil	1,275,935	1,258,669	1,323,033	5.11%
	LPG	194,298	197,121	201,454	2.20%
	Avgas	11,005	9,813	8,407	-14.32%
	Total	4,760,364	4,953,944	4,955,013	0.02%
	Bpd	13,042	13,572	13,575	0.02%

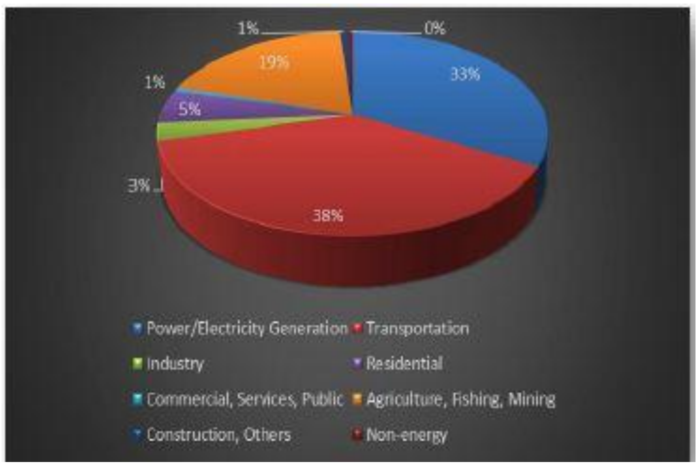


Fuel oil consumption increased over the years and GEA attributed this trend to an increased demand by GPL in keeping with its transition away from diesel-based power generation to fuel oil generation (GEA, 2015, 2014a).

[38] The GEA determines consumption based on a consolidation of opening stock and imported volumes subtracted from the closing stock.

Historically, the electricity-generating sector was recognised as the main consumer of imported fossil fuel products, corresponding with the largest share of historical CO_2 emissions for the energy sector for the period 1990-2004. However, in recent years, the transport sector has emerged as the largest energy user and according to the GEA consumed approximately 38% of total petroleum-based products, superceding the electricity-generating sector at 33% (GEA, 2014b), Figure 2.27. Other sectors such as agriculture, fishing and mining consumed 19% of the total share followed by residential sector at 5% and the industry/manufacturing sector at 3% (GEA, 2014b).

Figure 2.27: Consumption by sector of petroleum-based products. *Source: GEA, 2014b*



The transport sector's consumption is driven largely by the demand for gasoline (Mogas) and diesel (Gasoil), GEA, 2014b), as seen in Figure 2.28 below. The GEA concluded that this demand is significantly driven by the growing vehicle fleet in the country and data from the Licence Revenue Office (LRO) support this assertion. According to data from the LRO, a total of 200,816 new motor vehicles were registered over the period 1994 to 2015 (BoS, 2016). While the total number of new registered vehicles fluctuated over the period, there was a decline from 1996 – 2002 followed by a minor increase to 2004/2005 and a rapid increase to 2006. Thereafter, until 2009 the number of registered new vehicles remained somewhat constant. However, from 2010 onwards the number of registered new vehicles increased significantly, peaking in 2012, (Figure 2.29) at 16,174. The number of new vehicles registered by the LRO post 2012 decreased, with a total of 13,793 vehicles registered in 2015 (BoS, 2016).

Figure 2-28 Share of petroleum-based products consumed by the transport sector for 2012.
Source: GEA, 2014b.

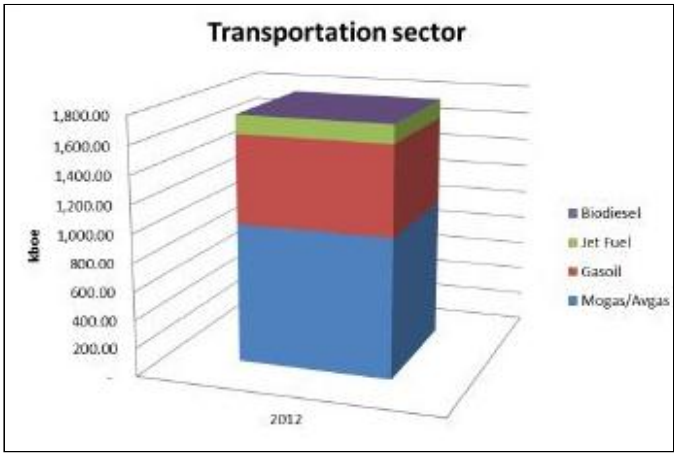
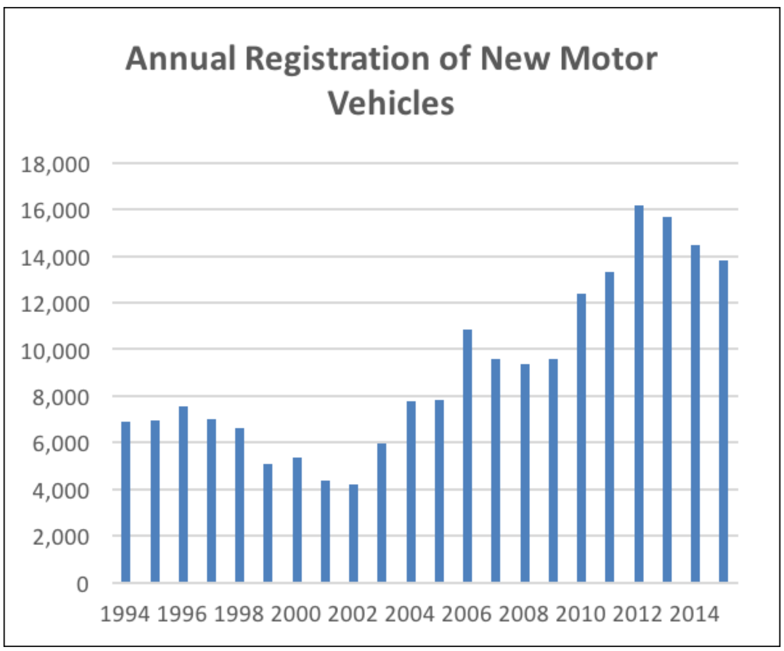


Figure 2.29: Annual registration of new motor vehicles for the period 1994-2015.
Source : BoS, 2016



Private cars and motor cycles were the most dominant types of vehicles registered by the LRO. The total number of private cars and motor cycles registered over the period 1994 to 2015, were 62,337 and 52,651, respectively. A third category, 'Other', is classified by the Bureau of Statistics (BoS) to include trucks, jeeps, pick-ups, articulated vehicles, water tender, hearse and tapirs and the LRO recorded a total of 19,864 new vehicles registered in this category for the period. All remaining categories - buses, hire cars, station wagons (inclusive of land cruisers and land rovers), vans, tractors and trailers were below 15,000 for the period. LRO registered a total number 15,526 lorries for the period (BoS, 2016). Given the significant increase in the number of vehicles over the years, in particular post 2004, and the increasing trend in imported petroleum-based products, such as mogas and gasoil, a clear link has been established to support the conclusion that the transport sector has grown to become the country's largest consumer of fossil fuel products. Moreover, from an emissions perspective, there is a high probability of increased emissions of CO_2 from this sector over the years as a result of increased consumption of petroleum-based products.

Additionally, recent efforts in the electricity-generating sector to increase the share of renewable energy technologies for power production, as well as, increased transmission, distribution, and operational efficiency could contribute to overall reduced consumption of petroleum-based products in this sector. However, these trends will be explored in future GhG inventories for Guyana.

INDUSTRIAL

There is high probability of increased emissions from road paving (asphalt) given the increased number of road works (repairs, resurfacing and road network expansion) undertaken by the Ministry of Public Infrastructure post 2004, in order to accommodate the increased number of vehicles traversing the existing networks. These were evident along major highways in the country inclusive of works along the East Bank Demerara, East and West Coast Demerara and the Ogle to Diamond Road expansion project, construction of the Berbice River Bridge.

AGRICULTURE SECTOR

The burning of paddy husk was identified as a source of GhG emissions in the inventory prepared for the SNC (1990 – 2004), however, in recent years the GEA has been exploring opportunities to use the husk as an energy source for rice mills through the process of gasification. In a study conducted by the GEA, it was found that sixty-seven (67) rice mills process cumulatively, approximately 611,348.60Mt paddy per year, thereby, generating approximately 122,311.90Mt of rice husk[39] annually (GEA, 2014c). While the GEA recognised that 47% or 57,503Mt of total annual production of rice husk, is currently reused in some form, either as an energy source for paddy drying, parboiling and/or electricity production, the study concluded that 53% or 64,808.91Mt are currently burnt or discharged directly into the environment, thereby, producing 24,199,495.41kg of carbon dioxide annually (GEA, 2014c). The study identified the Administrative Region 5 as the largest producer by volume of rice husk and is responsible for 7,941,842.406kg of CO_2 emitted for the assessment period 2008-2012. Taking into account the annual total quantity of rice husk produced and discarded (or burnt), over this five (5) year study period, approximately 92,685,292.84kg of CO_2 was emitted (GEA, 2014c). In

[39] Rice husk was noted to be about 20-22% of the paddy weight (GEA, 2014b).

this regard, the GoG is exploring opportunities to use the rice husk as feedstock for the production of energy. Should this venture be successful, there is a possibility that emissions produced from this sector could decrease in the future.

LAND USE CHANGE AND FORESTRY

The potential total CO_2 removals, as a result of changes in forest and biomass stocks, would significantly increase post 2004, since the GhG inventory calculations were done using estimated total forested area as 16.45 million hectares. Over the years, with technological advances, Guyana has been able to determine with greater accuracy its total forest cover, which is currently estimated at 18.48 million hectares (GFC, *et. al*, 2015). This is converted to forest coverage of 85% of the country, storing 19.6Gt CO_2eq in carbon stocks (GFC, 2015 & GoG, 2015b).

Additionally, Guyana is categorised as having high forest cover/low deforestation (HFLD) and in partnership with the Government of Norway embarked on a national-scale REDD+ payment-for-performance agreement with the support of a robust MRVS. Through the implementation of these initiatives, CO_2 emissions from the forest sector were assessed. These assessments determined that Guyana can avoid emissions in the amount of 48.7Mt CO_2 eq annually through a national-scale REDD+ programme and reforms in the timber and mining industries (GoG, 2015b).

The INDC expressed that the majority of emissions in the forest sector originate from mining and logging activities. It concluded that timber harvesting contributed to 40% of Guyana's emissions from land use between 2001 and 2012 and committed the sector to annual reductions by 13.5% (430,000 t CO_2 per year) through the implementation of RIL techniques. This allows for annual emissions reduction from the timber industry from 3.5Mt CO_2 to 2.3 Mt CO_2 or 11% of overall historical levels for this sector (GOG, 2015b).

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CHAPTER 3

Waste

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INTRODUCTION

The frequency, amount and quality of information related to waste in Guyana is currently an issue that needs to be addressed in order to inform the adequate planning of sectorial policies. It should be noted that the most recent waste characterizations dates back to 2010 and concrete studies go as far back as 2004. Within each type of waste, the current situation, as well as, the pressures affecting the environment shall be presented.

DESCRIPTION OF PRESSURES

INCREASE IN THE USE OF NON-BIODEGRADABLE PACKAGING MATERIAL.

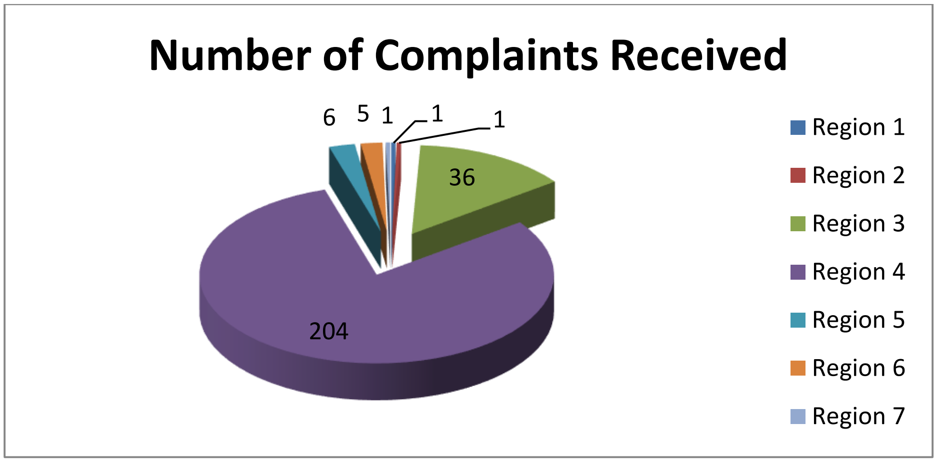
Over the last years, Guyana has experienced a considerable increase in the usage of non-biodegradable packaging materials such as Styrofoam. This increase can be observed through analysis of the waste reaching the Hague Bosch Sanitary Landfill site. It can be observed in the supermarkets and fast food stores where Styrofoam packages are mostly used. Such a heavy increase implies an increased pressure on the environment and health due to the fact that this waste clogs the channels, potentially increasing vector borne disease.

UNREGULATED COLLECTION OF WASTE / ILLEGAL DUMPING

Illegal dumping is a big concern in Guyana. As such, the GoG has put emphasis on sensitizing the local population through littering campaigns and enforcement of laws and regulations through EPA’s Litter Enforcement Unit.

As can be observed in figure 3.1 and with regard to illegal dumping and littering, the Litter Enforcement Unit of the EPA received a total of two hundred and fifty-four (254) complaints of which 80.3% (204) originated from Region 4, 14.1% (36) from Region 3, 2.4% (6) from Region 5, 2% (5) from Region 6 and 0.4(1) from Regions 1, 2 and 7 each.

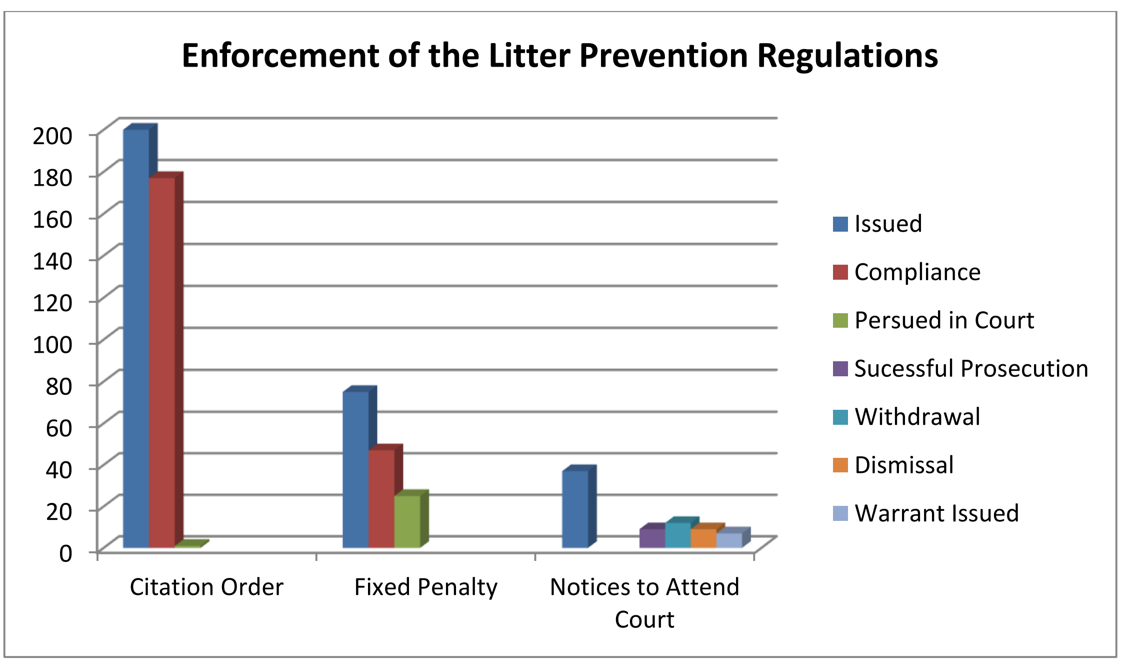
Figure 3.1 Number of complaints received in 2015. Source: Litter Enforcement Unit, EPA.



A general analysis of all the complaint cases received indicates that 90% were offenses relating to Littering a Public Place, 9.1% to Littering a Private Place and 0.9% to Littering from a Motor Vehicle. The analysis also indicates that 65.8% of the complaints' offences referred to domestic waste, 15.7% to industrial/construction, 15.4% to other offences including dumping and burning, 2.4% to human/sewage waste and 0.4% to electronic and medical waste.

With regard to reoccurring complaints, the Unit recorded a 2.8% (7) reoccurring rate of which 86% (6) are repeated offenders who were issued citation orders and warning letters at the first offence. More severe actions are recommended for repeated offenders.

Figure 3.2 Enforcement of the litter prevention regulations. Source: Litter Enforcement Unit, EPA.



Citations

According to the Litter Enforcement Unit within EPA, (Figure 3.2 above) a total of two hundred (200) citation orders (Clean-up and Litter Removal Order) were issued within Administrative Regions 4, 3 and 5, with the majority (76%) issued within Region4, including Georgetown. A compliance rate of 89% with citation order was recorded for 2015.

Further, to-date one (1) citation order was pursued in Court and subsequently resulted in an Arrest Warrant being issued for the offender.

Fixed penalties

A total of seventy-five (75) fixed penalties were issued within Region 4 and 3. In this regard, 63% were issued within Region 4, including Georgetown, while 37% were issued within Region 3.

A compliance rate with fixed penalty of 61.3% was recorded for 2015. As a consequence of noncompliance, 33.3% of the penalties issued were pursued in Court.

Notice to attend court

A total of thirty-seven (37) Notices to attend Court for litter offenses, with charges varying from thirty thousand dollars ($ 30,000) to fifty thousand dollars ($ 50,000) were issued within Region 3 (43%) and 4 (57%). This includes the twenty-five (25) fixed penalties that were pursued in Court, which significantly increased the number of Notices issued in Region 3.

A general analysis of the notices issued indicates that 24.3% were successfully prosecuted, 32.5% were withdrawn by the Agency, 24.3% were dismissed by the Courts and 18.9% warrants issued.

INEFFICIENT WASTE COLLECTION SERVICES

The Neighborhood Democratic Councils (NDCs) and Town/City Councils are responsible for providing the waste collection services. Due to budgetary constraints and old and inefficient equipment, the collection system is inefficient and thus coverage is less than optimal.

Another problem related to waste is its transportation. Existing transportation does not require haulage transporters to be licensed although under the Environment Protection Regulations, they are required to ensure that the load is covered to prevent littering.

CHALLENGES AT THE DISPOSAL STATIONS

The current disposal system is not without challenges. The GWI's Sanitation Department's main responsibility is to ensure the effective functioning of the sewage pumps to reduce or prevent sewage overflow into the populated areas in keeping with its mandate, to ensure safe sewerage systems for improved public health. While the disposal of untreated sewage is a critical issue, downstream of the liquid waste stream, the sewerage system at the point of collection can be severely impacted, or abused, to affect effective downstream functions. In the absence of screening processes in both the Central Georgetown and Tucville stations, large volumes of solid waste were often found entering the system such as plastic bags, newspapers and clothing. These solid materials passing through the system to the outfall create blockage in the yard sewers and in the inlets of the pumps (in the wet wells) (GWI, 2013). GWI noted the pumps were required to operate at greater loads, thus, causing motor failure, and as a result of blockage, raw sewage backs up in populated areas, through gully and yard chambers. Moreover, these systems are manually operated and require the presence of the operators during pump operation to prevent flooding of the dry wells. As a consequence, blocked chambers and manholes are cleared manually or through the use of a jetting machine or tanker.

The sewage pumps and motors in operation today were installed during the period 1985 – 1988. Over the years, constant rewinding of the motors has led to reduced efficiency of these units and thus the wet wells, along with the pressure on the system means it takes a longer period to pump (GWI, 2013).

IMPROPER DISPOSAL OF HAZARDOUS WASTES

The generation of hazardous waste has been steadily increasing and is likely to continue to increase. The improper management, treatment and disposal of hazardous waste is a significant environmental problem in Guyana since there are no hazardous waste disposal facilities, and the treatment facilities that exist in Guyana are currently inadequate. There are only two facilities authorized to treat hazardous wastes, one specifically focused on medical waste sterilization, and the other dedicated to treatment of hazardous wastes generated from Petroleum Exploration. It should be noted also, that there has been an increase in the number of persons becoming authorized for the export of used lead acid batteries for recovery. As such, over the years, the amount of hazardous waste has accumulated due to the lack of disposal options in Guyana. Generators of hazardous waste are advised to store their waste in the most appropriate manner. The EPA, however, recognizes that space is finite, and despite being the best option available, storing increased volumes of hazardous waste would pose a greater risk, given the lack of disposal options in the Country.

The National Strategy and Management Plan for the Sound Management of Hazardous Waste for Improved Public and Environmental Health in Guyana, (an output of the Hazardous Waste Inventory Study for Guyana), identified the lack of awareness as a major constraint to the proper management of hazardous waste. "A large majority of Operations in Guyana had a very low level of awareness on the special issues of hazardous waste management and the National obligations associated with the implementation of the Basel Convention (CEHI, 2009 p. 35). Although the study was conducted some time ago, the lack of awareness among generators of hazardous waste was still considered an issue by the participants of the 2016 workshop.

LACK OF TECHNICAL CAPACITY ON HAZARDOUS WASTES

The EPA, as the implementing Agency for the Environmental Protection (Hazardous Wastes Management) Regulations, 2000, has been constrained in its ability to provide the necessary guidance on hazardous wastes management. Apart from unavailable facilities to dispose of hazardous wastes, the EPA is constrained by the lack of data, limited resources, experienced personnel and technical expertise required to discharge its mandate.

The lack of technical expertise also results in an inability to provide appropriate hazardous waste management solutions to the public. The absence of adequate analytical capabilities within the EPA and the lack thereof within the Country is a severe hindrance to the evaluation of treatment and disposal options, towards more appropriate hazardous wastes management approaches. There are also inadequate financial resources to facilitate training in the area of hazardous wastes management and Staff of the Environmental Protection Agency most times only benefit from basic training offered by external parties and extensive desk study.

HEALTH CENTERS WITH NO TREATMENT FACILITIES

Table 3.1 shows the waste management and current disposal practices in the main health centres. There is only one facility, the West Demerara Regional Hospital, considered to implement appropriate disposal practices nationally according to PAHO/WHO assessment and only two which maintain waste disposal records[40].

Most of the health care centres in the Municipalities and NDCs outside of Georgetown burn their medical and other wastes and then bury the ashes.

[40] Putting Waste in its Place, A National Solid Waste Management Strategy for the Cooperative Republic of Guyana, 2013-2014, HYDEA, Ministry of Local Government and Regional Development.

Table 3.1 Summary of healthcare waste management practices at major facilities. Source: PAHO/WHO 2015

Facility	Segregation	Collection	Treatment	Transport	Disposal
GPHC	Bins supplied, but incorrect placement of waste	Conforming to guidelines	Hydroclave-modern appropriate technology	Compactors-according to guidelines	Land filling-appropriate
New Amsterdam Regional Hospital	Segregation, but inadequate red bags	Conforming to guidelines	Sharps only incinerator-not adequate; an infectious waste incinerator needed	Contract out	Communal site-inappropriate
Skeldon Hospital	Segregation in place but inadequate bags	Conforming to guidelines	Sharps waste are taken to New Amsterdam for treatment	Corriverton Municipality collects and transport waste	Infectious waste is dumped in a communal site-inappropriate
Linden Hospital Complex	Segregation, but insufficient red bags	Conforming to guidelines	A sharps incinerator; an open box burner had been ordered closed, but there is need for a treatment facility for infectious	Linden Municipality collects ash from sharps only incinerator, as well as infectious waste	Infectious waste is deposited in a communal dump site
Mabaruma Regional Hospital	Segregation, but insufficient red bags	Waste is collected with prescribed regularity	No treatment of waste takes place	Waste is transported by hand-inappropriately	All waste is dumped in a gully not far the hospital, but near to the mortuary
Lethem Regional Hospital	Segregation, but insufficient red bags	Conforming to guidelines	No treatment of waste takes place	Transported by Lethem Municipality	All healthcare waste is deposited in a communal dump site inappropriate

Facility	Segregation	Collection	Treatment	Transport	Disposal
Mahdia Regional Hospital	Segregation, but no bags	Conforming to guidelines	No treatment of waste takes place	Mahdia NDC collects waste	All healthcare waste is deposited in a communal dump site
West Demerara Regional Hospital	Segregation in practice according to guidelines	Waste is stored and collected properly	A De Montfort incinerator in place-good	Hazardous waste is incinerated; domestic waste taken to landfill at Haags Bosch	Hazardous waste landfilled-good
Bartica Regional Hospital	Segregation is practiced	Storage of waste – good	De Montfort incinerator is down-chimney has fallen off	Hazardous waste is buried on site; non-hazardous waste transported to communal dump site	Landfilling of waste-inappropriate an open dump

BURNING OF PADDY SHAFT

The by-products or waste from rice mills and fish processing facilities, such as scales, guts and shrimp carapace, are produced in excess of sources available for reuse. Paddy husk is commonly used as bedding in poultry coups, as soil mix by small vegetable farmers and re-used by rice mills, to provide energy in the furnaces to dry paddy (mechanical drying) and for parboiling. However, there is only re-use capacity averaging 40% of the paddy husk produced, leaving large masses of paddy husk at rice mills. This can increase ambient particulate matter in the atmosphere, especially when burnt, potentially affecting the respiratory and cardiovascular health of neighbouring communities (World Health Organization, 2006), (Brook et al., 2010).

Fish and seafood waste is processed by a protein recovery facility, which produces fishmeal for use in the agricultural industry. However, currently more fish and seafood waste is currently being produced that can be accommodated by one protein recovery plant, and by the small numbers of pig farmers who reuse fish waste within feed.

STATE AND TRENDS

Solid waste in Guyana is yet to be classified by legislation. Nevertheless, the Public Health Department at Georgetown Municipality recognizes the following types of solid waste:

- General domestic;
- Commercial;
- Industrial Processes;
- Construction and demolition;
- Trees / Wood;
- Street and drain cleaning; and
- Abattoir and market.

The EPAs document “Criteria for the identification and approval of landfill sites for solid waste disposal in Guyana” (PAHO/WHO 2004) considers two waste classifications; i) municipal solid waste which includes non-hazardous waste generated in households, commercial and business establishment, institutions and light industrial processes wastes, agricultural wastes and sewage sludge (USEPA, 1996), and ii) special waste which include hazardous wastes, ship generated waste, clinical waste and aircraft waste. This same characterization and description is followed through this chapter.

According to the division of waste agreed upon during the SoE workshops conducted in Georgetown in February 2016, with the presence and technical input from national technicians, the MSW is the combined household and commercial waste generated in the different regions of the country.

WASTE GENERATION

According to the most recent study conducted by Hydroplan (Hydroplan, CEMCO Inc 2010), the combined household and commercial waste generation is approximately 0.73kg/person/day in urban areas and 0.42kg/person/day in the rural communities with the commercial entities generating approximately 0.71kg/person/day. It is estimated that a total of 455,000 kg/day or 166,000 tons/year of MSW is generated in Guyana. The Ministry of Communities in its draft National Solid Waste Recycling Programme estimated that over a period of three years, an average of 112,000 tons per year of MSW was received at the Haags Bosch (HB) Sanitary Landfill. According to data for the period 2014 to 2015, provided by the Ministry of Communities, the landfill received a total of 124,990 tons in 2014, and 128,013 tons, in 2015 (although, no data was provided for September 2015 thus altering the total tons for the year).

The Ministry of Communities, in the Draft Solid Waste Recycling Programme, estimated, based on the urban and rural generation rates from the 2010, waste characterization study, the solid waste generation and composition for all administrative regions of the country. Please refer to table 3.2.

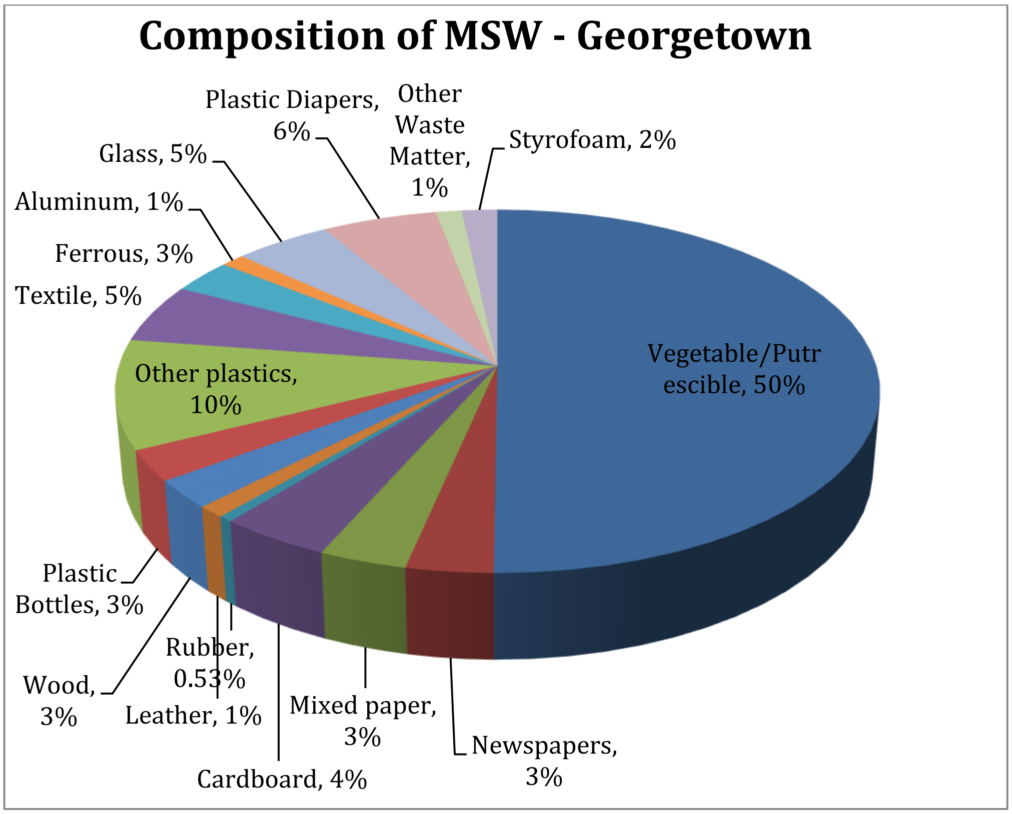
Table 3.2 Solid Waste Generation and Composition in Guyana. *Source: Draft National Solid Waste Recycling Programme, Opportunities for Recycling, Ministry of Local Government and Regional Development, GoG.*

Region			**1**	**2**		**3**	**4**		**5**	**6**		**7**	**8**	**9**	**10**		**Total Population**
				Rural	Urban		Rural	Urban	Rural	Rural	Urban	Rural	Rural	Rural	Rural	Urban	
Population			26,941	11,793	46,810	107,416	195,066	118,363	49,723	75,054	34,377	20,280	10,190	24,212	10,220	29,232	**759,677**
Generation Rates (kg/c/d)	Urban	0.71															
	Rural	0.42	**Total by Region**														**Total**
Waste Stream	**Composition by weight**		**Kg/day**														**kg/day**
Vegetable Matter	50.14%		9,591	2,483	16,664	38,239	41,079	42,137	17,701	15,805	12,238	7,220	3,628	8,619	2,152	10,406	**227,963**
Newspapers	3.24%		620	160	1,077	2,471	2,654	2,723	1,144	1,021	791	467	234	557	139	672	**14,731**
Mix Paper	3.38%		647	167	1,123	2,578	2,769	2,840	1,193	1,065	825	487	245	581	145	702	**15,367**
Cardboard	4.17%		798	207	1,386	3,180	3,416	3,504	1,472	1,314	1,018	600	302	717	179	865	**18,959**
Rubber	0.53%		101	26	176	404	434	445	187	167	129	76	38	91	23	110	**2,410**
Leather	1.04%		199	52	346	793	852	874	367	328	254	150	75	179	45	216	**4,728**
Wood	2.52%		482	125	838	1,922	2,065	2,118	890	794	615	363	182	433	108	523	**11,457**
Plastic Bottles	2.76%		528	137	917	2,105	2,261	2,319	974	870	674	397	200	474	118	573	**12,548**
Other Plastic	9.72%		1,859	481	3,230	7,413	7,963	8,168	3,431	3,064	2,372	1,400	703	1,671	417	2,017	**44,192**

Textile	5.24%	1,002	260	1,742	3,996	4,293	4,404	1,850	1,652	1,279	754	379	901	225	1,088	**23,824**
Ferros	3.00%	574	149	997	2,288	2,458	2,521	1,059	946	732	432	217	516	129	623	**13,640**
Alunimum	1.15%	220	57	382	877	942	966	406	363	281	166	83	198	49	239	**5,228**
Glass	4.69%	897	232	1,559	3,577	3,842	3,941	1,656	1,478	1,145	675	339	806	201	973	**21,323**
Plastic Diapers	5.59%	1,069	277	1,858	4,263	4,580	4,698	1,973	1,762	1,364	805	404	961	240	1,160	**25,415**
Other Waste Matter	1.24%	237	61	412	946	1,016	1,042	438	391	303	179	90	213	53	257	**5,638**
Styrofoam	1.72%	329	85	572	1,312	1,409	1,445	607	542	420	248	124	296	74	357	**7,820**
Total	**100.00%**	**19,153**	**4,959**	**33,278**	**76,365**	**82,034**	**84,147**	**35,349**	**31,564**	**24,439**	**14,418**	**7,244**	**17,213**	**4,298**	**20,782**	**455,243**

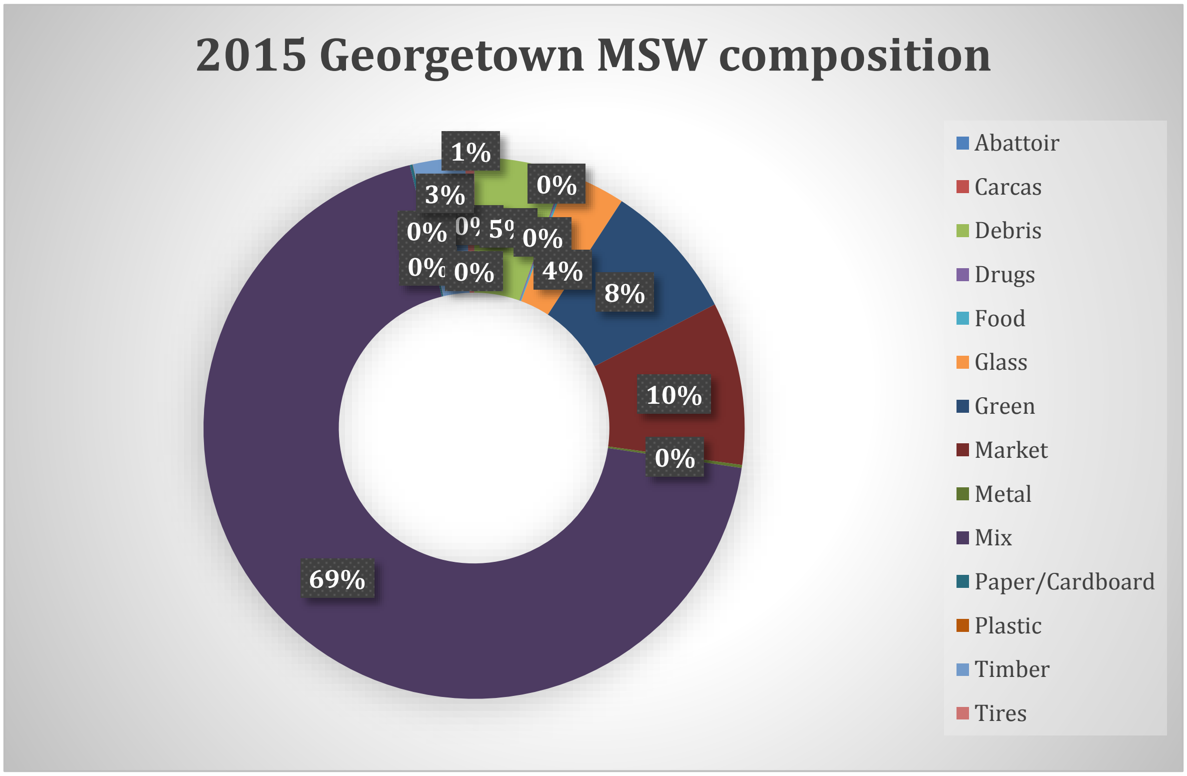
According to the waste characterization study (Hydroplan, CEMCO Inc 2010), the composition by weight of MSW in Georgetown is as shown in Figure 3.3. It is important to note that the waste flow survey was conducted at Le Repentir disposal site, which was the main landfill site for the city of Georgetown prior to its closure and the use of the Haags Bosch facility.

Figure 3.3 Composition of MSW for Georgetown in 2010. *Source Hydroplan 2010, CEMCO Inc 2010*



Based on the data provided for the period 2014 to 2015, and as can be observed from Figure 3.4 below, the MSW composition has not changed that much since 2010, with a high percentage of vegetable or putrescible waste and mixed waste.

Figure 3.4 Composition of MSW for Georgetown 2015. *Source: Own elaboration with data provided by the MoC from the HB Sanitary Landfill for the period 2014 and 2015.*

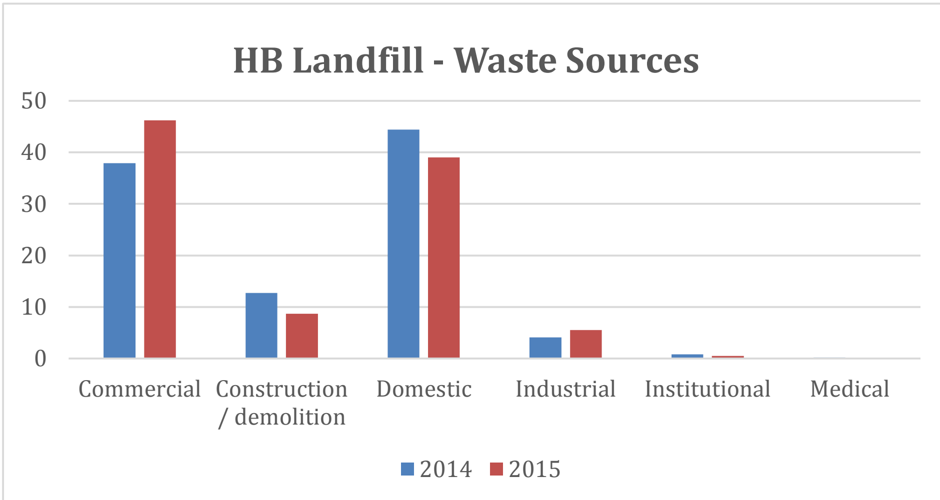


In 2015, the major waste groups relate to timber with 3.1%, glass with 3.5%, debris with 5.4%, green with 8.2%, market with 9.7% and mixed waste accounting for the largest percentage, with 68.8%.

The data provided for HB Sanitary Landfill by the MoC indicate that, for both 2014 and 2015, the largest categories of waste come from both commercial and domestic sources for Region 4 (the areas serviced by HB landfill are Georgetown and the upper East Bank of Demerara) with a slight increase of commercial versus domestic for the year 2015. (Refer to Figure 3.5 below)

The forecasts for future waste generation have been estimated by the National Solid Waste Management Strategy for the Cooperative Republic of Guyana 2013-2024. The Ministry of Communities has forecast waste generation from 2010 (date of the last waste characterization study) to 2024, the end of the strategic planning period proposed by the Strategy. With the assumption of a growth in per capita waste generation of about 18%, consistent with global forecasts for low middle income countries (Hoornweg & and Bhada-Tata, 2012) and considering the steady population of the country, a total waste amount of 575 tons/day is forecast based on increase in per capita waste generation. For this increase, and looking at the past generation, it could be argued that the domestic type of waste will still be predominant having a mild increase in commercial source vs domestic and a slight increase from industrial.

Figure 3.5 Sources of Waste at HB Sanitary Landfill site by category for 2015 and 2015. *Source: Own elaboration with data provided by the MoC from the HB Sanitary Landfill for the period 2014 and 2015.*



WASTE DISPOSAL

According to the National Waste Management Strategy (2013-2024), the main waste disposal methods in Guyana are, open burning, open dumping and controlled dumping. Even though there is officially a sanitary landfill, the Ministry of Communities considers it to be a controlled dumping site since it is not yet fully operational. Even though the situation has improved during the past years, closing down open dump sites and opening a new sanitary landfill, it is clear that the situation is far from ideal. The following table 3.3 shows the current disposal arrangements in the country.

Table 3.3 Waste disposal arrangements in Guyana. *Source: Putting Waste in its Place: A National Solid Waste Management Strategy for the Cooperative Republic of Guyana 2013-2024 (Draft), Ministry of Local Government and Regional Development. Hydea.*

Region	Designated waste disposal site	Type of Facility
1	Khans Hill	Controlled dump
2	Lima Dump	Controlled dump
	Charity Dump	Controlled dump
3	Nil (waste currently sent to HB, until construction of landfill in Winsor Forest is complete)	N/A
4	Le Repentir Dump (now closed to the public permanently and soon to be rehabilitated)	Open dump
	Bosch Sanitary Landfill	Controlled dump
	Lusignan Landfill (design of rehabilitation is in progress)	Controlled dump
	Diamond Grove (design of closure is in progress)	Open dump
5	Zorgenhoop	Controlled dump
	Naarsteghied	Controlled dump
	West of Burma Road	Controlled dump
6	New Amsterdam-Belle Vieu	Controlled dump
	Kilcoy/Chesney	Controlled dump
	Number 0 Village	Controlled dump
7	Byderabo dump	Open dump
8	Nil (site identification in progress)	
9	Bonn Success	Controlled dump
10	Caracara dump	Open dump
	Dokara dump	Open dump

SEWAGE

Guyana lacks a system to fully collect and treat sewage from all sources. Sewage was identified as a critical issue for Guyana to address within its waste management framework (GoG, 2001). Based on available data from the 2002 Housing and Population Census, the distribution of household by type of sanitation facility up to that period indicated 5.1% of the population had links to a sewer system; 36.4% had access to cesspits or septic tanks and 56.5% used pit latrines[41]. With the exception of pit latrines, the sewage generated by 41.5% of the population requires some form of collection and disposal.

There are two (2) main methods of addressing the collection and disposal of sewage. These are the use of piped sewerage system serving specific areas in Georgetown

[41] In the absence of the release of the full 2012 Housing and Population Census report by the Bureau of Statistics to include population distribution and sanitation facilities, these figures are referenced with the understating that changes may have occurred over the period 2002 to 2012 as a result of improvement in sanitation.

and septic tanks or cesspits for new areas in Georgetown and rural and outlying areas.

PIPED SEWERAGE SYSTEM

Georgetown is served by two (2) piped sewerage systems – the Central Georgetown and Tucville Sewerage Systems. The communal sewerage system serving an approximate population of 50,000 in Central Georgetown was constructed in 1929 and is bounded by the Demerara River in the West, Vlissengen Road in the East, the Atlantic Ocean in the North and Sussex Street South (GoG, 2014; GWI 2013). This aged system was designed to serve approximately 10,000 residents and consists of twenty-four (24) sewerage basins with network gravity sewers that drain into one (1) pump station delivering untreated sewage into a common ring force main. The untreated sewage is then discharged through a submarine outfall located at Fort Groyne, Kingston, into the mouth of the Demerara River (GoG, 2014; GWI 2013).

A smaller sewerage system was constructed in 1970 to serve an approximate population of 3,000. This Tucville Sewerage System consists of a smaller network of gravity sewers which drain into a treatment system to undertake physical and biological treatment of domestic waste through extended aeration activated sludge process and thereafter treated effluent discharged into the surrounding canals (GoG, 2014; GWI 2013). However, the treatment works have been dormant or non-functional for a number of years and instead a mechanically driven pump transfers the sewage from the reception chamber to a settling tank and thereafter the untreated effluent is discharged into the Laing canal (GWI, 2013). In 2009, the Guyana Water Inc. (GWI) transformed the Tucville Sewerage System into a septage receiving station for the disposal of sludge collected from septic tanks.

SEPTIC TANKS OR CESSPITS

Septic tanks are being promoted as the sanitation system of choice to address liquid waste generated by households, especially, with the drive to improve sanitation by moving away from pit latrine to onsite treatment (GoG, 2014). These systems are designed using a Guyana Nationals Bureau of Standards (GNBS) Code of Practice for the Design and Construction of Septic Tanks and Associated Secondary Treatment and Disposal Systems and includes a soak away or filter system to separate the effluent. Filled septic tanks are emptied by private contractors and in most instances taken to the Tucville system for disposal via the Fort Gryone, Kingston outfall. This measure was introduced a few years ago to reduce the illegal dumping of sewage into the Demerara River. The Tucville system is currently connected to the existing ring through a delivery main and has been effectively integrated into the Central Georgetown Sewerage System (GoG, 2014).

VOLUME OF SEWAGE DISCHARGED VIA THE KINGSTON OUTFALL

The sewer pumping stations operating systems are fixed and their operating points are relatively constant. Pumps were sized to ensure disposal of accumulated sewerage from each station and once operational, these pumps are able to dispose of the accumulated sewerage effectively, which is used by GWI as a good indicator of the disposal efficiency (GWI, 2016). In the absence of instrumentation at the Tucville Sewerage Station to measure discharge volumes, GWI estimated the average volume of sewage discharged for 2015, at the Kingston outfall from both the Tucville Station and Central Georgetown as shown in Table 3.4.

Table 3.4 Average discharge volume of sewage from the Kingston Outfall for 2015. *Source: GWI 2016*

Discharges for the year 2015	Average Discharge volumes (US gallons)
Tucville Station	79,143,834
Central Georgetown Stations	*1,199,653,898*

MEDICAL WASTE

Health care institutions in Guyana are classified mainly in health posts, health centres, district hospitals, regional hospitals, private hospitals and national hospitals. In total, in 2016, there are 380 of these health care centres distributed (see Table 3.5) in the ten administrative regions of the country. At the time of the report, only concrete data arising from HB Sanitary Landfill was available indicating that a total of 200, 83 tons in 2014 and 131, 15 tons in 2015, reached the landfill in Region 4 (no data was available for September 2015).

Table 3.5 Geographical Distribution of the Healthcare System. *Source: PAHO/WHO 2015, Draft Summary, an Assessment of Healthcare Waste Management, Guyana, 2013, updated for 2015*

Type of facility	National Total	Coastal Regions					Hinterland Regions				
		3	4	5	6	10	1	2	7	8	9
Specialist Hospitals	4	0	2	0	2	0	0	0	0	0	0
National Hospitals	1	0	1	0	0	0	0	0	0	0	0
Regional Hospitals	6	1	2	0	1	1	0	1	0	0	0
District Hospital	20	3	0	2	2	2	4	1	2	2	3
Health Centers	133	13	39	15	28	12	3	12	3	5	3
Health Posts	210	27	10	1	4	6	42	20	22	16	52
Private Hospitals	6	0	6	0	0	0	0	0	0	0	0
Facility Totals	380	44	60	18	37	31	49	34	27	22	57
% Total Population		13.3	41.0	7.1	19.7	5.4	2.5	6.0	2.0	0.8	2.1

The PAHO/WHO 2004 study estimated, having the total number of hospital beds for each region in Guyana, the total amount of hospital waste. Considering a generation of 3 kg/bed/day as a mean for Latin America and the Caribbean countries, from which, depending on the efficiency of hazardous waste segregation, 25% - 40% are hazardous waste (Safe management of wastes from health care activities, WHO), the estimated amount of solid wastes generated in health institutions of Regions 1 to 10 as shown in table 3.6.

Table 3.6 Estimated amount of hospital waste by region. *Source: PAHO/WHO 2015, Draft Summary, an Assessment of Healthcare Waste Management, Guyana, 2013, updated for 2015*

Regions	Total number of hospital beds	Hazardous waste (kg/day) (25-40%)		General waste (kg/day) (75-60%)		Total waste (kg/day)
		25%	40%	75%	60%	
1	85	63.75	102	191.25	153	255
2	107	80.25	128.40	240.75	192.60	321
3	183	137.25	219.60	411.75	329.40	549
4	951	713.25	1141.20	2139.75	1711.80	2853
5	37	27.75	44.40	83.25	66.60	111
6	554	415.50	664.80	1246.50	997.20	1662
7	56	42	67.20	126	100.80	168
8	28	21	33.60	63	50.40	84
9	40	30	48	90	72	120
10	146	109.50	175.20	328.5	262.80	438
Total	2187	1640.25	2624.40	4920.75	3936.6	6561

INDUSTRIAL WASTE

There is not much information regarding industrial waste management in Guyana. The main industries in Guyana are: mining, sugar, rice, forestry products and agriculture.

As reported in the Preliminary Diagnostic of Solid Waste Management in Guyana, bauxite and gold mining industries show the greatest signs of environmental degradation as released sediments are transported downstream causing siltation of streams and rivers. Also, drying and calcining in the bauxite process results in the escape of fugitive dust from the kilns, accidental oil spillage and the release of bauxite tailings.

AGRICULTURAL WASTE

Agriculture is a key contributor to the economy of Guyana as has been described in Chapter 1. In addition, it is expected that agriculture will continue growing in terms of land area and contribution to the GDP (MoA 2013). Increasing production and promoting agro-processing, to add value to the raw materials of agriculture also increases the quantity and type of waste produced; thus challenging Guyana to find sustainable methods for reuse and disposal.

The Guyana Sugar Corporation (Guysuco) operates eight (8) sugar factories transporting cane to the factories by water transport and they have been reported to dutifully deal with their own waste (PAHO/WHO 2004).

The second most important agricultural industry in Guyana is the rice industry. Agricultural practices can also adversely affect the environment in several ways, one being the application of chemical pesticides that are used without technical and sanitary measures. In this regard, the National Implementation Plan (NIP) for the Stockholm Convention on Persistent Organic Pollutants (POPS) identifies as the country's second highest priority on POPs issues, is the high per capita unintended release estimated for the country being 119 TEQ/year. This is mainly in the form of polychlorinated dibenzodioxins/dibenzofurans (PCDD/PCDF) released to air and land by open burning processes, being the burning of waste the largest source followed by burning of biomass from agricultural activities.

There is also a 6-ton stockpile of POPs of obsolete pesticides, including some POPs pesticides mainly held by PTCCB and GUYCSO in secure facilities. The NIP Action Plan proposes to export these pesticides for their proper disposal and for the development of a product stewardship based return system for currently generated expired agricultural chemicals (approximately 20 kg/year) to minimize future accumulation of obsolete pesticides.

EPA is required to authorize all farms and plantations based in sensitive areas or covering a minimum land mass of 1000 acres (404 hectares). EPA is also responsible for authorizing wildlife holding facilities, livestock (swine, goats, sheep, pigs or cattle of 70 heads or more), poultry farms (including ducks containing 500 birds or more), all aquaculture facilities and, all agro-processing facilities (rice and oil mills, as well as seafood processing facilities whether the final product is fish glue or fillets of fish for human consumption). This implies that the Agency is not required to authorize small farms or agricultural production units and thus there is a lack of information as to the number of existing farms and the associated waste being generated. Indeed, there is a cumulative impact on the environment which ought to be estimated and dutifully cared for.

IMPACTS

ECONOMIC

No specific data has yet been produced in Guyana to assess the economic impact of improper waste management. It is widely acknowledged that littering is directly related to canal clogging and flooding and therefore implies a heavy burden on NDCs and local governments due to increased costs of maintenance. The financial cost of this maintenance has not been calculated. The clogging of canals also increases flooding potential. When flooding occurs in Georgetown for example, heavy economic loss associated with infrastructure re-building and damage to property can occur.

HEALTH

Exposure to hazardous waste can affect human health. Populations living near illegal dump sites can be affected by the negative environmental impacts of these sites, such as the proliferation of vectors. (Refer to Table 3.7 below) Vectors such as flies transmit typhoid fever, cholera and amoebic and bacillary dysentery; rodents transmit leptospirosis, hepatitis and ringworm; mosquitoes transmit dengue, yellow fever, malaria and filariasis. According to PAHO/WHO 2004, report, diarrhoeal diseases have been amongst the leading causes of morbidity in children under 5 years old. The incidence rates for the period 1996-2000 fluctuated with 10,251 cases reported in 1996, 2,200 cases reported in 1998 and 8,604 cases reported in 2000.

Additionally, improper disposal of hazardous wastes can result in increased risk for injury and infection to the population. Direct dumping of hazardous wastes into rivers and other bodies of water can result in the accumulation of toxic substances in the food chain, including accumulation by plants and animals that rely on these water sources.

Nationally, the use and disposal of plastics not only have severe effects on human health but also on waste management. The burning of plastics produces persistent organic pollutants (POPs) known as furans and dioxins which are associated with a number of adverse effects in humans including immune and enzyme disorders, chloracne and cancers since they are classified as possible human carcinogens (PAHO/WHO 2004).

Disposal of medical waste can also cause health risks faced by garbage collectors and pickers such as hepatitis B and C from wounds, caused by discarded syringes.

Table 3.7 Solid Waste, Diseases and Injuries. *Source: PAHO/WHO 2004*

Communicable Diseases
Vector borne – diarrhea, filariasis, yellow fever, dengue fever, leptospirosis, lyme disease. Water borne – diarrhea, typhoid, cholera, hepatitis, gastroenteritis, dysentery. Food borne – salmonellosis, dysentery, gastroenteritis, hepatitis. Solid borne – roundworm, hookworm.
Non-communicable Diseases
Dust, fumes, odor – allergies, asthma, dyspnea, eye infections, chronic lung diseases Stress – headaches, nausea, fever, hypertension Hazardous materials – immune and enzyme disorders, chloracne, cancer
Injury
Accidents – bruises, fractured and / or broken limbs, burns Puncture wounds – tetanus, hepatitis, headaches, nausea, fever, HIV/AIDS Ergonomics – bone and muscles disorders, hernias.

SOCIAL

Lack of awareness and the necessary infrastructure has led to the improper management of hazardous wastes. In many cases, illegal dump sites are usually formed along roadways or waste is dumped in drains of many communities contributing to poor aesthetics and contamination of the environment. In addition, over time, these wastes would produce odors that are unpleasant to the persons living in the community. The EPA has received complaints in the past related to odor nuisance resulting from improper disposal of hazardous wastes.

ENVIRONMENTAL

The municipal solid waste in Georgetown, for example, contains approximately 51.3% of organic materials (PAHO/WHO 2004) that naturally decompose when landfilled. The decomposition process is both aerobic and anaerobic. The byproducts of the aerobic process are contaminated water in the form of leachate and carbon monoxide. Carbon dioxide and methane are the byproducts of the anaerobic process due to the absence of oxygen.

When waste enters waterways, it negatively changes the chemical composition of the water affecting all ecosystems existing in the water. Additionally, if hazardous waste is dumped and/or disposed improperly, especially in municipal landfills, it can produce leachate that may result in hazardous substances entering surface water, groundwater or soil.

Leachate from waste disposal sites is entering groundwater aquifers and impacting water supply systems. The leachate is normally considered to be highly contaminated as there is little or no waste separation. Since Guyana practices mainly dumping rather than landfilling, the leachate can pollute Guyana's water sources. Also, Guyana has a very high leachate potential due to the fact that it receives over 2000mm rainfall/year.

The White Sand Series is considered a very important source of potable water. The natural replenishment of the whole aquifer is by percolation of rainfall over the areas' vegetation. This would imply that current methods of waste disposal, particularly in this area, have placed Guyana's potable water at significant risk (PAHO/WHO 2004).

Pollutants from livestock and poultry in surface waters will detrimentally alter the aquatic ecosystem of waterways. Waterways of Guyana, for example the Canje and Kaituma Rivers are used by part of the population as a source of food and drinking water, as well as, domestic use in the household.

In the absence of comprehensive studies, general assessments were conducted over the years on the effects of the discharge of untreated or partially treated sewage into waterways and its impact on the environment and human health. Studies concluded that the practices of sewage disposal, and consequently overflows as a result of breakages in the system, result in faecal contamination of surface water bodies and at times, drinking water sources that led to incidences of water-borne diseases such as gastroenteritis, typhoid, diarrhea etc (GoG, 2001; UNEP, 2010).

The severe flood in 2005, flooded all septic tanks and pit latrines in eighty (80) areas assessed by the Pan American Health Organisation (PAHO) along the East Coast of Demerara. These systems were classified unusable and their contents mixed with the accumulated water. As a result, the risk of water related diseases significantly increased for the population in those areas. Common health issues recorded during that time were diarrhoea and skin fungal infections among others, of which data from the PAHO mobile clinics recorded a significant increase of diarrhoeal cases (PAHO, 2005).

RESPONSES

WASTE MANAGEMENT IN GENERAL

The GoG has drafted its National Solid Waste Management Strategy, for the 2013-2024 period, through the Ministry of Communities, formerly the Ministry of Local Government and Regional Development[42]. Presently, the MoC is in the process of organizing public consultations in all administrative regions. The goal is to have ten (10) Regional Waste Management Plans in place, aligned with the National Solid Waste Management Strategy. The Strategy sets the goals and targets for the coming years and is based on the basis of less litter and illegal dumping and generating less waste while improving current and new resource recovery, waste infrastructure, cost effective waste collection methods and strengthening human and institutional capacities and sets a highly needed implementation, monitoring and evaluation. Indeed, the Strategy is a comprehensive document which sets the needed guiding principles to improve the Solid Waste situation in the country.

RECYCLING

According to the PAHO/WHO Solid Waste Sectoral Analysis (2004), "while some degree of recycling already occurs, mainly through the pickers/sorties at the municipal landfill site in Georgetown and some waste collectors working with the private contractors, this is still highly disorganized and does not seem to extend much outside of Georgetown. There are odd cases where collectors of recyclables occur but the cost of transporting these to the city, as well as the low volumes of recyclable material, act against this activity being viable outside of Georgetown".

The GoG, acknowledging that the impact of solid waste generation has become critical, is seeking through the Ministry of Communities, a private operator to implement efficient and appropriate technologies for the processing and recycling of solid waste. The MoC's draft National Solid Waste Recycling Program clearly identifies what is currently taking place in terms of recycling of solid waste and proposes approaches to recycling and resource recovery, setting the following waste streams:

- Organic waste (mulching, composting and / or anaerobic digestion);
- Plastics (PET, HDPE, PVD, LDPE, etc.);
- Class containers;
- Construction and demolition materials (wood and concrete);
- Vehicle tyres;
- Paper and cardboard; and

[42] Hydea, Putting Waste in its Place: A National Solid Waste Management Strategy for the Cooperative Republic of Guyana. Ministry of Local Government and Regional Development.

- Electrical and Electronic waste.

The program follows the logic that "waste is more effectively managed at or near the source of generation" due to the geographic spread of Guyana which increases considerably the transportation costs.

The country has several material recovery and recycling initiatives worth pointing out[43]:

- Banks DIH operates an on-going beverage bottle return program;
- Scrap metal recycling is coordinated through the Guyana Metal Recyclers Association having 23 scrap metal dealers associated. In 2013, over 20,115 tons of ferrous and non-ferrous scrap metal and used lead acid batteries were exported, while 11,103 tons have been exported for the first half of 2014;
- A community composting pilot conducted in 2 NDCs in Region 4, as part of the GSWMP implementation. The finished compost was distributed to the residents;
- At the HB Sanitary Landfill, waste pickers were recently registered and formalized a group called GT Recyclers Cooperative Society which recover cardboard, metals, glass bottles and other containers; and
- The sugar industry reutilizes its bagasse to fuel the boilers, filter mud used as soil amendment as well as scrap metal and batteries and empty chemical containers.

Also, the Institute of Applied Science and Technology (IAST) has several pilot-scale recycling programs. These include:

- Production of roof shingles/tiles from waste high-density polyethylene plastics and sawdust;
- Conversion of waste vegetable and animal fats into biodiesel;
- Biogas generation;
- Processing of used tyres to produce crumbed tyre;
- Manufacture of rice hull briquettes; and
- Coconut shells.

Solid waste management continues to be a challenge for the institutions managing this sub-sector. Even though a number of initiatives were implemented to enhance waste collection, reuse and disposal, there is significant room for improvement (MoC, 2016). In a study conducted by HYROPLAN and CEMCO Inc. for the then Ministry of Local Government and Regional Development, in 2010, paper constitutes 10.7% of the municipal solid waste stream of which 4.2% is cardboard with mixed paper and newspaper comprising the remainder. Waste segregation

[43] Ministry of Local Government and Regional Development, Draft National Waste Recycling Program "Opportunities for Recycling"

with the objective of reusing or recycling components of the waste stream, could lead to significant reduction of daily and annual waste volumes. Even though cardboard contributes only 4.2% to the waste stream, it is light weight and bulky by nature, thus, removal of the material from the solid waste stream for the purpose of recycling will result in ease of landfill usage for example, as highlighted in Box 3.1.

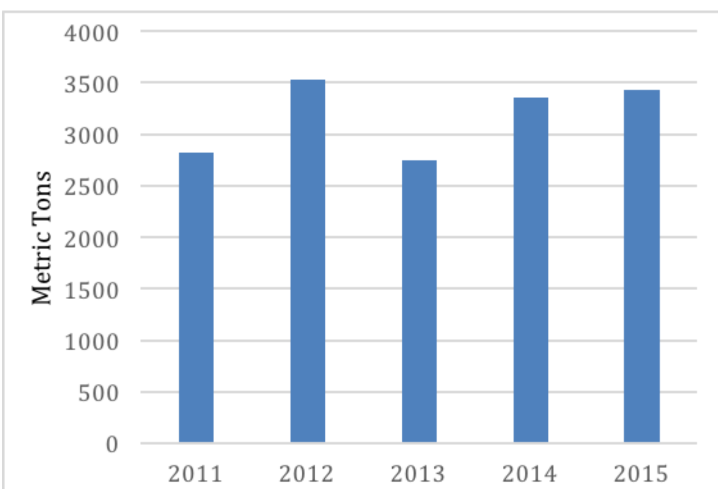
Box 3.1: Recycling of Old Corrugated Cardboard (OCC)

Caribbean Container Inc. (CCI), (formerly Seals and Packaging Industries Ltd.), is a Publicly Traded Manufacturing Company existing under the Companies Act 1991, of Guyana. The company's Pulp and Paper Division, collects and recycles Old Corrugated Cartons (OCC) and produces from the OCC fluting-medium and linerboard paper, which is then used by the adjacent Packaging Division.

In 2012, the Company launched its ECO PAK line of biodegradable food packaging containers. ECO PAK products are made from safe and renewable natural fibres (primarily sugar cane fibres) and are 100% biodegradable ninety (90) days after use. ECO PAK products are being marketed and distributed across Guyana as an environmentally friendly and healthy food packaging option.

CCI recycles approximately 4000 metric tons of OCC on an annual basis, see Figure 3.6, with supplies from domestic solid waste stream, as well as, from other CARICOM jurisdictions, namely, Trinidad & Tobago, Barbados and Suriname. Over the period 2011 to 2015, CCI received a total of 15,886.6 metric tons of OCC at its recycling plant from local, suppliers as well as, the listed CARICOM jurisdictions.

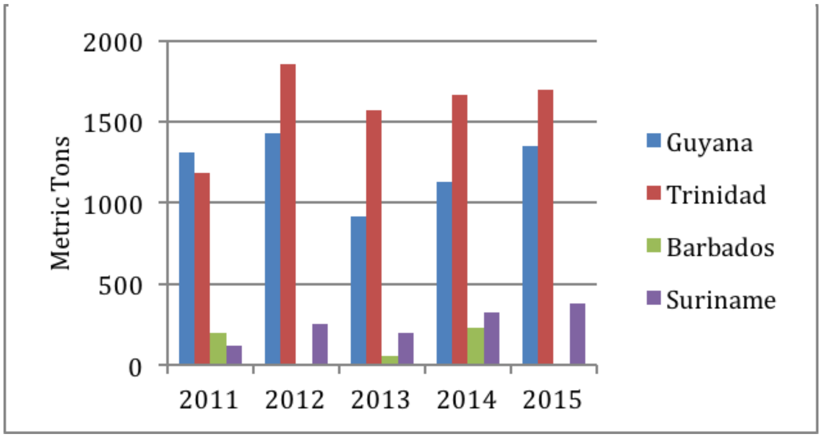
Figure 3.6 Annual quantity of OCC received by CCI´s Paper Recycling Plant.
Source: CCI 2016



Recycling approximately 4,000 metric tons of cardboard waste annually as opposed to using wood pulp, saves approximately 68,000 trees thereby allowing for the absorption of a total of 1 million pounds of carbon dioxide from the atmosphere.

Over the years CCI has seen an increasing trend of more foreign sourced OCC than locally supplied. This essentially results from more detailed solid waste management requirements in other Caribbean Jurisdictions that require the separation and baling of certain recyclable types of waste. The country was still able to supply a total of 6,140.62 metric tons of OCC to CCI over this five (5) year period. (Figure 3.7)

Figure 3.7 Annual quantity by source of OCC received and CCI´s Paper Recycling Plant. *Source: CCI 2016*



Moreover, CCI has the capacity to recycle an additional 12,000 metric tons per year, subject to certain conditions, the primary one being the local supply of significantly higher levels of OCC. The Company also purchases the material from the new Haags-Bosch Landfill, although the intention is to collect the material before it enters the solid waste stream since cardboard is lightweight and bulky, therefore, every metric tonne of cardboard recycled saves approximately nine (9) cubic yards of landfill space.

Notwithstanding these good results, the operation of the Recycling Plant is not without challenges and key among these are (i) the cost of production of the company's recycling operations, particularly its energy bill which is quite high, and (ii) inadequate local supply of OCC.

IMPLEMENTING THE LITTER ENFORCEMENT PROGRAMME

Implementation of the litter enforcement programme implies that the Litter Enforcement Unit conducts investgations of illegal dumpsites.

A total of fifty-three (53) illegal dumpsites were investigated by the Unit for the year of 2015. A general analysis of the dumpsites investigated indicated that 81% were located within Georgetown, 17% within the East Coast of Demerara and 2% within the East Bank of Demerara. With regard to all of the dumpsites, the relevant Local Organs (M&CC and NDCs) were apprised of the situation at the sites and advised of suitable recommended actions to have the sites cleaned and maintained. Consequently, 85% of the sites were cleaned (including all of the sites in the Georgetown area) and are currently maintained by the respective Local Organs.

During 2015, a total of fourteen (14) assessments were conducted within areas of Regions Four and Three with the exception of Georgetown.

A general analysis of the Litter Assessments indicated that 66% of the areas assessed in Region 4 were clean of litter while 34% were littered. With regard to Region 3, 69% of the areas assessed were clean while 31% were littered. The Local

Organs were apprised of the litter issues and challenges within respective areas under their jurisdiction and the Unit continues to collaborate with the Local Organs by-way of providing technical support to address litter issues within communities.

In addition, initial steps were taken by the Unit to facilitate the efficient enforcement of the Litter Regulations within Regions 2, 5, 6, 7 and 9. In this regard, collaborative systems were established with the various Local Organs (NDCs) and Magistrate Courts. Further, brief Litter Assessments were conducted within the afore-mentioned Regions within areas identified by the Local Organs.

Effective implementation of the Litter Enforcement Regulations implies having the necessary technical personnel properly trained in investigation skills, technical report writing and public relations techniques. According to the Litter Enforcement Unit, Litter Wardens did not receive any formal training during the year 2015.

During the year of 2015, the following challenges were encountered and effectively addressed by the Unit:

1. The absence of documented evidence with regard to offenders' acceptance of the fixed penalty offered by the Agency. As a consequence, accepting liability for the litter offence committed, created difficulty for successful prosecution when fixed penalties are pursued in Court because of noncompliance. In this regard, the **Consent to Accept Fixed Penalty** form was created and must be issued and signed by offenders prior to the issuance of the Fixed Penalty by the EPA.

2. With regard to the prosecution of litter offense in Court, the insufficient information provided by the Notice to Attend Court that is issued to the offender and copied to the Court often resulted with the Magistrate's lack of comprehension of the particulars of the offense. Consequently, cases are struck out by Magistrates and incorrect fines / charges are issued. In addressing this challenge, the **Plaint (Legal Document for Magistrate Court)** was created and must be issued with the Notice to attend Court to both the offender and Court.

3. A significant number (32.5%) of Court matters were withdrawn by the Agency given that the notices to attend Court were filed at the Georgetown Magistrate Court for offences that occurred outside of the Georgetown Magisterial District. To address this issue, the Agency has initiated formal collaboration with the various Magisterial Districts within Regions Three and Four.

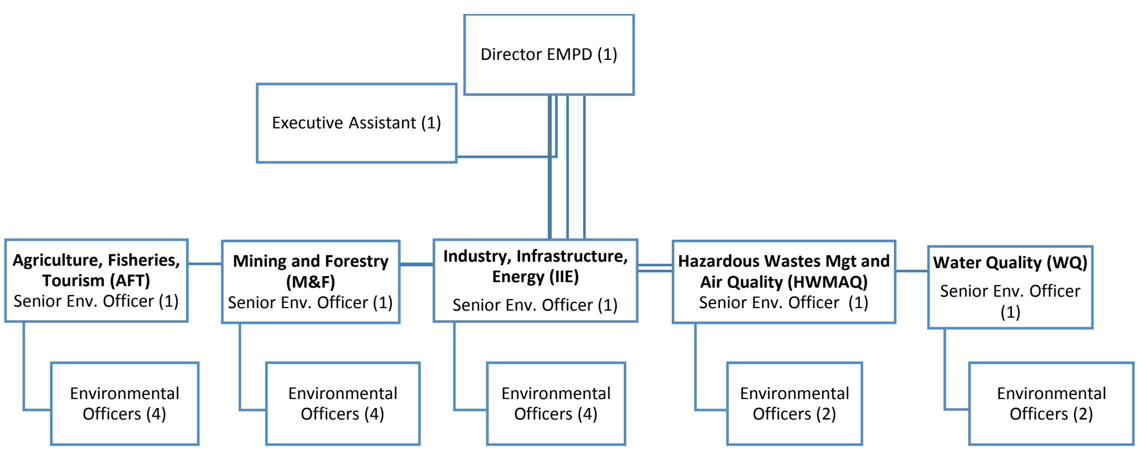
The Government of Guyana (GoG) over the years has recognized the need to upgrade the sewerage system and has invested over GYD 400M in rehabilitation works in Georgetown. In the first phase, fifteen (15) of the twenty-four (24) sewage basins were rehabilitated and new pumps installed at each station. In addition, through the Georgetown Sanitation Improvement Programme at an investment of GYD2B, rehabilitation works have commenced at all twenty-four (24) sewage basins, replacement of the force and riser mains and installation of new pumps at all the stations to enhance the efficiency and capacity of the sewer system to over 85% (GoG, 2014).

Through the Central Housing and Planning Authority and in collaboration with the European Union (EU) and the Inter-American Development Bank (IDB), the GoG has piloted a mechanism to reduce the installation cost of septic tanks for low income families by providing financing for the construction of the septic tanks at a value of USD 1,200. The selected applicant has to prequalify and is required to contribute equity in the form of plumbing and equipment to connect and activate the system (Gog, 2014).

HAZARDOUS WASTE

The Environmental Protection (Hazardous Wastes Management) Regulations, 2000, was created with the aim of protecting the environment from the impacts of hazardous wastes by managing their generation, transportation, treatment, storage and disposal. Although enacted since 2000, the Regulation has not been fully implemented due to the lack of expertise within the EPA. It was until 2011, that a special unit dedicated to the management of hazardous wastes was added to the organizational structure of the EPA and more specifically the Environmental Management Division, (now the Environmental Management Permitting Division-Figure 3.8).

Figure 3.8: Organizational Structure of the Environmental Management Permitting Division



It should be noted however, that this Unit is staffed with only three (3) individuals, who have the additional tasks of implementing the Environmental Protection (Air Quality) Regulations, 2000, and the Basel Convention. The Agency however, still lacks the ability to provide the expected regulatory oversight and guidance on the issues related to hazardous wastes management. This is primarily due to the absence of fundamental support systems required for the effective functioning of the Unit, including but not limited to expertise specific to hazardous wastes management, and facilities within the Country to treat or dispose of hazardous wastes. The lack of disposal or treatment options for hazardous wastes within the Country is one of the main reasons for the improper disposal of hazardous wastes.

Despite the challenges highlighted above, the Hazardous Wastes Unit, since its implementation has provided assistance to the Public through research and subsequent development of Guidelines, geared towards providing information related to the most appropriate strategies for the management of hazardous wastes (more specifically its storage, handling and transportation), given the current lack of facilities to treat or dispose of such. Additionally, the Hazardous Wastes Unit within the EPA provides guidance on the appropriate management of hazardous wastes, through the establishment of conditions to be included in Permits of Companies that are going through the Authorization process and those that generate hazardous wastes.

ANIMAL WASTE

Pig waste has been used by piggeries in bio-digesters, promoted by the Guyana Energy Agency as a cheap and sustainable source of energy (Guyana Energy Agency, 2013).

The bedding in poultry coups is in itself waste from saw mills (sawdust) or rice mills (paddy husk), which when combined with poultry excrement, is used very easily as fertilizer in the cultivation of crops. Such uses divert excremental waste away from percolating into the soil, ground and surface waters.

BIRD STRIKE

Due to an incident related to a bird strike and for the safety of activities at the Cheddi Jagan International Airport, The Government of Guyana (GoG) established the “Bird Strike Committee”. The Committee consists of representatives from the CJIA, Environmental Protection Agency (EPA), Te Huist Coverden/ Soesdyke Neighbourhood Democratic Council, Ministry of Public Infrastructure, and Ministry of Agriculture – The Guyana Livestock Development Authority (GLDA) and experts in airport operation.

The Committee’s primary objectives are to improve the management of waste including dead animals at poultry and animal (mainly pig) farms in order to reduce the vulture population within the ten-mile radius of the operations of the Cheddi Jagan International Airport Inc. The committee focuses on promoting education and awareness of vultures and their potential to bring down planes, the role farmers play in attracting vultures through their improper food storage and waste disposal and most importantly, providing recommendations on best practices to improve farm management.

The Committee's immediate initial response was to cull the vultures to immediately reduce the population in the area. With the support of the Guyana Amazon Tropical Bird Society (GATBS), the Committee was able to identify at least two vulture species in the area the Black Vulture (*Coragyps atratus*) and the Turkey Vulture (*Cathartes aura*).

Since its establishment in 2011, the Committee has inspected in excess of a 100 farms in the 10-mile radius of the CJIA, as well as, conducted a Public Awareness Seminar for stakeholders. The one-on-one approach was found to be more successful in disseminating information. During inspection, the team outlined to farm operators, waste management best practices such as burying, incineration and the use of a bio-digesters, proper storage of meal stocks, cleaning methods to reduce odour nuisance which is a common complaint of residents in close proximity to these farms.

Over the years, the Committee has witnessed improvement in farm management and a reduction in widespread open dumping of waste particularly offal in the key areas along the flight path. These achievements are due to continuous follow-up with farms by the Committee. The EPA utilizes its enforcement capabilities under the Environmental Protection Act, 1996, and other supporting regulations to increase compliance with the Committee's recommendations. In the face of continuous non-compliance, several farms have been issued with Prohibition Notices and legal action was taken against one operator who failed to adhere to the restrictions of the Prohibition Notice. With the gazetting of the Litter Prevention Regulations in 2013, the Committee was able to effectively address improper waste management with the issuance of Clean Orders or institute charges for non-compliance.

A reduction in the vulture population within the 10-mile radius of the CJIA reduces the risk of a bird strike and possible loss of life and property. Therefore, the Committee continues to explore options to improve the management of waste at farms such as the use of incinerators (a model has already been developed), an approved and environmentally sound landfill out of the flight path for waste disposal among other initiatives.

INSTITUTIONAL CURRENT SITUATION

A number of institutions are responsible for waste management in Guyana as it is stipulated by their specific mandates and laws. According to the draft "National

Waste Management Strategy" for the Cooperative Republic of Guyana 2013-2014, the main institutions involved in solid waste management are the following:

- **The Ministry of Communities** is responsible for formulating national waste management policies and providing waste management oversight of RDCs, NDCs and city councils.
- **The Ministry of Public Health (MoPH),** is responsible for the national policies on sanitation and health and provides technical advice to the municipalities and administrative centres regarding waste management. This is done through the Environmental Health Units, which are given responsibility for a number of public health districts.
- **The Environmental Protection Agency (EPA)** which is responsible for the administration of the environmental impact process (EIAs) pertaining to waste management systems and prescribes standards for waste management facilities and issues permits for waste management activities.
- **Regional Democratic Councils (RDCs).** Operate as decentralized offices of central government and oversee the waste management activities of Neighborhood Democratic Councils (NDCs).
- **Neighborhood Democratic Councils** are responsible for the administration of smaller divisions within each region and are responsible for the delivery of waste management, street sweeping and drain cleaning services to the residents within their boundaries.
- **City / Town Councils** are responsible for delivering management, street sweeping and drain cleaning services to the residents within their boundaries.

Other agencies also have competencies in the matter. Among them are the Ministry of Public Infrastructure, the Guyana National Bureau of Standards, the Institute of Applied Science and Technology and the Pesticides & Toxic Chemicals Control Board under the Ministry of Agriculture.

In terms of the current legislation applicable to waste management, the GoG has the following pieces of legislation enacted (Table 3.8):

Table 3.8 National Legislation related to solid waste management. *Source: Putting Waste in its place: A National Solid Waste Strategy for the Cooperative Republic of Guyana 2013-2024 (Draft); Ministry of Local Government and Regional Development, Hydea.*

Legislation	Lead Agency	Summary
Draft Solid Waste Management Bill 2014	Solid Waste Management Authority	Establishes licensing and permit systems for waste management facilities and waste haulers. Prescribes penalties for littering, illegal dumping, burning, operating without licenses and other infractions.

Legislation	Lead Agency	Summary
Customs Act	Guyana Revenue Authority	Levies and environmental tax of GY$10 on every unit of non-returnable metal, plastic, glass or cardboard container of any alcoholic or non-alcoholic beverage imported to Guyana
Environmental Protection Act 1996	EPA	Outlines the environmental impact assessment process and licenses polluting activities.
Environmental Protection (Litter Enforcement Regulations 2013)	EPA	Prescribes penalties for littering (including from a motor vehicle), and appoints Litter Prevention Wardens to enforce provisions.
Environmental Protection (Hazardous Wastes Management) Regulations 2000	EPA	Grants EPA powers to issue environmental authorizations for facilities that generate, treat, store, dispose, or transport hazardous wastes. Prescribes penalties for operation without an environmental authorization.
Municipal and District Councils Act	Municipalities and District Councils	Empowers councils to establish, maintain and carry out sanitary services for the removal and destruction or management of all kinds of refuse and effluent, and to make by-laws. Prescribes penalties for littering and illegal dumping
Old Metal Dealers Act & Old Metal Dealers (Amendment) Act 2006	Office of the Prime Minister	Regulates the export of old metal (scrap metal) and prohibits export without an export license. Requires old metal dealers to be registered and licensed.
Pesticides and Toxic Chemicals Act 2002	Pesticides and Toxic Chemicals Control Board, Ministry of Agriculture	Requires that importers and sellers of toxic chemicals and pesticides (and associated storage facilities) be licensed.
The Public Health Ordinance Act Cap 145 Laws of British Guyana 1953 Edition		Passed in 1934, it represents the oldest law regulating solid waste management. It is still relevant and used to enforce offences including littering

The legislative instruments stated above and the standards set are not as comprehensive as it could be expected. For example, there are provisions in the laws which prescribe standards for the analysis and characterization of waste. Besides for hazardous wastes, there are still no effective technical standards governing the disposal of other types of waste (PAHO/WHO 2004).

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Section 2

State of the Environment and Trends

CHAPTER 4

Land

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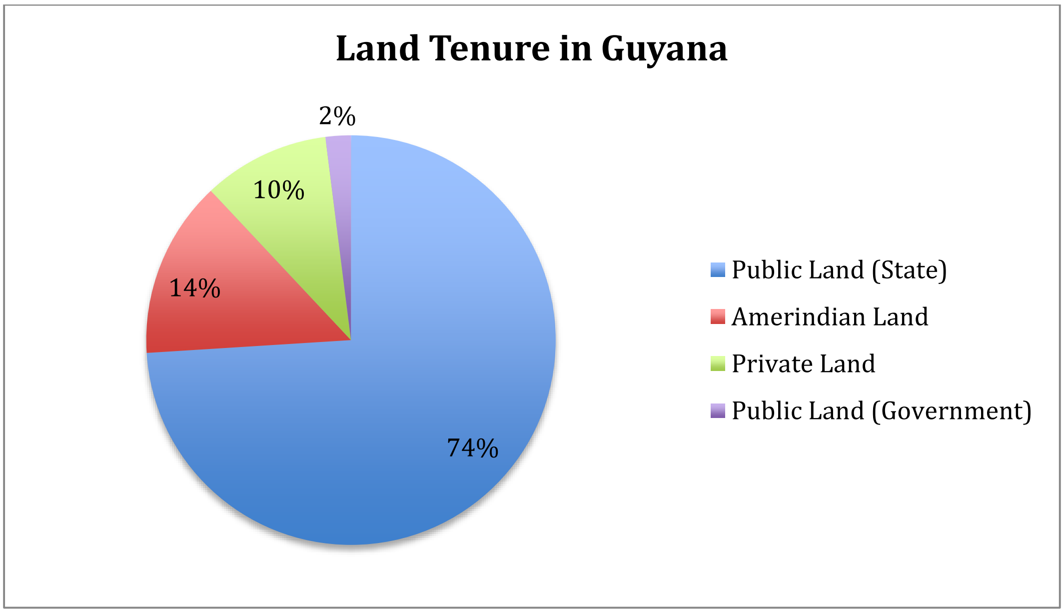
LAND TENURE AND LAND COVER

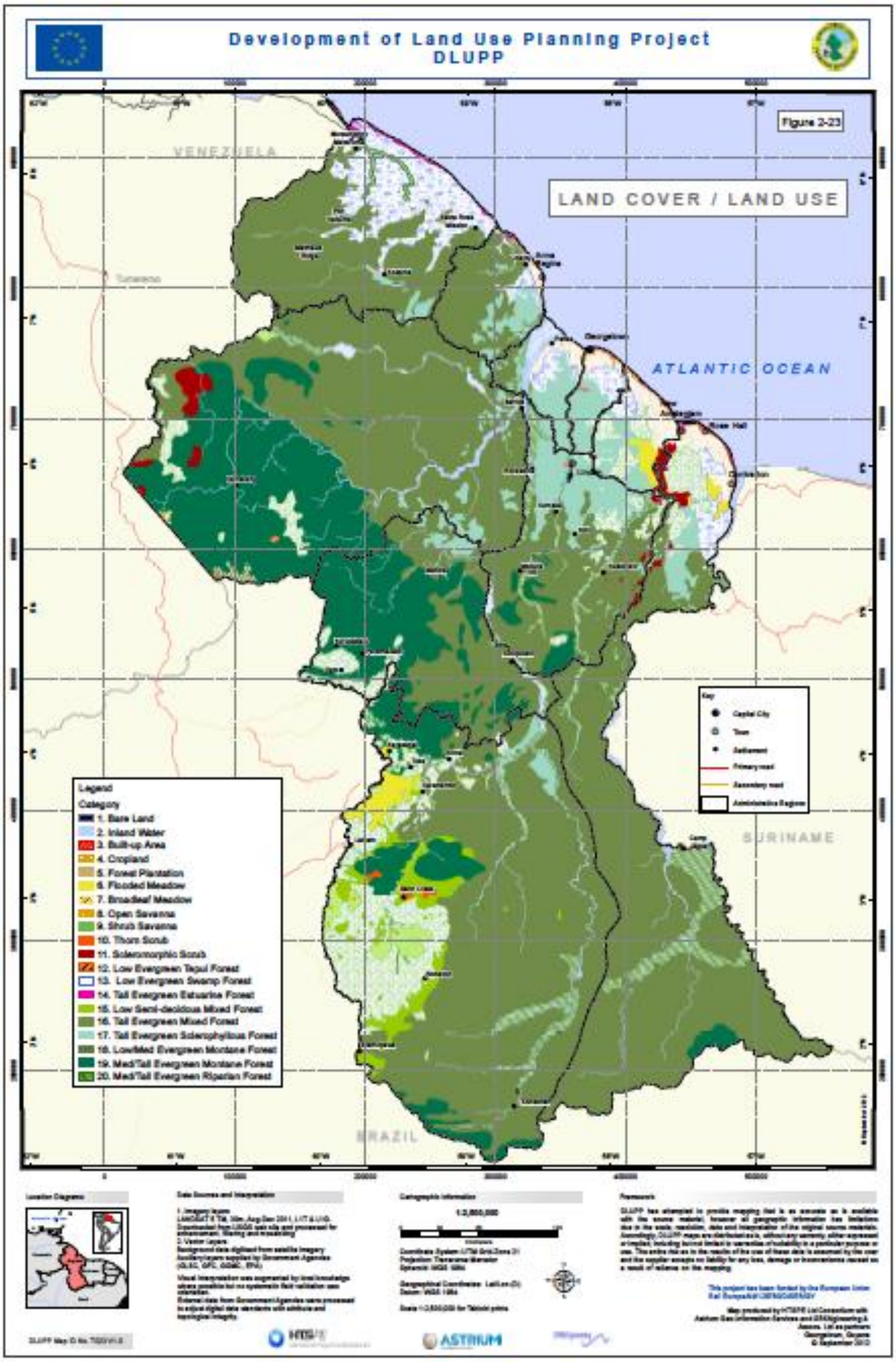
Land tenure distinguishes Guyana from most other South American countries. Figure 4.1 below shows the distribution of land tenure in Guyana, where more than 75 per cent of total land is public land, either as State land or as Government land (GLSC 2013). The figures for private land and Amerindian land are estimated at 10% and 14%, respectively. In the case of private land, the estimate of the National Land Use Plan places it at closer to 1% than to 10%. In the case of Amerindian lands, there are areas still waiting for dispute resolution or awaiting demarcation (GLSC 2013).

Figure 4.1 Land Tenure in Guyana. ***Source: GLSC 2013***



In terms of land cover, as Figure 4.2 illustrates, forests occupy most of the country (approximately 88%) followed by Savannahs with close to 8%. Less than 2% of Guyana´s land mass is influenced by permanent human use and the rates of transformation are low in comparison to regional trends. The deforestation rates are less than 0.06% per year, driven mainly by mining and marginally by agriculture (GLSC 2013).

Figure 4.2. Land Cover / Land Use Map *Source: GLSC, 2013*



The rest of this chapter describes the main land cover types and land uses present in the country, in particular the situation of Forests and Grasslands, which represent the most extensive land cover classes in Guyana. The analysis is structured on the DPSIR framework and is based on existing information and discussions conducted during the participatory workshop conducted in early 2016 (see Chapter 1).

FORESTS

LAND CLASSES AND FORESTS

Forests are the most extensive land cover of Guyana and its area is suitable for forestry, agriculture, mining and other important social and economic activities. Land Tenure arrangement in Guyana can be classified broadly into four main categories. The limits and activities for each category are outlined in Table 4.1 and Figure 4.3:

Table 4.1 Land Classes

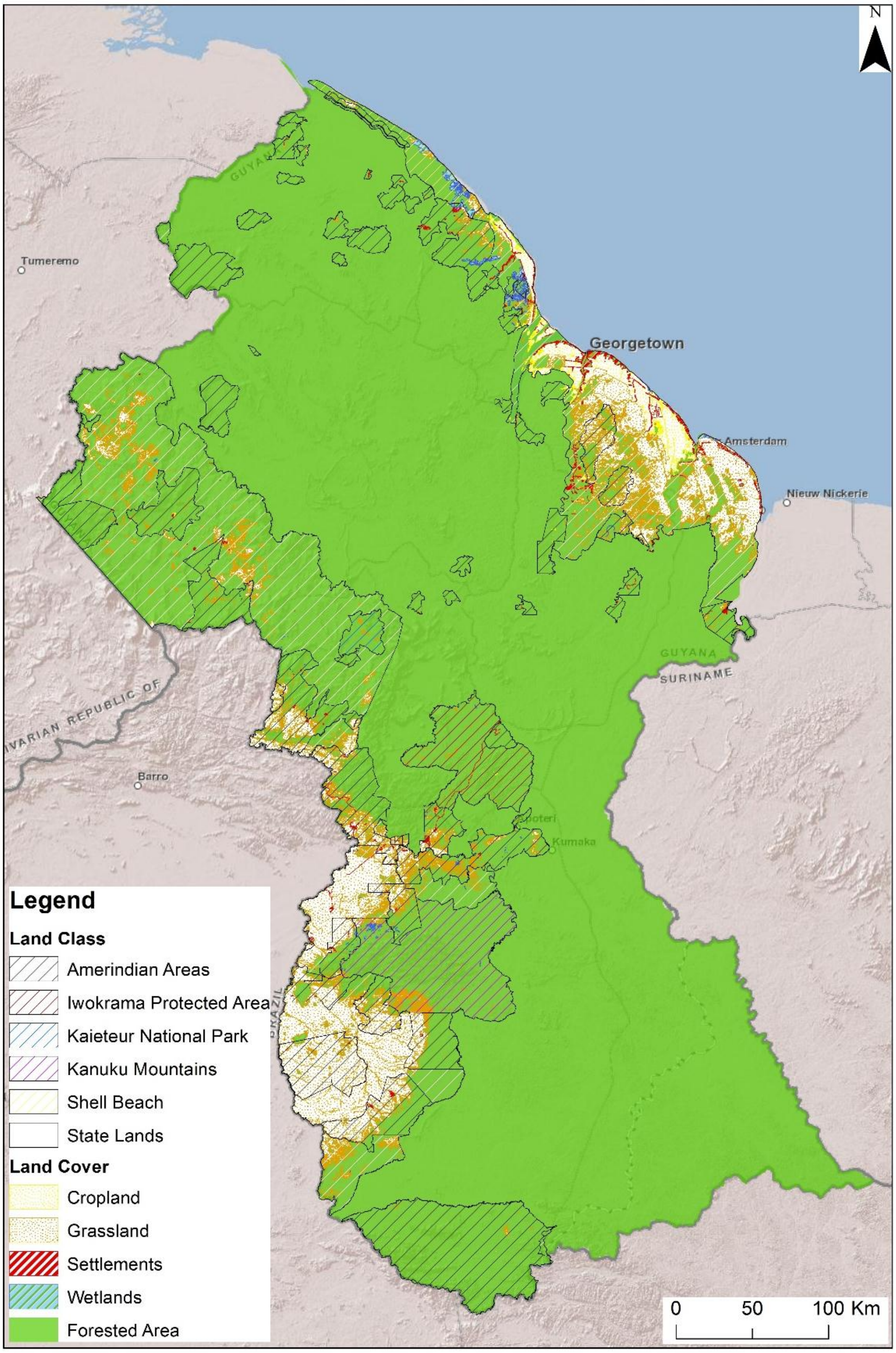
2014 Land Classes	Forest	Non-Forest					
		Grassland	Cropland	Settlements	Wetlands	Other Land	Total
	(Area '000 ha)						
State Forest Area	12 249	196	8	7	129	5	12 594
Titled Amerindian lands **	2 582	695	3	9	22	4	3 316
State Lands	2 560	993	332	44	100	44	4 073
Protected Areas	1 091	26	<1	<1	21	<1	1 139
Total Area	18 483	1 910	343	60	273	54	21 122
** Including newly titled lands. It should be noted that the process for titling Amerindian lands changes the forested and non-forested areas for the remaining categories.							

State Forest Area: According to the Forest Act 2009, Section 3, Chapter 61:01, the State Forest Area is that area of State Land that is designated as State Forest. This area of State Forest has been gazetted. As stipulated in the National Forest Policy Statement, 2011, the State Forests shall be classified as follows:

- Multiple Use Forests - forests to be utilised for the concurrent production of goods (timber and non-timber products), and the provision of, services such as those derived from the ecosystem and other natural resources.
- Permanent protection forests and biodiversity reserves - in which, because of the type of the forest ecosystem, no tree felling or other types of forest utilisation shall be permitted, and in which representative areas of biodiversity shall be inviolate.
- Reserve forests – forests, which are yet to be classified, and on which no extraction shall be permitted without Ministerial approval.
- Conversion forests - forests to be cleared for other uses.

State Lands: For purposes of this assessment, State Lands are identified as areas that are not included as part of the State Forest Area that are under the mandate of the State. This category predominantly includes State Lands, with isolated pockets of privately held land, but does not include titled Amerindian villages.

Figure 4.3 Location of Land Classes. *Source: GFC 2015*



Protected Areas: To date, the four Protected Areas that come under the scope of the Protected Areas Act are: Iwokrama, Shell Beach, Kanuku Mountains and Kaieteur

National Park. Altogether, these account for a total of 1 141 000 ha designated as Protected Areas.

Titled Amerindian Land: The Amerindian Act 2006, provides for areas that are titled to Amerindian villages. It includes both initial titles as well as extensions that have been granted to these titled areas.

State Forest Allocation: A total of 44% of the State Forest Estate is still unallocated, and totalling a size of 5.4 M hectares.

State Forest Permissions (SFPs) are granted for 2 years for an area no more than 8,047 ha; Wood Cutting Leases (WCLs) are granted for up to 10 years of an area between 8,047 ha and 24,000 ha; and Timber Sales Agreements (TSAs) are granted for a period up to 30 years for an area in excess of 24,000 ha. All leases are renewable subject to compliance with the terms of the agreement. State Forest Exploratory Permits (SFEPs) are granted for 3 years and is the precursor to a TSA and WCL. (Refer to Table 4.2)

Table 4.2 Classification and Extension of Production Lands

CLASSIFICATIONS	COUNT	Area (Hectares)	% Total Allocation	% State Forest
PRODUCTION LANDS				
State Forest Permits (SFP)	568	2,045,211	28	16
State Exploratory Permits (SFEP)	6	570,302	8	5
Wood Cutting Leases (WCL)	1	21,268	0.30	0.17
Timber Sale Agreements (TSA)	27	4,527,345	63	36
Total Production Area Allocated by GFC	**602**	**7,164,126**	**100**	**56.89**
PERMANENT RESEARCH AND RESERVES				
GFC Forest Reserves	11	17,797		
Total Forest Allocated (Management by GFC)		**7,181,923**		
Unallocated State Forest Estate		5,412,077		
Total State Forest Estate		**12,594,000**		
PROTECTED AREAS				
Iwokrama	1	371,681		
Kaieteur National Park	1	61,091		
Other Protected Areas (Shell Beach and Kanuku Mountains)	2	730,300		

Guyana's forests are characterised by high species diversity, and the main commercial species have a low standing volume per unit area. The high species diversity results in low volume extraction per unit area (ITTO, 2003).

Degradation is defined here as a persistent, long-term decrease in canopy cover and biomass caused by anthropogenic activities that do not qualify as deforestation. The National framework for MRVS, or Roadmap, developed in 2009, describes the main causes of deforestation and degradation (referred to as “drivers”) (GFC, 2009), and the MRVS Interim Measures Report (Poyry, 2010 and Indufor 2011, 2012) further defines each driver and details their impacts.

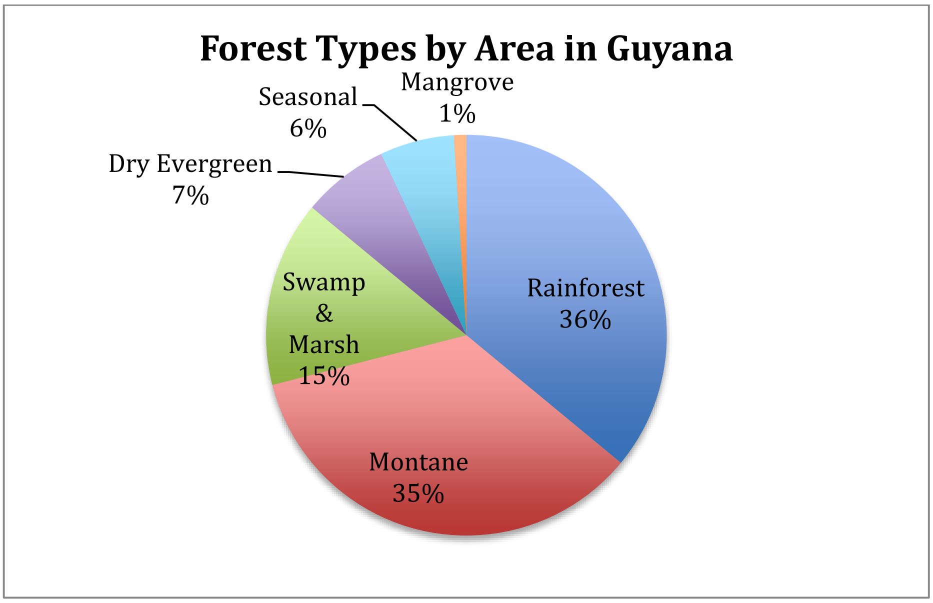
Each driver results in different levels of emissions, though the associated carbon stocks prior to deforestation or degradation do not necessarily differ by driver. The impact selective logging cannot be detected well with medium (e.g. Landsat) and high (e.g. RapidEye) resolution remote sensing imagery. Thus, a methodology was developed that uses available activity data such as timber extraction, and a system to collect data for developing emission factors related to such activity data.

The sustainable utilization of forest under concession management, has allowed for multiple use of the forest, while ensuring that the forest cover remained intact. The best example of this is given by the positive results produced as evidenced by the last 5 years with payments being received under the Guyana Norway Forest and Climate Agreement, for keeping the forest intact and under good management.

FOREST TYPES

Despite its size, Guyana has a significant diversity of forest types (see Figure 4.4). Rainforest and Montane Forests compromise more than 70 % of the country´s forests with approximately 35% each and Mangroves lie on the other end with 1% of total forests. As it is described in Chapter 6, the forests of Guyana are valuable reservoirs of biodiversity. They provide home to approximately 8,000 plant species and in excess of 1,000 species of terrestrial vertebrates (GFC, 2011). Of the plant and animal species, it is estimated that 5% of all flora species in Guyana are endemic. Guyana’s forests provide numerous habitats for wildlife, and are an integral part of the country’s freshwater ecosystems. In addition, the forests provide other ecological services: the regulation of water regimes by intercepting rainfall and regulating its flow through the hydrological system; the maintenance of soil quality and the provision of organic materials through leaf and branch fall; the limiting of erosion and protection of soil from the direct impact of rainfall; and modulating climate (GFC, 2011).

Figure 4.4 Forest Types. Source GFC



MIXED FOREST

This unit is the most common type of forest occurring in Guyana. It occurs in lowlands (10-400m) with high rainfall. The evergreen units occur in the north-west areas of Regions 1 and 7 commonly known as 'Rainforest' as well in the Pakaraimas (on the border with Venezuela) and the uplands on the border with Brazil. In the southern areas of Region 9 they are mainly deciduous and occur at the border of the Rupununi savannahs to the South – East, and have a high abundance of endemic and commercial timber species.

MONTANE AND STEEP FOREST

Montane forest units in Guyana are associated with high rainfall tolerant species (*ombrophilous*) and slopes in the uplands (500-2,000m). They occur mainly in the southern regions, the Kanuku Mountains, the Pakaraima Mountains and the upper Mazaruni valley.

SWAMPS AND MARSH FOREST

In permanently flooded, flat plains in the present coastal zone a low swamp forest is found. Characteristic species are *Symphonia globulifera*, *Tabebuia insignis/fluviatilis*, *Pterocarpus officinalis* and *Euterpe oleracea*. Species that can become locally dominant in this forest type in Guyana are *Pentaclethra macroloba, Vatairea guianensis, Pterocarpus officinalis* and *Virola surinamensis. Manicaria saccifera* is commonly found as a narrow belt along rivers. More inland, the duration of flooding is less pronounced and forest composition is slightly different. Common species here are *Symphonia* *globulifera*, *Virola surinamensis*, *Iryanthera spp.*, *Terocarpus officinalis*, *Mora excelsa*, *Pachira aquatica*, *Manicaria saccifera* and *Euterpe oleracea*.

WALLABA/DAKAMA/MURI SCRUB

In areas where fires are very regular or in flood-prone areas, Dakama forest degrades into Muri-scrub, dominated by *Humiria balsamifera*. Other common species in this scrub are *Swartzia bannia, Clusia fockeana, Licania incana, Bombax flaviflorum, Ocotea schomburgkiana, Trattinickia burserifolia, Ternstroemia punctata* and *Byrsonima crassifolia*

MANGROVE FOREST

Mangrove vegetation primarily comprises trees and shrubs, with a limited number of palms and lianas (Evans, 1998). There are three main mangrove species occurring in Guyana. These are *Avicennia germinans, Rhizophora* mangle and *Laguncularia racemosa* (Hussein, 1995as cited by FAO, 2010).

STAKEHOLDERS

The Guyana Forestry Commission (GFC) was formed in 1979, under the Guyana Forestry Commission Act, and is the agency responsible for administration of the Forests Act. The GFC Board has 12 members. Each Board member is appointed for a period of 12 months, although each incumbent is eligible for re-appointment on the expiry of his or her term of appointment. The Board meets monthly and is responsible for the Commission's governance including policy development. GFC has a legal mandate to manage and control the utilization of the State Forest Estate. Its main role is to ensure the sustainable utilization of the State Forest Estate in keeping with sustainable forest management principles and guidelines captured in the Forest Act 2009.

Governed by a developmental mandate, this agency ensures that that there is a balance among the pillars of social, economic and environmental development. Over the past decade, the Commission has undergone rapid development in the implementation of sustainable forest management, legality, and environmental standards.

The main stakeholders within the forest sector have been identified based on stakeholder mapping. Users range from local communities living in and near the forest to large concessionaires headquartered in urban areas or overseas. These include:

- Regulatory forestry bodies & sister agencies: GFC, Forestry Training Centre Inc., Forest Products Development & Marketing Council
- Ministries & sector agencies: agencies involved in natural resources management and climate change, including the Office of Climate Change, Ministries of Natural Resources & Environment, Agriculture, Indigenous Peoples Affairs, Public Infrastructure, Communities, Finance, as well as, the Energy, Land Administration, Mining, and Environmental Management sectors;

- Private Sector Bodies: Loggers and Miners Associations, Forest Producers Association, Guyana Gold and Diamond Miners Association, Private Sector Commission (PSC), etc;
- Civil Society Organizations and community organizations & NGOs including Trade Unions Congress, Federation of Independent Trade Unions of Guyana; Indigenous NGOs;
- Amerindian villages and communities;
- Other forest dependent communities, including miners;
- Academia; and
- International: international community and others.

PRESSURES

Several pressures were identified as the main causes of forest degradation and deforestation in Guyana. Table 4.3 below shows the extent of each one of these pressures on deforestation and degradation. The rest of the section briefly describes each one of the main pressures.

Table 4.3 Anthropogenic Drivers of Forest Change 1990 to 2015. *Source: GFC, 2016.*

Driver	Historical Period			Year 1	Year 2 2010-11 (15 months)		Year 3 2012		Year 4 2013		Year 5 2014	
	1990 to 2000	2001 to 2005	2006 to 2009	2009-10	Deforestation	Degradation	Deforestation	Degradation	Deforestation	Degradation	Deforestation	Degradation
	Area (ha)											
[1]Forestry (including forestry infrastructure)	6 094	8 420	4 784	294	233	147	240	113	330	85	204	62
Agriculture (permanent)	2 030	2 852	1 797	513	52	-	440	0	424	-	817	-
[2]Mining (includes mining infrastructure)	10 843	21 438	12 624	9 384	9 175	5 287	13 516	1 629	[2]11 251	2 955	10 191	3 674
Infrastructure	590	1 304	195	64	148	5	127	13	278	112	141	63
Fire	1 708	235		32	58	28	184	208	96	395	259	265
Settlements									23	20	71	-
Shifting Agriculture										765		167
Year 2 forest degradation converted to deforestation							148		67		22	
Year 3 forest degradation converted to deforestation									200		94	
Year 4 forest degradation converted to deforestation											127	
[3]Amaila Falls Development (Infrastructure roads**)**					225				64	20	49	20
Area Change	**21 267**	**34 249**	**19 400**	**10 287**	**9 891**	**5 467**	**14 655**	**1 963**	**12 733**	**4 352**	**11 975**	**4 251**
Area Change less Shifting Agriculture										**3 587**		**4 064**
Total Forest Area of Guyana	18 473 394	18 452 127	18 417 878	18 398 47 8	18 388 190		**18 502 531**		18 487 876		[4]**18 482 547**	
Total Forest Area of Guyana Remaining	18 452 127	18 417 878	18 398 478	18 388 19 0	18 378 299		18 487 876		18 475 143		18 470 572	
Period Deforestation (%)	0.01%	0.04%	0.02%	0.056%	0.054%		0.079%		0.068%		0.065%	

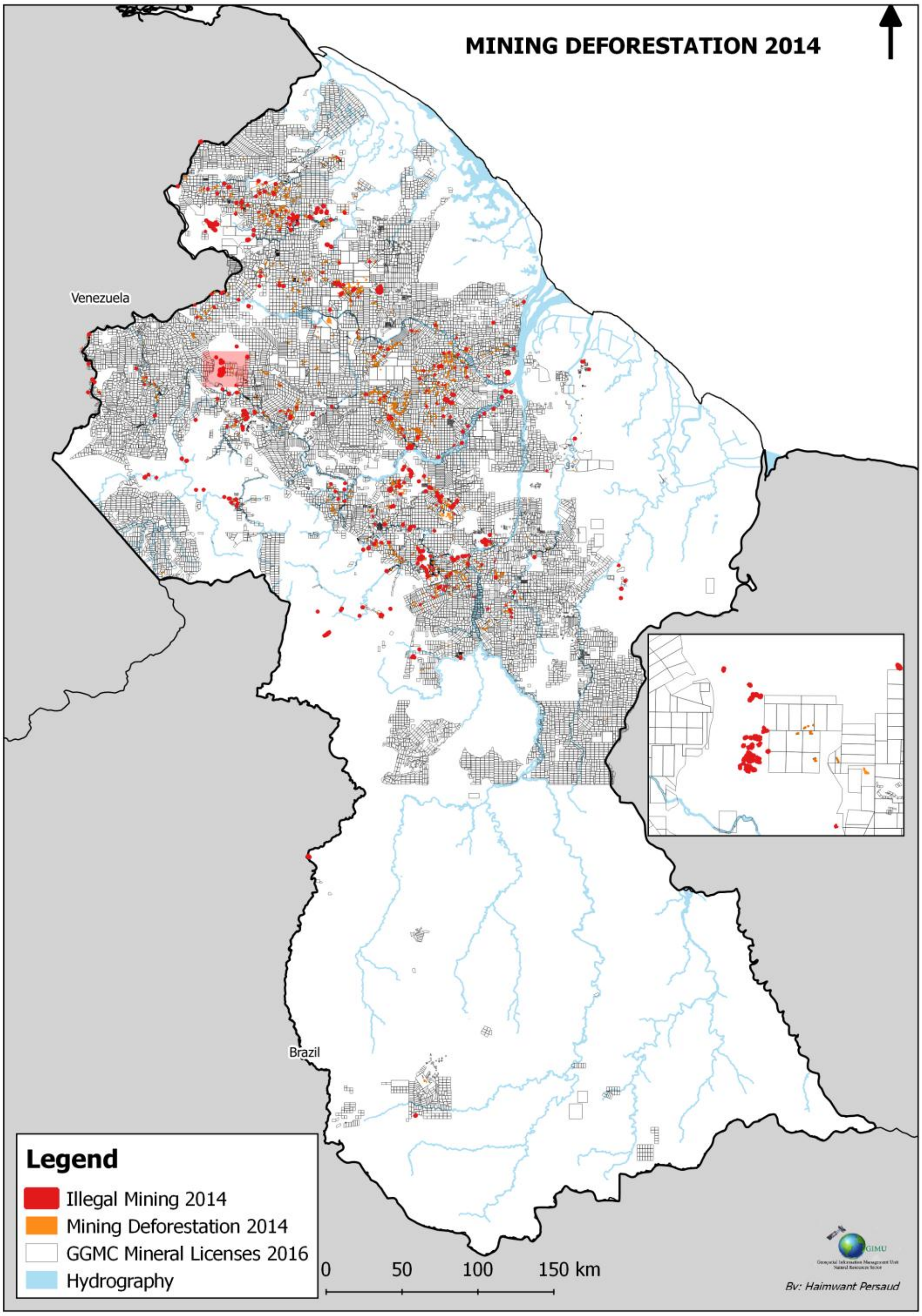
[1]Forestry infrastructure accounts for the full total of deforestation from forestry activities.
[2]Mining Infrastructure accounts for 918 ha in 2013 out of the total deforestation driven by mining of 11 518 ha, when Year 2 & 3 transitional areas are taken into account.
[3]Amaila Falls Development has been split from other infrastructure driven change for reporting purposes.
[4]Using the updated start forest area as derived from Year 5 mapping.
[5] Area change totals may vary between 1 to 3 hectares owing to the rounding of numbers.

LEGAL AND ILLEGAL MINING

As described in Chapter 1, mining is the greatest cause of deforestation in Guyana, and results in long-term deforestation. Large-scale, open-pit mining effectively reduces all of the carbon stocks of the forest vegetation (live and dead biomass) to zero. Ground excavation activities have a major impact on the soil, removing the top soil, which then often gets buried when overburden is excavated and piled onto the topsoil. However, top soil that includes soil organic matter is disturbed, resulting in soil carbon emissions due to mining.

Figure 4.5 shows the extent of legal and illegal mining in 2014 and existing GGMC licences in 2016. The incidence of illegal mining exceeds that of legal mining operations and represents an important pressure on forests and rivers throughout the country.

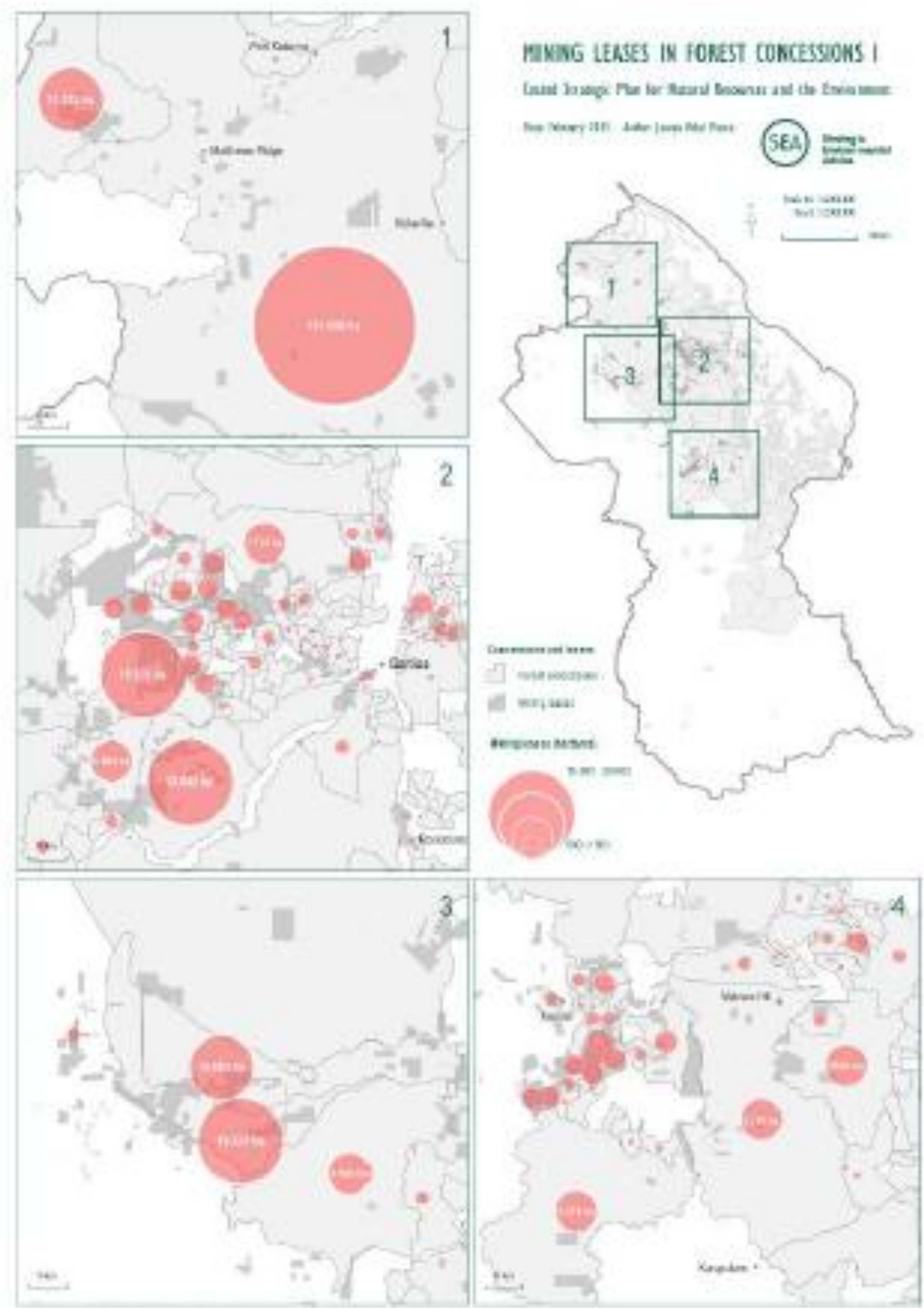
Figure 4.5 Deforestation from Legal and Illegal Mining 2014. *Source MNR 2016*



Mining activities, including associated road construction, are concentrated in the northwest of the country. Forest change related to mining includes mining sites and any infrastructure associated with the operation, and historical degraded areas that have been converted to deforestation. This includes any roads that lead directly to mining.

In addition to the illegal mining problems, the allocation and exploitation of legal mining operations also affects the efficient exploitation of forests. An analysis conducted in 2013 shows that 385.265 hectares of mining leases fall within existing forest concessions (Figure 4.6). The overlapping of these extractive industries presents serious problems, particularly when mining exploitations arrive to the location prior to forest exploitation and valuable species are lost.

Figure 4.6 Mining Leases in Forest Concessions. *Source: AAE 2013 based on information from GLSC, GFC and GGMC*



Small-scale mining that affects a smaller land area, often less than one hectare, is classed as degradation. This practice is likely to result in fewer trees being cleared per unit area than medium or large-scale mining. Therefore, the immediate impact of such activities should be classified as degradation due to the definition of a forest as having a minimum area of one hectare. However, small-scale mining operations often coalesce, resulting in what appears to be a medium-scale mine (Figure 4.7). Small-scale mining operations will be tracked using very high resolution satellite imagery in post 2010 work by GFC. Regeneration (gain) could occur over time on small clearings when abandoned but at this stage no assumptions as to what this value might be will be made given that it is conservative not to include it.

Figure 4.7 Multiple Small Scale Mining Coalescing. *Source: F Casarim*

LEGAL AND ILLEGAL LOGGING

The majority of the forestry activities are located inside the State Forest Area. The removal of trees during selective logging, whether legal or illegal[44], and the incidental damage– broken branches and snapped or uprooted trees – caused by felling timber trees leads to forest degradation through the loss of carbon stocks in the remaining forest stand. The creation of skid trails (trails created by bulldozer type skidders to extract logs out of the forest), log markets (landings or decks where logs are piled when extracted from the forest), and logging roads also decrease canopy cover and standing carbon stocks with resultant emissions. In addition, the gaps created by logging may increase the growth rate of the residual trees and allow ingrowth of saplings. Because logging practices are diffuse in the landscape and these dynamics exist, the gain-loss method is the best approach to determining emission factors. (see Figure 4.8 below for forestry spatial and temporal distribution)

A demand exists within Guyana for both charcoal and firewood, and the quantities produced are tracked by GFC. Charcoal is produced from offcuts of commercially felled timber and so is included in the accounting method for timber extraction.

Firewood is produced from lands designated for this purpose as “firewood leases”. These lands are generally covered by poorly stocked forests, and in some cases they may not even fall within the definition of a forest (<30% canopy cover),

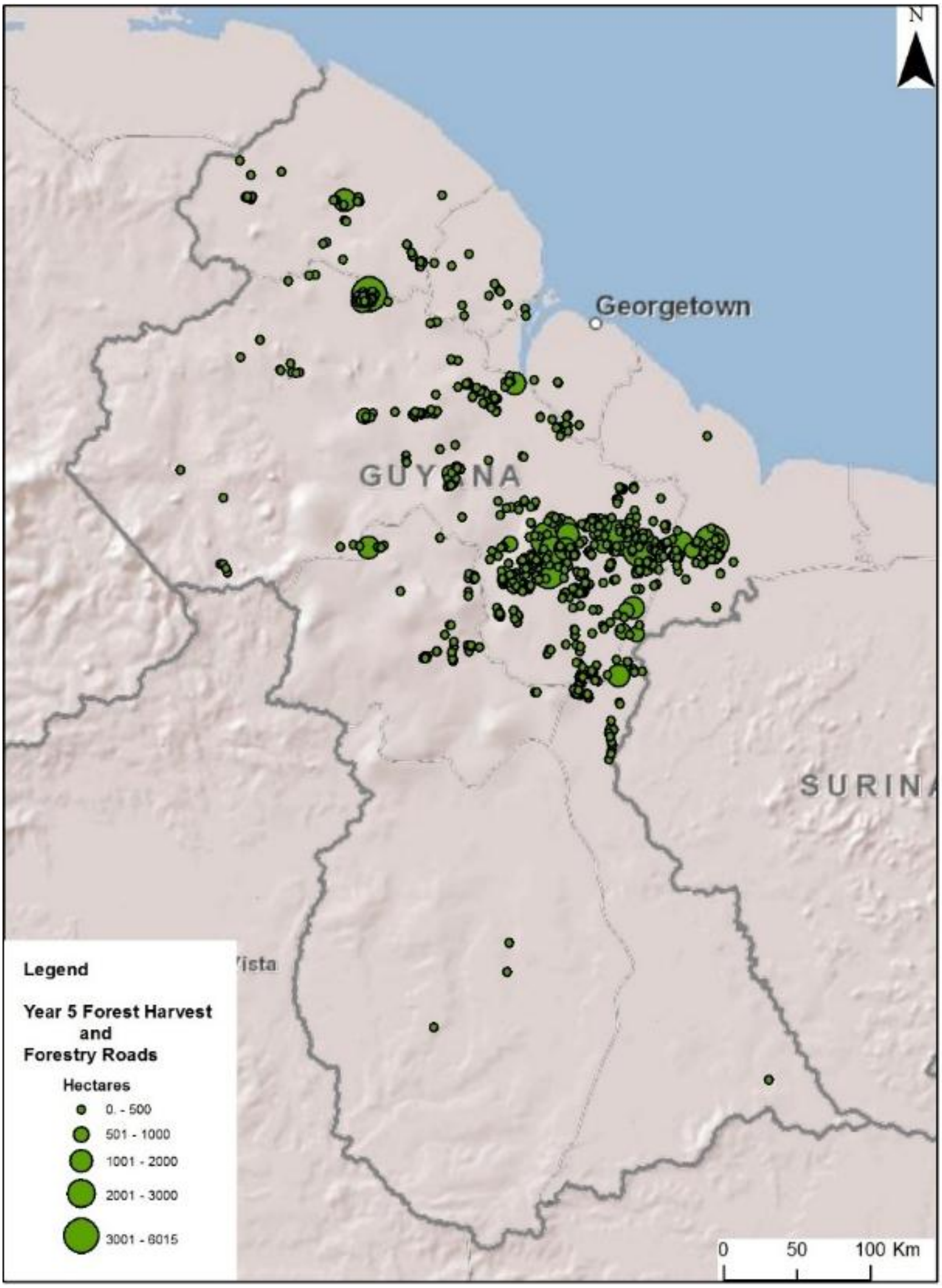
[44] GFC currently uses a monitoring system to estimate the volume of wood illegally logged every year, estimated to be an additional 10% of the volume of timber legally logged.

and the woody material is allowed to be collected before the land is converted to agriculture. Thus, this activity should be considered to fall under deforestation when the canopy cover is > 30% but the carbon stock will be considerably lower than those for activities in the more dense forests.

During the Year 5 period, all deforestation events are associated with forestry harvest operations. The main causes of forest clearance include road and log market construction. The reported Year 5 value (of 204 ha) is a decrease when compared to the previous two Years.

Under the existing interim measures, forest harvesting is reported in terms of carbon removal (tCO_2) rather than spatially. However, overall activity at the harvest block level (100 ha) across concessions is monitored.

Figure 4.8 Forestry Spatial and Temporal Distribution *Source: ?*



INFRASTRUCTURE (TRANSPORTATION, SETTLEMENT, HYDRO-ELECTRIC, ADMIN FACILITIES, SCHOOLS)

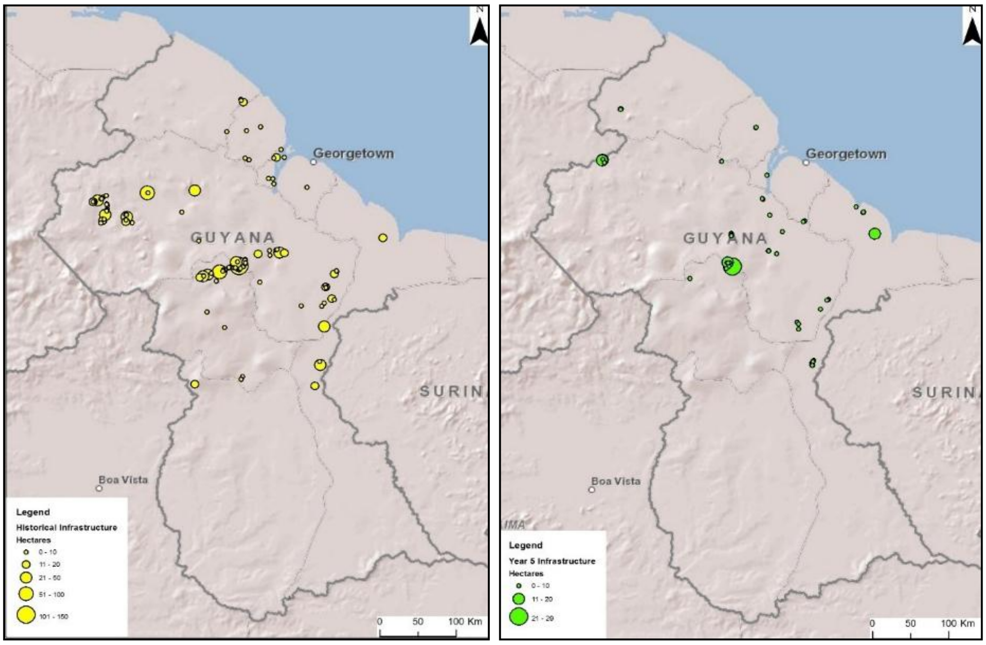
In the national monitoring and mapping system (MRVS), roads are readily identifiable by their distinctive linearity. Linear features are deemed to be roads if the spectral response shows the presence of bare soil which is associated with the construction of unpaved roads.

The roads were traced from the imagery as linear features and converted to areas by applying a 20 metre wide buffer, on either side of the features, and where appropriate, the buffer was edited. This width is considered to be realistic as it corresponds to the image resolution at which bare ground is detected. Road lines captured with GPS (since 2003) were also overlaid to ensure that road lines were completed. This dataset also contains information about the class of road. Where posible, the driver of the road construction was also attributed.

The distribution pattern of deforestation also shows that areas of increased activity tend to be clustered around the existing road infrastructure and rivers.

The building of new roads within forests both for transportation and to facilitate logging and mining activities results in deforestation through the reduction of forest cover. These emissions can be estimated using the stock difference method. Log landings are often part of the logging roads and are considered deforestation that can also be estimated using stock difference method. Emission factors from soil disturbance due to building roads will depend on whether a road is paved or not. If paved, it will be assumed there are no soil carbon emissions.

Figure 4.9 Infrastructure Roads Spatial & Temporal Distribution up to 2014 *Source: GFC, 2015*



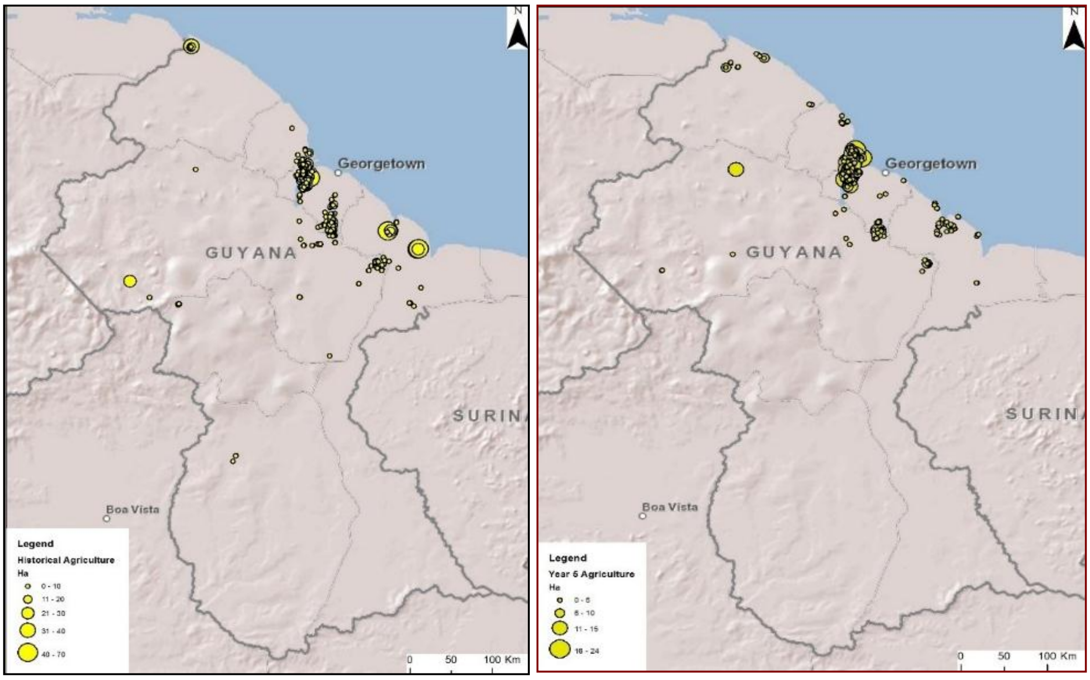
AGRICULTURE, METHOD OF LAND PREPARATION, SUBSISTENCE AGRICULTURE, SCALE

This category includes arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for the forest land category, consistent with the selection of national definitions. Cropland is identified as permanent fields, mainly sugar cane fields, but also other crops or mixed agricultural land, as long as the agricultural component appears to be dominant. These areas are also located in close proximity to settlements and along the coastal fringe and appear in the form of larger >5 ha regular shaped blocks. The GL&SC also provided registered agricultural leases, which provide an additional reference layer.

Intensive production agriculture is identified by the presence of large rectangular patches arranged in an ordered regular pattern. Each patch has its own distinctive spectral signature in the national mapping process. The converted land generally lies adjacent to existing established farmland.

Deforestation results from the conversion of forest land to agricultural land. This reduces carbon present in all forest vegetation to practically zero, and if converted to annual croplands, common practice in Guyana, losses in soil carbon will also occur. Emissions resulting from agricultural conversion will be estimated using the stock difference method.

Figure 4.10 Agriculture Development Spatial & Temporal Distribution Historical and Year 5 (2014). *Source GFC, 2015*



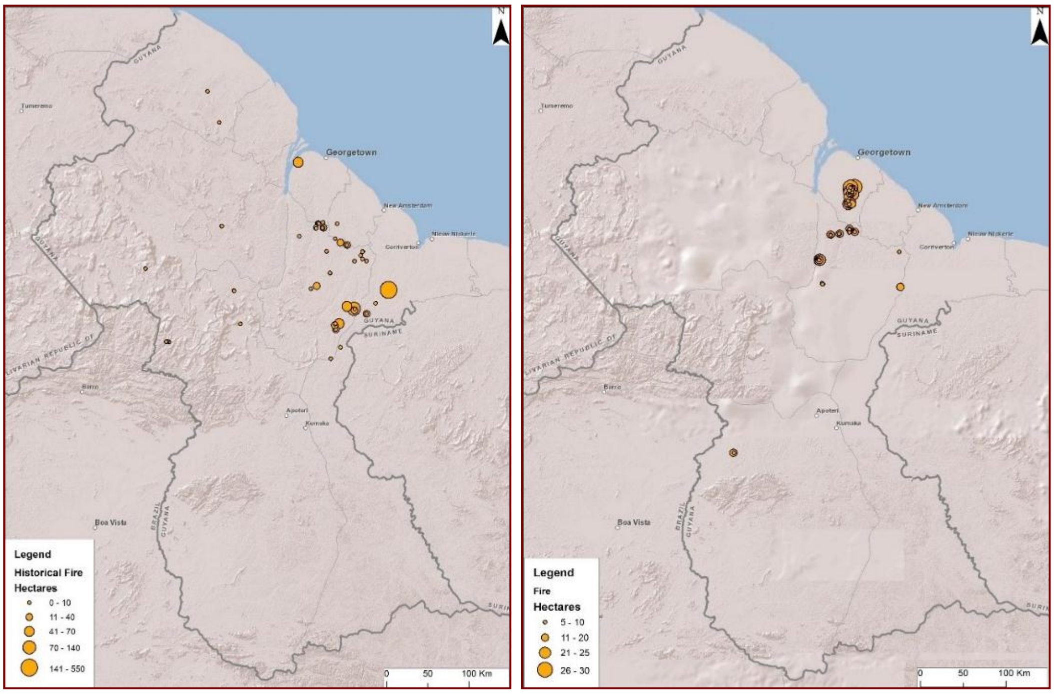
FIRE, NATURAL AND ANTHROPOGENIC

The cause of all fires (biomass burning) is assumed to be human induced or anthropogenic events. The Fire Information for Resource Management System (FIRMS) and the 500 m burnt area product provides information about historic and present day fire locations using the Moderate Resolution Imaging Spectroradiometer (MODIS) and this is used in the national MRVS. Since MODIS works on the basis of detecting thermal anomalies, it is only effective in cloud-free conditions.

Successful detection of burnt areas depends on the intensity and the scale of the fire. If the event has occurred recently, the burnt areas will show a strong response in near infrared band due to a decrease in actively photosynthesising vegetation. In Guyana, the areas most at risk include the coastal zone and savannah or white sands regions. Often, burning is associated with land clearance and if not detected immediately may be classified as shifting agriculture.

When large enough in scale and intensity, fires are detected in the satellite imagery based on manual methods (Guyana MRVS Interim Measures Report 16 March 2011). The impact of fires on the soil carbon pool likely depends on the intensity of the fire. With relatively low intensity of fires, the soil will not become hot enough to cause a reduction of carbon stocks; alternatively, it could increase the stocks due to the formation of charcoal from burned debris. Even if losses occur, if the area is allowed to regrow then the soil carbon is likely to recover rapidly given deposition of ash.

Figure 4.11 Biomass Burning - Fire Temporal and Spatial Distribution Historical to Year 5 (2014). *Source : GFC, 2015*



STATE AND TRENDS

The 1990 forest cover was estimated to be 18.47 million ha. This was determined using manual interpretation of historical aerial photography and satellite images and verified independently by the University of Durham (UoD, 2010 and 2011). By 2011, the forest cover had reduced to 18.38 million ha due to deforestation. In 2012, the forest cover was reassessed using high-resolution imagery and the baseline figure increased to 18.5 million ha. Further updates to the high-resolution imagery resulted in a final update in 2014, with an estimated start forest area of 18.48 million ha.

Deforestation and forest degradation occur in the State Forest Estate where logging, mining and agricultural activity co-exist, as well as in other forestlands. Deforestation and forest degradation are driven by five principal factors, namely: 1) the clearing of forested areas for mining; 2) logging; 3) the conversion of forested areas to allow for agricultural activities; 4) infrastructural developments such as roads; and 5) Forest Fires. (Source: Guyana's MRVS 2010 Interim Measures Report).

DEFORESTATION

Deforestation is the long-term anthropogenic conversion of forest land to another land cover category, with forest land in Guyana defined as land which meets these criteria:

- Tree cover of 30% or more;
- With a minimum height of 5 meters; and
- Covering an area of at least one hectare.

The six (6) historic anthropogenic change drivers that lead to deforestation include:

- Forestry (clearance activities such as roads and log landings);
- Mining (ground excavation associated with small, medium and large scale mining);
- Infrastructure such as roads (included are forestry and mining roads);
- Agricultural conversion;
- Fire (all considered anthropogenic and depending on intensity and frequency can lead to deforestation); and
- Settlements was added as a driver in Year 4 (2013), a new driver 'settlements'. This allows for human settlement driven change such as new housing developments to be accounted for.

Table 4.4 below shows the area of deforestation since 1990 and with more detail for the 2010-2014 period, during which the Monitoring, Reporting and Verification System (MRV) was in place as well as verified by third party independent auditors. Yearly deforestation rates have been between 0.056% and 0.065% per cent. This figure is low compared to global and developing countries' tropical deforestation rates and has allowed Guyana to receive payments in the framework of the agreement with Norway (see chapter 2).

Table 4.4 Deforestation Rate. *Source: GFC 2016*

Period	Years	Analysis Imagery resolution	Forest Area ('000 ha)	Change ('000 ha)	Change Rate (%)
Initial forest area 1990		30 m	18 473.39		
Benchmark (Sept 2009)	19.75	30 m	18 398.48	74.92	0.41
Year 1 (Sept 2010)	1	30 m	18 388.19	10.28	0.056
Year 2 (Oct 2010 to Dec 2011)	1.25	30 m & 5 m	18 378.30	9.88	0.054
Year 3 (Jan 2012 to Dec 2012)	1	5 m	18 487.88	14.65	0.079
Year 4 (Jan 2013 to Dec 2013)	1	5 m	18 475.14	12.73	0.068
Year 5 (Jan 2014 to Dec 2014)	1	5 m	18 470.57	11.98	0.065

Table 4.5 below describes deforestation during the same period in relation to the different drivers described before.

Initial steps in the development of the MRVS over the Year 1 to Year 5 periods have allowed for a historical assessment of forest cover to be completed, key database integration to be fulfilled and for interim/intermediate indicators of emissions from deforestation and forest degradation to be reported on for subsequent periods.

To date, five national annual assessments have been conducted. The first assessment period covered Year 1 (01 October, 2009 to 30 September, 2010), while the second assessment period covered Year 2 (01 October 2010 to 31 December 2011); the third assessment, Year 3, covered a twelve-month period from 01 January 2012 to 31 December 2012. The fourth assessment, Year 4, covered the subsequent twelve-month period from 01 January, 2013 to 31 December, 2013; and the fifth annual assessment covered the period 01 January, 2014 to 31 December, 2014.

Table 4.5 Annualised Rate of Forest Change by Period & Driver from 1990 to 2014. ***Source: GFC 2015***

Change Period	Change Period	Annualised Rate of Change by Driver						Annual Area of Change (ha)
		Forestry	Agriculture	Mining	Infrastructure	Fire	Settlements	
	(Years)	Annual Area (ha)						
1990-2000	10	609	203	1 084	59	171	-	2 127
2001-2005	5	1 684	570	4 288	261	47	-	6 850
2006-2009	4.8	1 007	378	2 658	41	-	-	4 084
2009-10	1	294	513	9 384	64	32	-	10 287
2010-11	1.25	186	41	7 340	298	46	-	7 912
2012	1	240	440	13 664	127	184	-	14 655
2013	1	330	424	11 518	342	96	23	12 733
2014	**1**	**204**	**817**	**10 191**	**141**	**259**	**71**	**11 975**

BOX 4.1: Progress on Monitoring Reporting and Verification System (MRVS) in Guyana

Guyana has made significant achievements in implementing a national forest monitoring and MRV system. This system has served to report on performance on "REDD+ Interim Indicators" outlined in the Memorandum of Understanding (MoU) between the governments of Guyana and Norway, the results of which are represented in the annual MRVS Interim Measures Reports. The Guyana-Norway Partnership has shown that some of the methods discussed at international levels are working, especially partnerships between developed and developing countries. Guyana has accomplished pioneering work and substantial capacity improvements, is able to measure and monitor both deforestation and forest degradation and is developing protocols specific to measuring and monitoring the individual drivers of forest change.

Work began in 2010, in the areas of forest area change assessment and forest carbon stock assessment and monitoring. These activities were carried out in collaboration with international experts on REDD+, namely Winrock International, Poyry and Indufor. The aim of these work areas was to determine the historical and current patterns of deforestation and their drivers.

To date, Guyana has completed forest area change assessments for the periods 1990–2000; 2001–2005; 2006 to September 2009 (Benchmark); 1 October 2009 to 30 September 2010 (Year 1); and 1 October 2010 to 31 December 2011 (Year 2), January to December 2012, and January to December 2013. Work was finalised in November 2015 on Year 5 (assessment year 2014). Each year, an independent, third party verification is completed on every annual assessment. These verifications have, for every year, validated the GFC's methods and reporting on the MRVS.

Area Deforested 1990 to 2014

Tabe 4.6: Forest Change Area by Period & Driver from 1990 to 2013

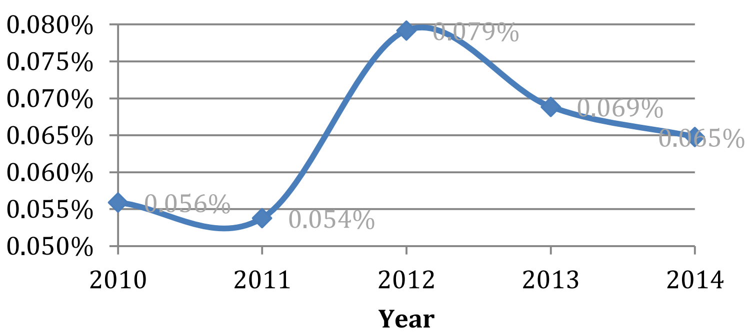
Period	Years	Analysis resolution	Forest Area ('000 ha)	Change ('000 ha)	Change Rate (%)
Initial forest area 1990		30 m	18 473.39		
Benchmark (Sept 2009)	19.75	30 m	18 398.48	74.92	0.41
Year 1 (Sept 2010)	1	30 m	18 388.19	10.28	0.056
Year 2 (Oct 2010 to Dec 2011)	1.25	30 m & 5 m	18 378.30	9.88	0.054
Year 3 (Jan 2012 to Dec 2012)	1	5 m	*18 487.88	14.65	0.079
Year 4 (Jan 2013 to Dec 2013)	1	5 m	18 475.14	12.73	0.068
Year 5 (Jan 2014 to Dec 2014)	1	5 m	**18 470.57	11.98	0.065

**Forestry infrastructure accounts for the full total of deforestation from forestry activities.

**Mining Infrastructure accounts for 918 ha in 2013 out of the total deforestation driven by mining of 11 518 ha, when Year 2 & 3 transitional areas are taken into account.

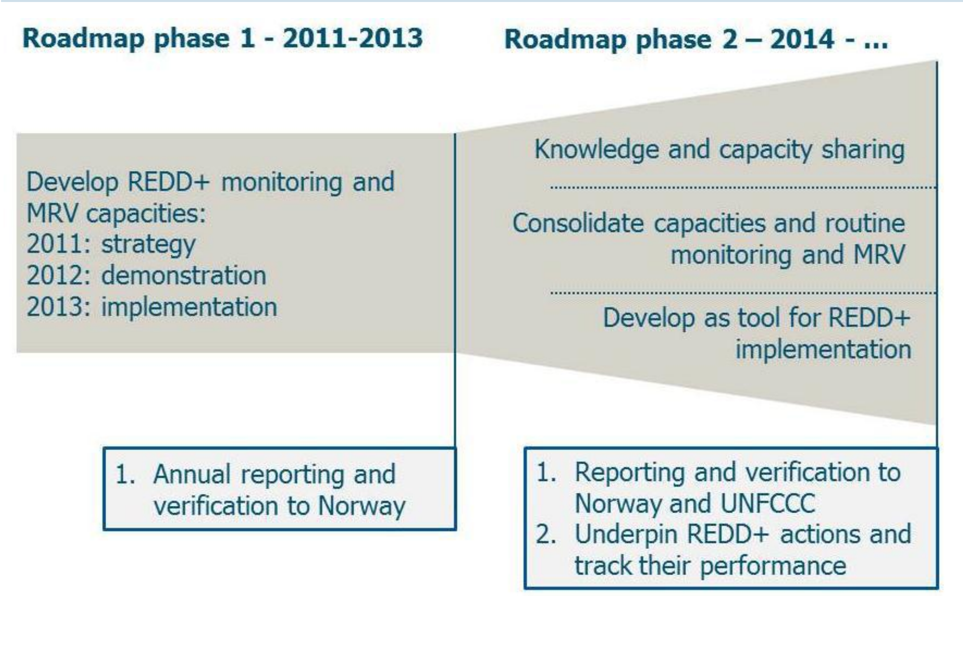
***Amaila Falls Development has been split from other infrastructure driven change for reporting purposes.

Figure 4.12: Annual rate of deforestation 2010-2014



Progression of Guyana's REDD+ monitoring: frame for Roadmap Phase 1 and Roadmap Phase 2.

Figure 4.13. *Source: Terms of Reference for continuing to Develop Capacities for a National Forest Monitoring and Measurement, Reporting and Verification System to Support REDD+ Participation of Guyana Roadmap Phase 1 Achievements, Evolving Requirements and Roadmap for Phase 2 Activities, Guyana Forestry Commission, September 2014*



One of the main challenges has been to work with satellite data that is affected by cloud cover. The GFC developed special designed programme routines in the analysis process to address this.

Among the main lessons learned is the ability of the system to be very dynamic in informing a range of decisions on various drivers of deforestation as well as forest degradation.

DEGRADATION

Degradation is defined here as a long-term decrease in canopy cover and/or biomass caused by human activities that does not qualify as deforestation. The main sources of degradation are identified as:

- Harvesting of timber;
- Shifting cultivation;
- Fire; and
- Associated with mining sites and road infrastructure.

Each activity results in different levels of emissions, though the associated carbon stocks prior to deforestation or degradation do not necessarily differ by driver. The area of degradation in close proximity to deforestation events in Year 1 (2010) was estimated as 92 413 ha. In Year 2, infrastructure as measured from satellite imagery was estimated at 5 467 ha. This figure is substantially lower than the figure previously reported. The difference is due to implementation of a revised and more precise methodology for degradation assessment. In the Year 1 assessment, it was not possible to reliably measure degradation from Landsat type imagery (30 m) due to the resolution of the imagery, and the scale of degradation events in Guyana. From Year 2 onwards, the approach was changed and high-resolution imagery was used to identify forest degradation events.

In Year 5 (2014), the area degraded was 4 251 ha (4 064 excluding shifting agriculture) which is a slight decrease from 4 352 ha as reported in Year 4. The fluctuation in areas mapped as degraded does not track with the associated deforested area. It is thought this is due to significant areas near mining sites being degraded in initial activities and then deforested once the site is fully operational.

The main driver of degradation in Year 5 continues to be mining which accounts for 87% of all degradation mapped. This is expected as mining also accounts for the largest area of deforestation. The established trend is that forest degradation impacts are largely detected around mining areas. The remaining contributors to degradation are from fire (6%) and newly established (pioneer) shifting agriculture areas (4%). Infrastructure and forestry related activities such as degradation during road formation contribute approximately 1% each to total year 5 degradation.

EXPECTED TRENDS

Historical deforestation in Guyana has been very low (0.02% to 0.079% yr-1 over the past 22 years), but this trend may change in the future as deforestation increases to meet growing demands for agriculture, timber, minerals, and human settlements (GoG, 2014). In Guyana´s submission to the FCPF, it is envisioned that deforestation rates are likely to increase in the near future mainly due to the drivers described next (Conservation International et al 2009). Although data presented above in Table 5 for the last 5 years shows that deforestation rates have not increased significantly, the drivers and situational analysis described are still present.

1. Much of Guyana's forest is suitable for logging and conversion to agriculture.

2. There is a growing national and regional demand for agricultural products.

3. There is a growing international demand for tropical timber and a strong presence of international logging companies in Guyana.

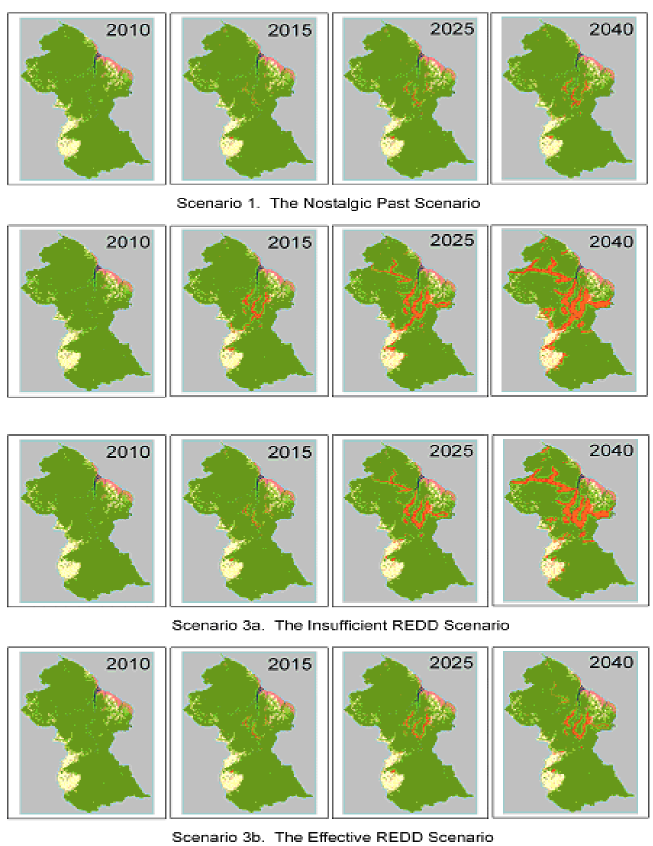
4. Access to Guyana's forests will be significantly increased during this decade. Most notably, a major international highway from Brazil through southern Guyana to the north coast will be built [the Georgetown-Lethem road].

5. Brazil has a very large and dynamic human population that could rapidly move into Guyana for both logging and agricultural activities.

6. Implementation of REDD and other conservation measures in Brazil leads to a high potential for international leakage of deforestation and degradation into Guyana, via the highway.

The same report (Conservation International et al. 2009) presents a series of scenarios based in models to describe the potential impact of these drivers on Guyana´s forests. Figure 4.14 below shows the extent of deforestation under each one of the proposed and modelled scenarios. A complete description of the scenarios and methodology is described in the report.

Figure 4.14 Potential Deforestation Scenarios. *Source: Conservation International et al 2009.*



IMPACTS

ECONOMIC

Guyana's forest sector provides for substantial contribution to the national economy in terms of contribution to GDP, increased export earnings and employment creation. The total employment in the forestry and wood products sector also includes seasonal or sporadic employment in the production of charcoal, shingles, joinery, wood and nibbi furniture, wooden crafts, latex collection, medicinal plants, etc. (NDS, 1996). Forestry activities continue to contribute to the country's economic development.

With the implementation of the Guyana Norway partnership, Norway has committed in providing Guyana up to US$250M by 2015, for avoided deforestation once certain performance indicators are met. Having satisfied the Indicators of the MoU, Guyana has already received five sets of performance based payments totalling US$ 190 million[45].

HEALTH

The forest sector makes an important contribution to the health sector. Many concessions are located in very remote areas. Facilities such as health clinics, roads, water supply and electric power provided by concessionaires, especially the larger ones, for their workers and their families often constitute the only social infrastructure and amenities for surrounding communities in these locations.

ENVIRONMENTAL

The impact of timber harvesting practices on deforestation and soil erosion in Guyana's forest are not major problems at present. In addition to control guided by the Code of Practice, the low volume cut per hectare does not create large canopy gaps. Infrastructural development is carried out within stipulated guidelines.

Guyana's forests offer multiple benefits from ecosystem services such as biodiversity, production of food and water, watershed protection, disaster prevention: preventing floods and soil erosion. The utilisation of these ecosystem services boosts benefits such as socio-economic in terms of improved livelihoods; and protection of biodiversity and watersheds. The use of these multiple benefits will make it possible for Guyana to be more resilient in its dependence on the forests in the face of the impacts of climate change and be able to adapt in order to avoid harm and maximize multiple benefits.

Along with the carbon sequestration potential of Guyana's forests, other key ecosystem services being explored are watershed services, biodiversity and

[45] http://www.lcds.gov.gy/norway-partnership

ecotourism. Watershed services: Watershed services fall into the regulatory category of ecosystem services. Water can act as both a source and a sink function. For example, in comparison to agricultural regions forested ecosystems regulate storm surges, reduce sediment loading in rivers/streams, and promote sustained water flow. This is an example of how both forested and agricultural ecosystems regulate water serving as source functions, yet forested ecosystems provide greater climate mitigation potential. An example of water as a sink function is a water body, such as the Essequibo River, diluting pollution from gold mining. Water flow, water quality, transportation provided by waterways, and habitat provided for fishes and marine life are the most common watershed ecosystem services.

Biodiversity: more information is needed on biodiversity in Guyana due to the remoteness and associated inaccessibility of the landscape. The abundance of intact forests in Guyana provides biological corridors important for sustaining biodiversity. The richness of faunal groups in Guyana is very high compared to other countries and regions in the same hemisphere (Table 4.7).

Table 4.7. Faunal Species Richness. *Source: Bina Hill Institute for Learning Ecosystem Services Education Modules 2010*

Faunal Group	Manu Peru	Rupununi Guyana	Everglades USA	Pantanal Brazil	Guyana Total	Guiana Shield
Birds	850	>643	349	390	820	1,004
Fish	210	>410	432	263	573	1,168
Mammals	200	>191	76	130	223	282
Reptiles	68	>103	60	40	177	295
Amphibians	140	>67	38	96	157	269
Area (km^2)	18,811	32,000	8,000	160,000	215,000	2,500,000
Totals	>1,468	>1,414	955	919	1,950	3,018

In addition to species richness and diversity, the biodiversity in Guyana likely holds great potential for bio-prospecting.

Eco-tourism: Eco-tourism profits are directly correlated with the health of the ecosystem (e.g. degraded ecosystems are less profitable for tourism) (CBD 2009). Well-managed eco-tourism can have the co-benefits of enhancing livelihoods, protecting habitat and biodiversity and raising environmental awareness. Poorly managed eco-tourism can lead to ecosystem degradation. For example, the development of new infrastructure, waste disposal, resource use and depletion, water pollution and tourism activities may negatively impact the environment.

SOCIAL

Within the Community Forestry Programme, approximately 2,000 members within 73 Community Forestry Organisation/Associations, benefitted from assistance and technical support. A total of 128 concessions (488,015 hectares of forest land) were issued to these Associations, providing direct and indirect socio-economic benefits for members and others residing in and around the respective concessions.

The following areas of capacity building were undertaken at the community level in 2014.

- **Community Development Unit Training Interventions**: A total of 215 members from 21 community groups and other stakeholders received training and updates in community governance, MRVS and REDD+, while an additional 36 members from 6 CFOs received training in sustainable forest management practices.
- **Support Financing**: This project allowed the community to engage in alternative income generation mechanism such as fish drying and craft while improving their capacity to manage their forest operations by constructing and furnishing an office.
- **Scholarship**: One student (from Aroaima) was sponsored to read for a Certificate in Forestry at the Guyana School of Agriculture for academic year 2014/2015.

Important to the implementation to REDD+ in Guyana has been the continued involvement and empowerment of local communities through building the capacities of local communities to become engaged in activities relating to the MRV System. While Guyana's approach to the MRV System is that of a national approach, its success lies with the involvement of local communities, the private sector and to some extent, local NGOs. This will allow for the local communities to engage more effectively in any emerging forest payment schemes such as REDD+. It is foreseen that communities will benefit from new training and employment opportunities and will support REDD+ benefit-sharing mechanisms that compensate them or provide incentives for maintaining their forests.

In continuing to support efforts at the development of MRV at the subnational level, the GFC has been continuing its work with the North Rupununi District Development Board (NRDDB) as well as commencing support of the Wai Wai Konashen Community Owned Conservation Area (COCA) CMRV Projection collaboration with the WWF.

A key area of focus during the GFC's interaction with the NRDDB, was that of improving pathways for integrating community data into national forest monitoring systems

RESPONSES

The main piece of legislation dealing with forestry is the Forests Act, which was enacted in 1953 (Chapter 67.01 of the Laws of Guyana). This Act provided essentially for the following:

- Substantive powers for designating State forests;
- The award of forestry concessions;
- The protection of State forests;
- The enforcement of law relating to State forests; and
- Making of regulations concerning State forests.

In keeping with its main objectives listed above, the Forests Act also sought to determine questions relating to:

- Sale of forest produce;
- Suspension and cancellation of leases;
- Ownership of forest produce;
- Offenses, including;
- Trespass;
- Unlawful possession of forest produce; and
- Counterfeiting and similar Offenses.

The Forests Act, 2009, sets out a system for the sustainable forest management within State forests, including the biodiversity conservation and the use of environmental services provided by the forest. It emphasizes the importance of multiple uses of forest resources.

The Act provides for the issuance of five types of state forest authorizations: concessions, exploratory permits, use permits, community forest management agreements and afforestation agreements. There are four major categories of concessions:

- Timber Sales Agreements (TSAs) are issued for concessions covering more than 24,000 ha and allocated for more than 20 years.
- Wood Cutting Licenses (WCLs) comprise forest blocks of between 8,000 and 24,000 ha and are issued for 3 to 10 years. WCLs and TSAs are considered “larger concessions”. They include a previous exploratory permit, as well as management and annual operation plans.
- State Forest Authorisations (SFAs) cover areas of less than 8,000 ha. They are given for two years, generally to community-based associations or small-scale operators.
- Community Forest Authorisations- cover areas of less than 8,000 ha. They are given for two years, generally to community-based associations or small-scale operators.
- State Forest Exploratory Permits (SFEPs) are issued for undertaking exploratory operations such as inventories; environmental and social impact assessments and the

preparation of management plans. SFEPs do not include commercial cutting rights. They are a pre-requirement for any large-scale concession.

Accompanying these, are also specific activity licenses, valid for only one calendar year and requiring annual renewals. They are issued for activities within the sector such as charcoal and firewood production, timber depots, timber dealers, sawpits and sawmills.

Specific emphasis is placed on value-added activities in addressing issues of quality control through legally binding codes of practice, which can be subject to amendments from time to time.

Through the Act, ownership of all forest produce on public lands are vested in the State until such time as they are disposed of in accordance with law. Forest produce includes not only trees and other plants but everything growing on or derived from trees and other plants.

Included are provisions for forest conservation through the designation of specially protected areas within State forests, the protection of specified species of trees and other plants and the voluntary designation of forests on private lands as forest conservation areas.

The Act also clarifies the position on:

- Power of the court to confiscate forest produce;
- Penalties for erection of unauthorized building and so forth;
- Power to search for forest produce;
- Power to seize and detain;
- Powers of forest officers;
- Protection of rights of Amerindian Communities; and
- National Forest Policy and Forest Legislation.

Over the period 2010-2011, the National Forest Policy 2011, was reviewed and revised following a national-wide consultation exercise conducted over 2010. This is the first official policy statement since 1953, and was developed over a period of two years through a process that involved extensive consultation with interest groups. The revised Policy reflects the dynamic thrust of forest in Guyana and covers areas of forest monitoring and forest management, as well new and emerging areas such as REDD+, and new bilateral and multi-lateral cooperation.

Among the areas of updates to the Plan, are areas of REDD+ within the framework of forest planning, management and operations. The Policy was also updated to include the revised legislative framework provided by the new Forest Act and the GFC Act and progress in the development and implementation of sustainable forest management policies and strategies.

The objectives of the National Forest Policy 2011 are to:

- Promote sustainable and efficient forest activities, which utilize the broad range of forest resources and contribute to national development while allowing fair returns to local and foreign entrepreneurs and investors.
- Achieve improved sustainable forest resources yield while ensuring the conservation of ecosystems, biodiversity, and the environment.
- Ensure water protection and rehabilitation: prevent and arrest the erosion of soils and the degradation of forests, grazing lands, soil, and water; promote natural regeneration and reforestation and protect the forest against fire, pest, and other hazards.

A subsection of the national forest policy addresses the forest industry:

- The fundamental objective shall be to develop a financially and economically viable forest industry.
- The number and types of forest based industries established shall be consistent with the capacity of the nation's forest for sustainable management.

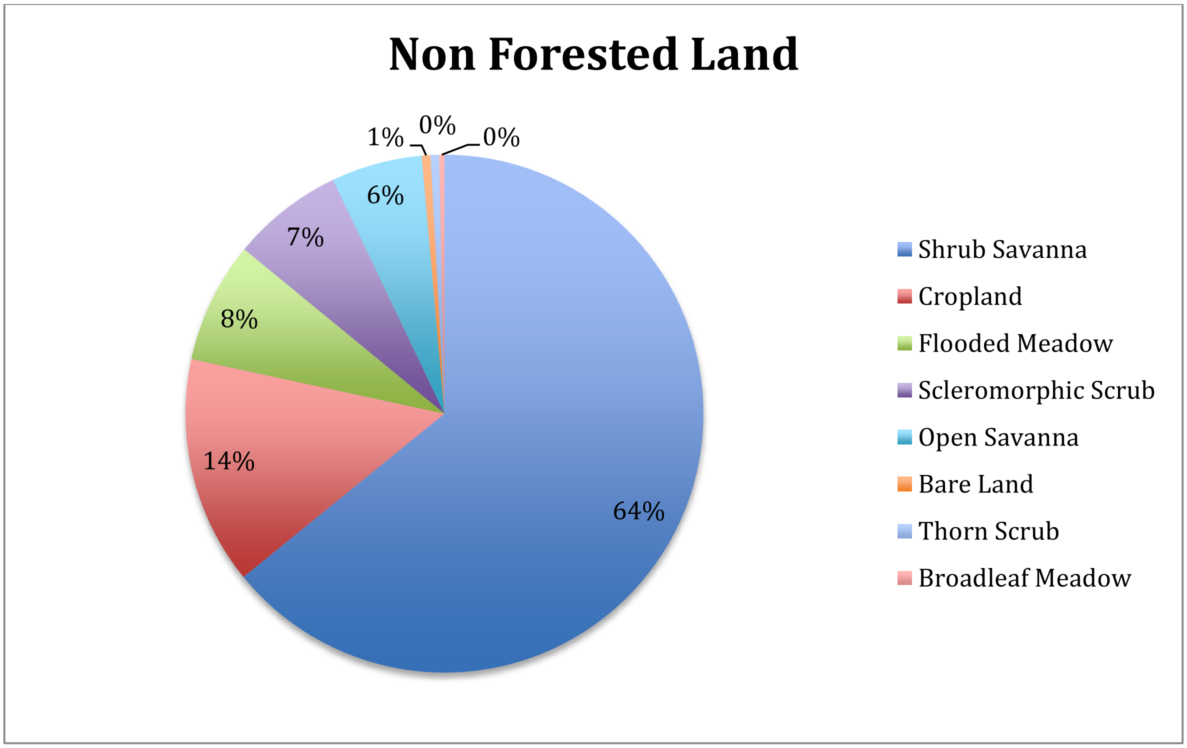
Another important response is the National Forest Plan, which was revised in 2011, in tandem with the National Forest Policy Statement, through a period of wide consultation with stakeholders in the sector. The Plan provides a framework, and identifies programmes and activities that must be accomplished, to ensure implementation of the policy and compliance with the law. Recognizing the broad purview of modern forestry, it stated clear objectives, with associated activities, for national planning, forest resource management, forest industry, research and information, education and training and social development.

SAVANNAH

DISTRIBUTION AND DESCRIPTION

Most of the non-forested land in Guyana can be characterized as a Savannah. According to the NLUP, 70% of non-forested land is located in savannah areas, mainly in the Intermediate Savannahs, the Canje Basin area and the Rupununi and Southern Pakaraimas. Figure 4.15 below shows the distribution of non-forested land in the country.

Figure 4.15. Distribution of Non Forested Land. the *Source: GLSC 2013 based on DLUPP*



Guyana´s Fifth National Report to the CBD describes the country´s Savannah Ecosystems as "characterized by shrublands and grasslands found at all altitudinal levels within Guyana. In the lowlands, the scleromorphic scrub (also known as Muri scrub) is located on White sands and savannahs. It also occurs in the Pakaraima Mountains and the Kanuku foothills up to 1,500 m. Savannahs dominated by grasses are found at all altitudinal levels, from the lowlands to the uplands. In the white sand plateau area in the north, shrub savannahs form an interrupted chain stretching from Guyana into Suriname heavily degraded by human activities. In the Rupununi savannahs, there is a mix of shrub savannahs with woody elements *Curatella americana* and *Byrsomima crassifolia* mixed with open areas dominated by grass *Trachypogon sp*.. They form large alluvial plains crossed by rivers and riparian forests and are exposed to annual dry season fires. The only upland savannah known in the Guiana Shield is located in the Pakaraima Mountains of north-west Guyana. It occurs on some plateaus between 600-1,200 m in the upper Mazaruni. Other herbaceous systems called meadows are characterized by non-grass species associated with highly acidic substrates such as sandy soils on White sands (broadleaf meadows) and also occur in flooded conditions in the Rupununi savannahs." (EPA and MNRE 2014: 22)

PRESSURES AND STATE

There is scarce information available describing the state and trends of Savannah ecosystems in Guyana. The land use information that is available does not describe the state of the ecosystem in places where it is under anthropocentric use and several key gaps remain. The National Action Plan to Combat Land Degradation for example does not include information on soil erosion, state of conservation of grassland ecosystems under exploitation by livestock or agriculture.

Despite the lack of specific information on impacts of current use, it can be concluded that the main pressures come from mining, agriculture, livestock and indirectly from infrastructure development projects. The extent of these pressures is still geographically limited, but likely to change if key infrastructure developments are carried through. In this subsection, we describe the main pressures for grassland ecosystems and some of the expected trends according to existing government plans, land potential for agriculture and livestock and infrastructure plans.

LIVESTOCK AND AGRICULTURE

Chapter 1 describes the importance of livestock in Guyana´s economy and the main areas of livestock production, the coastal plain and the Intermediate and Rupununi Savannahs. Livestock production still has relatively small numbers, however, an analysis of national and regional land use plans shows that future concentration of livestock activity is probably going to concentrate on existing grasslands.

A similar dynamic can be found in agricultural production, which is now concentrated in the coastal plains and given the infrastructure investments necessary for its expansion it is likely to do so on non-forested land as national and regional land use plans describe.

According to the GLDA, the potential livestock development is to be concentrated on non-forested land (GLSC 2013). The Region 9 Land Use Plan describes the enormous potential of the región, for livestock production given the appropriate investment in improving pastures.

With regard to agriculture, the NLUP describes how the Government of Guyana intends to develop its agricultural base, which is mainly through investment in the Coastal Plain and targeting non-forested areas in the Intermediate and Rupununi Savannahs where the GLSC is opening new areas for leasing (GLSC 2015).

More specifically the indicators used in the Ministry of Agriculture's 2013- 2020 plan include "at least 25,000 hectares of new land cultivation as mega-farms in Canje Basin by 2020"; "at least 10,000 hectares new cultivation area in the Intermediate Savannah by 2020"; and "at least 20,000 hectares in mega-farms in region 9 by 2020" (MoA 2013: 51).

There are no reported plantation forestry activities to date, however, the plantation forestry sector is also being considered under the NLUP and could therefore become an added pressure on grassland ecosystems. According to the NLUP, there is growing interest in these plantations for wood pulp, poles or biofuel and the suitable areas are coastal plains and savannahs.

Most of the planned developments described above in agriculture and cattle ranching will only occur if significant investments are made, mainly in the infrastructure sector, but also in research and innovation sectors linked to agriculture and livestock production.

The need for infrastructure development to promote development in Guyana is recognized in the NLUP and some of the key projects in relation to the sectors described above are the Georgetown to Lethem road and “the roads and bridges to non-forested agricultural development areas such as the Intermediate Savannahs” (GLSC 2013: 22). These infrastructure development projects will facilitate access to ports and markets at a lower price and combined with investment in genetics, fertilization and infrastructure could result the expansion of production activities in Guyana´s grasslands. This will result in new economic and social opportunities and in new pressures for this ecosystem

Savannahs and grasslands are among the most endangered ecosystems in the world and the one with less proportion of area designated as protected area. The current draft land use plan for Subregion I of Region 9 does not consider the establishment of a grassland protected area in the region. A protected area for this ecosystem would represent an important contribution to biodiversity preservation, particularly considering the added pressure that will come when planned infrastructure projects are completed.

Protected areas are one important instrument for ecosystem conservation, but the conservation of Guyana´s grasslands only by the creation of protected areas will be insufficient if sustainable practices are not incorporated into productive activities in the agricultural and livestock sectors.

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CHAPTER 5

Fresh Water Resources

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INTRODUCTION

Guyana is rich in hydrological resources with an expansive network of rivers, streams, reservoirs and drainage canals which provide an abundance of surface and ground water throughout the country (AQUASTAT, 2015; Parsram, 2010; US Army Topographic Engineering Center (UATEC), 1998). The Essequibo, Demerara, Berbice and Corentyne Rivers are the four (4) major systems that drain the vast tropical forest of the interior Guyana along with several smaller rivers. Water supplies are also contained in reservoirs called conservancies, located in the upper stream catchment areas on the coast and supply water year round for various usage (UATEC, 1998; Parsram, 2010). The internal renewable water resources (IRWR) were estimated to be 271 km^3 per year, with an estimated 241 km^3 per year for surface water resources; groundwater resources 103 km^3 per year and the overlap between surface and ground water is estimated to be 100% (AQUASTAT, 2015). (Table 5.1)

Table 5.1: Renewable Freshwater Resources. *Source, AQUASTAT, 2015*

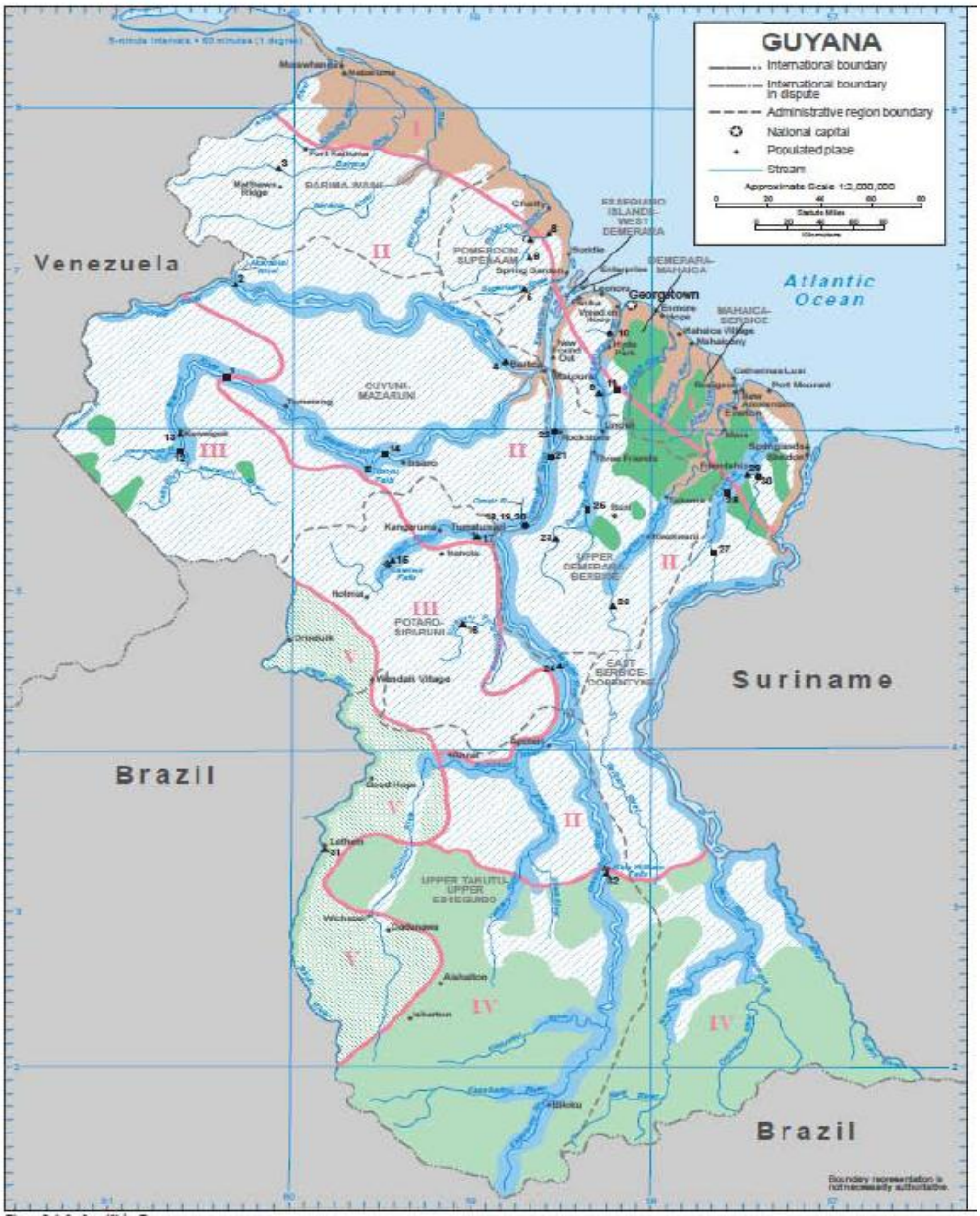
Renewable Freshwater Resources			
Precipitation (long-term average)	-	2,387	mm/year
	-	513,100	million m^3/year
Internal renewable water resources (long-term average)	-	241,000	million m^3/year
Total renewable water resources		271,000	million m^3/year
Dependency ratio	-	11	%
Total renewable water resources per inhabitant	2013	338,750	m^3/year
Total dam capacity	2011	809.15	million m^3

SURFACE WATER

Guyana's surface water sources are available through a network of rivers and creeks and extracted from reservoirs, streams and drainage canals mainly for agricultural and industrial purposes (UATEC, 1998) with a small amount for domestic use. Mainly, the rivers drain northward to the coast from the western highlands region and from the southern uplands region, inclusive of the smaller rivers originating in the interior plains region. Additionally, there are a few minor Amazon tributaries that flow southwest out of the country and are part of the Amazon watershed.

The Essequibo River forms the country's largest river system, and its drainage basin encompasses most of the country. It flows through the entire length of the country from the southern border to the Atlantic Ocean. Its major tributaries are the Cuyuni, the Mazaruni, the Potaro, and the Rupununi Rivers. Tidal influences can extend as far as 64 kilometres to 80 kilometres (40 to 50 miles) upstream on the four major rivers. Guyana has fourteen (14) major drainage basins with six (6) of the rivers forming part of the country's boundary. While these rivers provide abundant surface water resources, there are marked seasonal differences in the flows. Dense tropical vegetation contributes to a high rate of infiltration that sustains a continuous discharge to most rivers (UATEC, 1998). Figure 5.1 shows surface water resources found across the country.

Figure 5.1: Map of surface water resources (main rivers & sources) found across Guyana. *Source: UATEC, 1998 as sourced by GL&SC, 2013.*



Key for Figure 5.1: Surface water resources[46]	
PHYSIOGRAPHIC REGIONS	
I	Coastal Lowlands
II	Interior Plains
III	Western Highlands
IV	Southern uplands
V	Southwest Savannahs
	Physiographic region boundary
31▲	Gaging station
30•	Water quality points
25▪	Water quality/gaging station
	Waterfall
FRESHWATER PERENNIALLY PLENTIFUL	
Map Unit	
1	Enormous quantities year-round from perennial rivers and streams, extending throughout the country.
2	Enormous quantities from April through August and November through January from perennial rivers and streams draining the interior plains, coastal lowlands and western highlands. Large to very large quantities available the rest of the year.
FRESHWATER SEASONALLY PLENTIFUL	
3	Large quantities from April through August and November through January available form perennial intermittent streams, tributaries, canals and ditches in the coastal lowlands, interior plains and western highlands. Small to moderate quantities available the rest of the year in perennial streams.
4	Large quantities from April through August generally available from perennial and intermittent streams tributaries in the southern uplands. Meager to moderate quantities available the rest of the year.
5	Moderate to large quantities from April through August generally available from perennial and intermittent streams and tributaries in the southwest savannah and tributaries of the Amazon. Meager to small quantities available the rest of the year in perennial streams, while intermittent streams generally have no discharge.
FRESH WATER SCARCE OR LACKING	
6	Large to enormous quantities of brackish to saline water available throughout the year from tidal influenced rivers and streams, coastal marshes, mangrove swamps and tidal lowlands.
QUANTITATIVE TERMS	
Enormous	>400,000 litres per minute (L/min) (100,000 gallons/min)
Very large	>40,000 to 400,000 L/min (10,000 to 100,000 gal/min)
Large	>4,000 to 40,000 L/min (1,000 to 10,000 gal/min)
Moderate	> 400 to 4,000 L/min (100 to 1,000 gal/min)
Small	>40 to 400 L/min (10 to 100 gal/min)
Very small	>4 to 40 L/min (1 to 10 gal/min)
Meager	4 L/min (1 gal/min)
QUALITATIVE TERMS	
Freshwater	aximum total dissolved solids (TDS) <1,000 milligrams per litre (mg/L); maximum chlorides <500 mg/L; maximum sulphates <300mg/L
Brackish water	aximum TDS >1,000 mg/L but <15,000 mg/L
Saline water	DS >15,000 mg/L

[46] Map Unit numbers and station numbers refer to entries in Table C-1 of the UATEC, 1998 report.

SURFACE WATER COASTAL

Guyana's coast encompasses parts of Administrative Regions 1, & 6 and Regions 2, 3, 4 & 5. According to the US Army Topographic Engineering Center report (1998), varying quantities of freshwater are available across these regions throughout the year. Quantities of brackish to saline water are available along the coastal areas due to tidal influences of the rivers, streams, coastal marshes, mangrove swamps and tidal lowlands. Specifically brakish to saline water can be found along the Atlantic Coast and parts of Essequibo, Demerara, Mahaica, Mahaicony, Berbice Rivers and tributies and canals.

Additionally, the Guyana Water Inc. (GWI) with its mandate to distribute, store and provide safe and adequate potable water has three (3) main surface water sources one (1) of which services the city of Georgetown and the other two (2), serve Linden. The Lama Canal feeds the water treatment plant located at the GWI's main office in Georgetown before being distributed to West Ruimveldt, Charlestown, Albouystown, La Penitence, Kitty Pulic Road, Kingston, Water Street, Meadow Bank, Atlantic Ville, Crown Dam, Sophia water treatment plant areas and Durban Backlands.

SURFACE WATER INLAND

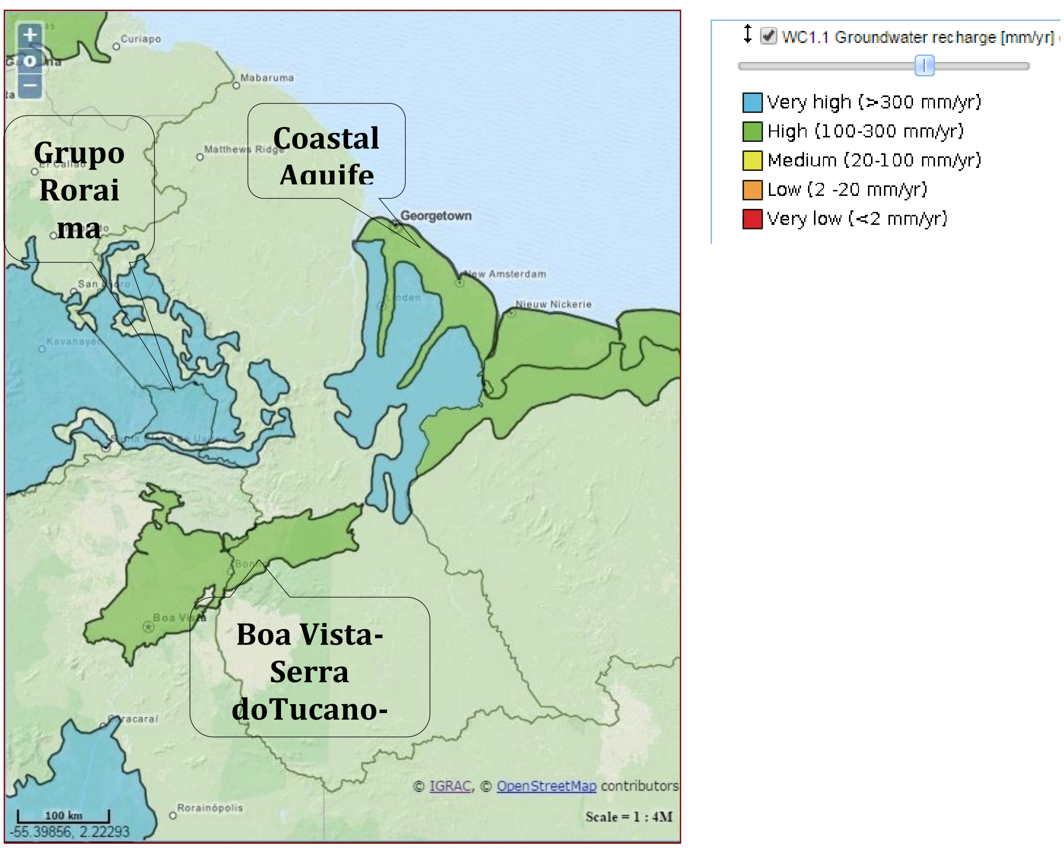
The inland regions occupy mainly Administrative Regions 7, 8, 9, 10 and parts of Region 1 & 6. The areas south of the coastal lowlands in Region 1, lies in the interior plains where quanties of fresh water can vary throughout the year, with notable differences during the two (2) rainy seasons. The Cuyuni, Mazaruni, and Essequibo Rivers store and have enormous quantities of fresh water available all year. However, large quantities of fresh water are available only during April to August of the year, with little availability for the rest of the year in the southern uplands, found in the Upper Takutu-Upper Essequibo and East Berbice–Corentyne Regions (UATEC, 1998).

GWI's surface water sources that service the town of Linden with potable water are the Dakura Creek and the Demerara River. The Dakura Creek provides potable water to sections of Wismar Shore (Wisroc, Block 22, Blueberry Hill, One Mile Extension, One Mine and Half Mile. While the Demerara River provides potable water to West Watooka, Silvertown, Christianburg, Victory Valley, Wismar Hill Housing Scheme, Canvas City, sections of One Mile and Half Mile and sections of Mc Kenzie Shore.

GROUND WATER

Groundwater is an invaluable source of water throughout Guyana and accessible through shallow unconfined aquifers in the inland region and deep confined aquifers along the coast. With three major aquifer systems, in addition to the numerous rivers and creeks, carving this landmass, it is easy to understand why Guyana is called the 'land of many waters'. The three main aquifers together, cover an estimated recharge area of 53,515 km^2, with rainfall ranging from 1,500 mm/year to 2,400 mm/year, for the inland aquifers, to exceeding 2,500 mm/year for the coastal aquifers. The availability of groundwater throughout Guyana is significantly high. This is evident particularly with the inland aquifers, which have approximately 490,000 and 1,500,000 m^3/year/capita, see Figure 5.2 (Transboundary Waters Assessment Programme, 2015). The coastal aquifers are expected to have a much lower per capita rate given that 90% of Guyana's population lives along the coast and use this water source, unfortunately, this information was not available for the country.

Figure 5.2: Map of Guyana showing the three main trans boundary aquifers and their estimated recharge. *Source: Transboundary Waters Assessment Programme, 2015.*

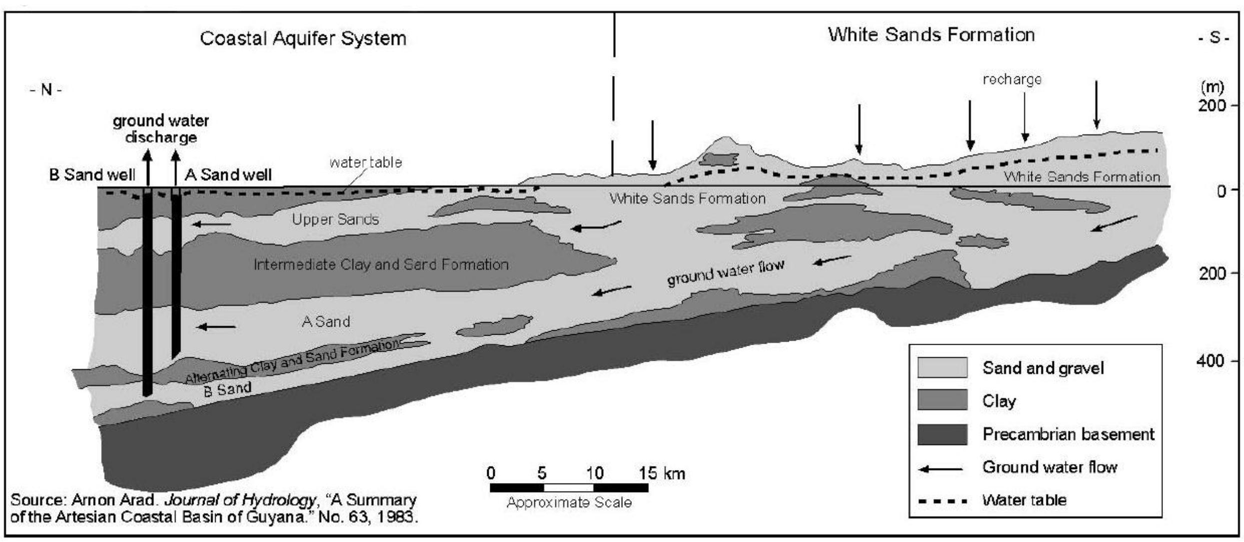


GROUND WATER COASTAL

Worts Jr. (1963), described the coastal aquifers as being overlain by a combination of the Coropina formation and the Demerara Clay with a combined thickness of 50 m. The formation varies in length along the entire coast from 10 m to 100 m from northwest to northeast of the aquifer. This overlays the White Sands Series, which Worts Jr. estimated to be approximately 1,500 m thick with five distinct subdivisions. These subdivisions commence with the sub-angular quartz ‘Upper Sands’ which is 80 m in thickness. The ‘Intermediate Clays’ comprises kaolinitic clay, shale, and fragments of unconsolidated quartz and separates the ‘Upper Sands’ and the ‘A Sands’ (Worts Jr., 1963; Edward, et al., 2013). Worts Jr. (1963) further noted that the ‘A Sands’ series is a composition of sub-angular sands and fine gravel and increase in thickness south-eastward of the aquifer but decreases towards the eastern boundary of the aquifer, that is, the border between Guyana and Suriname. Worts Jr. (1963) further described the third confining layer as the ‘Alternating Sand and Clay’ formation, which is followed by the ‘B Sands’ aquifer which sits at a depth of 425 m to 500 m.

The coastal aquifer has three main confined stores, the ‘Upper Sands’, ‘A Sands’, and ‘B Sands’ aquifers. These were described in detail by Worts Jr. and a visual depiction (Figure 5.3) was presented by Arad (1983).

Figure 5.3: Cross-section of coastal aquifer basin. *Source: US Army Topographic Engineering Center, 1998.*



Worts Jr. (1963) added that subsequent to the ‘B Sands’ aquifer was the Berbice formation comprising consolidated sedimentary rocks, conglomerate sandstone, and shale below which lays the basement system of composed gneiss, granite, and volcanic schist. He noted this was shallowest to the east of the aquifer, in Essequibo, at 91 m and deepest to the west, in New Amsterdam, at 2,225 m.

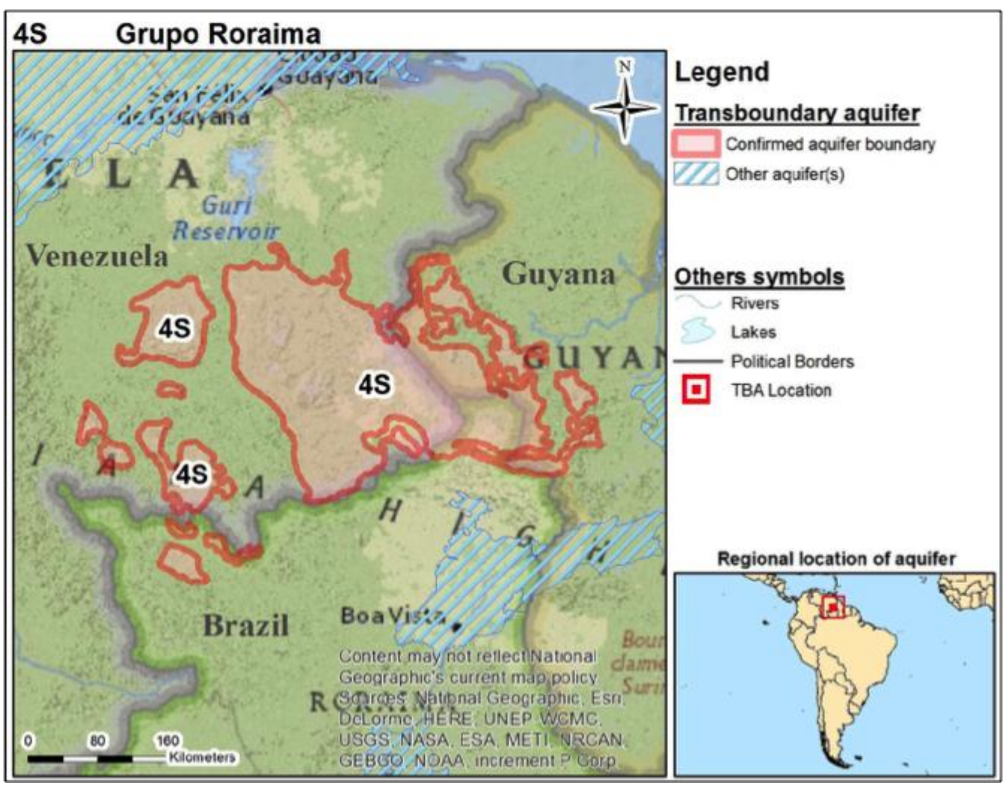
Much of the information on groundwater resources inland of Guyana is available from the Trans-boundary Waters Assessment Programme (TWAP). TWAP has determined there are two major groundwater reserves inland of Guyana both of which are trans-boundary: "Grupo Roraima" and the "Boa Vista-Serra do Tucano-North Savanah".

GROUND WATER INLAND

The Grupo Roraima aquifer system is shared between Guyana, Brazil, and Venezuela, see Figure 5.4. The aquifer has multiple layers that are hydraulically connected. It is mostly semi-confined with some parts being unconfined. The aquifer is approximately 14,871 km^2 but the depth has not been reported by TWAP (2015).

TWAP (2015) described the aquifer as having two layers which are hydraulically connected. The aquifer is mostly semi-confined with the unconfined portion being located within the Venezuelan boundary. It was further described as composing of potentially porous sedimentary rocks (arkosic, sandstones, tuffs, paleoproterozoic conglomerates, and siltstones). Its primary porosity has been reduced due to sedimentation of pores as a result of which it exhibits intergranular/ fractured characteristics. TWAP further described the aquifer as having low to high horizontal and high vertical connectivity.

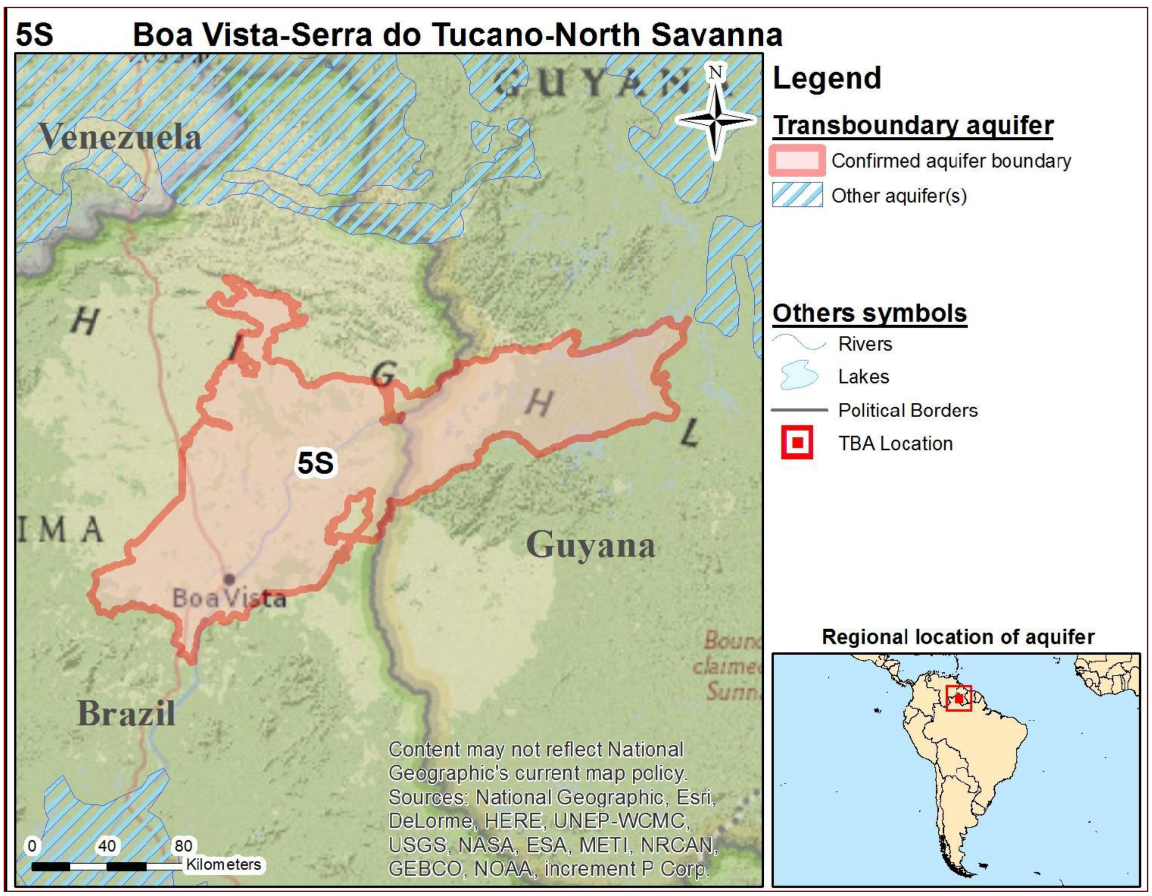
Figure 5.4: Trans boundary aquifer shared between Guyana, Brazil, and Venezuela (*Source: TWAP, 2015*)



Very little information is available on the aquifer and additionally, there is no existing legal framework among the three countries or under preparation for its management. While national institutions are in place, these are not fully operational (Transboundary Waters Assessment Programme, 2015).

TWAP describes the Boa Vista-Serra do Tucano-North Savannah aquifer, refer to Figure 5.5, as comprising potentially porous sedimentary rocks, with a reduced primary porosity as a result of cementation of pores. This, results in the aquifer exhibiting characteristics of secondary porosity: dissolution. The aquifer is also described as having low horizontal and vertical connectivity.

Figure 5.5: Trans boundary aquifer shared between Guyana and Brazil. *Source: TWAP, 2015*.



PRESSURES ON FRESHWATER RESOURCES

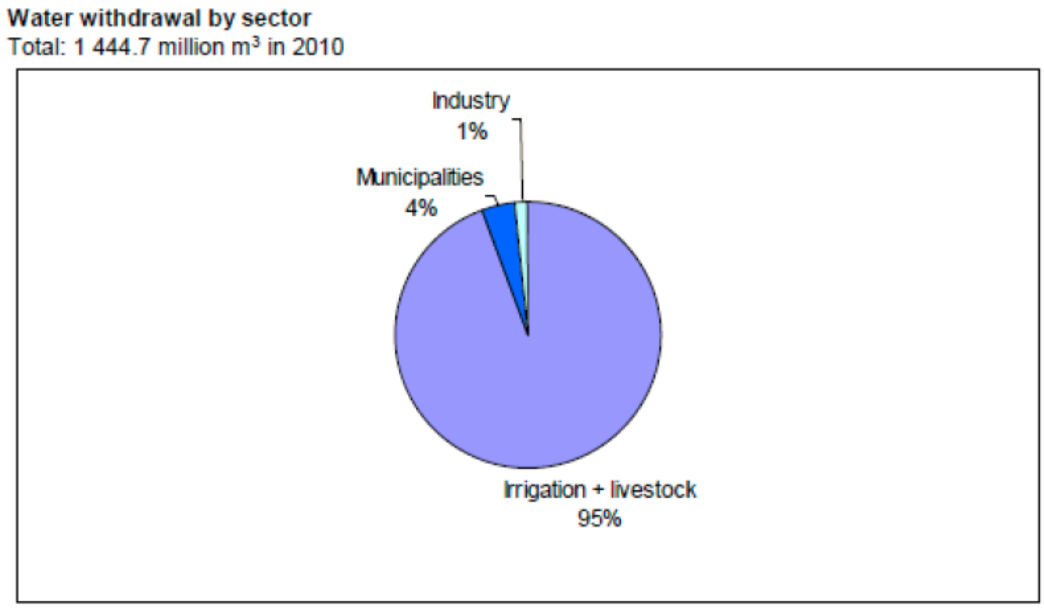
Water resources, both in quantity and quality, are influenced by land-use change, the construction and management of reservoirs, pollutant emissions, water and wastewater treatment and climate change (Narayan, 2006; Kundzewicz et al., 2007; IPCC, 2007). Water use is driven by changes in population dynamics, consumption of food, economic policies (including water pricing), technology, general lifestyle, and views of humans in society on the value of freshwater ecosystems (IPCC, 2007). In Guyana, pressures on water resources vary, based on population dynamics and needs. Large quantities of water are consumed for domestic, agricultural, mining and industrial purposes from both surface and ground water (AQUASTAT, 2015; UATEC, 1998). These sectors place enormous strain on Guyana's freshwater resources, since there is a lack of or inadequate sewage, agricultural and industrial waste treatment plants and proper tailings management, which result in direct discharge of untreated waste, chemicals and sediments into surface water systems across the country. Salt water intrusion on the coast is also another threat to freshwater resources in Guyana.

While no official information or data are available, in 2010, the estimated values of water withdrawal were 1.445 km^3, whereby Industrial purposes accounted for 1.4%, municipal 4.2% and agricultural purposes accounted for 94.4% (see Table 5.2 and Figure 5.6 below). Informed decision-making and the development of relevant policies and plans to manage water resources in Guyana can be difficult and challenging in the absence of viable and concrete data on pressures (AQUASTAT, 2015).

Table 5.2: Extraction of water resources by sectors and per inhabitant. *Source, AQUASTAT, 2015*

Water withdrawal:			
Total water withdrawal	2010	1 444.7	million m^3/year
- Agriculture (Irrigation + Livestock + Aquaculture)	2010	1 363	million m^3/year
- Municipalities	2005	61.3	million m^3/year
- Industry	2005	20.4	million m^3/year
• Per inhabitant	2010	1 838	m^3/year
Surface water and groundwater withdrawal (primary and secondary)	2010	1 444.7	million m^3/year
• As % of total renewable water resources	2010	0.5	%
Non-conventional sources of water:			
Produced municipal wastewater	-	-	million m^3/year
Treated municipal wastewater	-	-	million m^3/year
Direct use of treated municipal wastewater	-	-	million m^3/year
Direct use of agricultural drainage water	-	-	million m^3/year
Desalinated water produced	-	-	million m^3/year

Figure 5-6: Extraction of water resources by sector. *Source: AQUASTAT, 2015*



SURFACE WATER - COASTAL

In Guyana, most of the water supply for agriculture (sugarcane and rice) and industry comes from surface water (UATEC, 1998). The remaining 10% surface water is used for drinking purposes (UATEC, 1998; Parsram, 2010). There are approximately eight (8) surface water supply sources in the country that come from conservancies and rivers. There are four (4) conservancies found along the coast in Administrative Regions 2, 3, 4 and 5 which supply fresh water to agricultural lands by a system of canals and irrigation ditches, while the other sources are from the Essequibo, Demerara, Berbice and Corentyne Rivers, respectively (Parsram, 2010).

The highest population density of about 90% is within the coastal areas of Guyana, which result in serious water pollution problems similar to other developing countries in tropical regions. The biological and chemical surface water contamination varies in magnitude according to location, but is increasing with population growth and land use changes (UATEC, 1998). Several broad categories of contamination sources are from households, industries, agricultures and tourism related activities. Saline intrusion also affects the quality of water on the coast with influence from the Atlantic Ocean (Parsram, 2010; AQUASTAT, 2015).

DISCHARGE OF UNTREATED WATER FROM HOUSEHOLDS

In Georgetown, there is a demand for 20 million gallons of water per day with about 8 million being furnished from surface water sources and 12 million from ground water. Wastewater generated by households can be considered as domestic effluent consisting of blackwater (excreta, urine and faecal sludge) and greywater (kitchen and bathing wastewater). Grey water is usually discharged into surface drainage systems and eventually ends up in nearby rivers and the Atlantic Ocean. Blackwater is managed by several methods such as sewerage system, septic tanks and pit latrines, but contents are eventually discharged in the canals, rivers and the Atlantic Ocean because of poor system maintenance, leakages and lack of adequate treatment facilities to properly treat and discharge of domestic waste into the environment, see Chapter 3 (UATEC, 1998; MoC, 2014; AQUASTAT, 2015).

DISCHARGE OF UNTREATED WATER FROM INDUSTRIES

About 90% of Guyana's industries can be found in the Demerara basin and the key sectors include food, beverages, tobacco, paint, footwear, clothing, furniture, tourism and pharmaceuticals along the Atlantic coast (Cimab (2010) as cited by MoC, 2014. These developments can have adverse effects on water extraction and surface water contamination through waste water generation, most of which is discharged untreated directly into the surrounding drainage systems and eventually flow into rivers and the Atlantic Ocean. There is very little available data on industrial discharge, however, attempts were made to characterize industrial pollution, although dated, Table 5.3, (NDS, 1996).

Table 5.3 showing Sources of Industrial Waste in Guyana. *Source NDS, 1996*

INDUSTRY	NUMBER	POTENTIAL POLLUTANTS
Sawmills	66	BOD, dust
Food processing	47	BOD, phosphates, solids, dust, pathogens
Detergents/soaps	9	BOD, phosphates, caustics
Metalworking/foundry	8	Heavy metals, solids
Sugar refinery	7	BOD, solids, caustics, phosphates
Chemical/pharmaceutical	6	Acids, alkalies, phosphates, solids
Distilleries/breweries	5	BOD, phosphates, thermal
Plastics	4	CFCs, solids

In the seafood industry, processing can generate large amount of effluent, from use of significant quantity of water and most of this effluent is discharged directly into the rivers. The larger industrial operations such as Banks DIH and Demerara Distillers Limited (DDL) have installed wastewater treatment facilities and a biomethanisation Plant respectively to treat wastewater effluent (UATEC, 1998; Parsram, 2010).

This action is in response to legislative requirements by the Environmental Protection Agency (EPA) and adherence to international quality standards. More recently, the Splashmins Ecoresort, in partnership with the Ministry of Communities (MoC) under the Caribbean Regional Fund for Wastewater Management (CReW) project, was exploring the possibility of installing a treatment plant at its facility. However, the partnership was terminated and the project ceased.

AGRICULTURAL USE IN COASTAL WATERS

As a result of surface runoff from agriculture, pesticides and other chemicals are usually discharged untreated to the drainage systems and nearest waterways, which finally enter into major streams, rivers or to the Atlantic Ocean, refer to Chapters 1 & 3 for additional information.

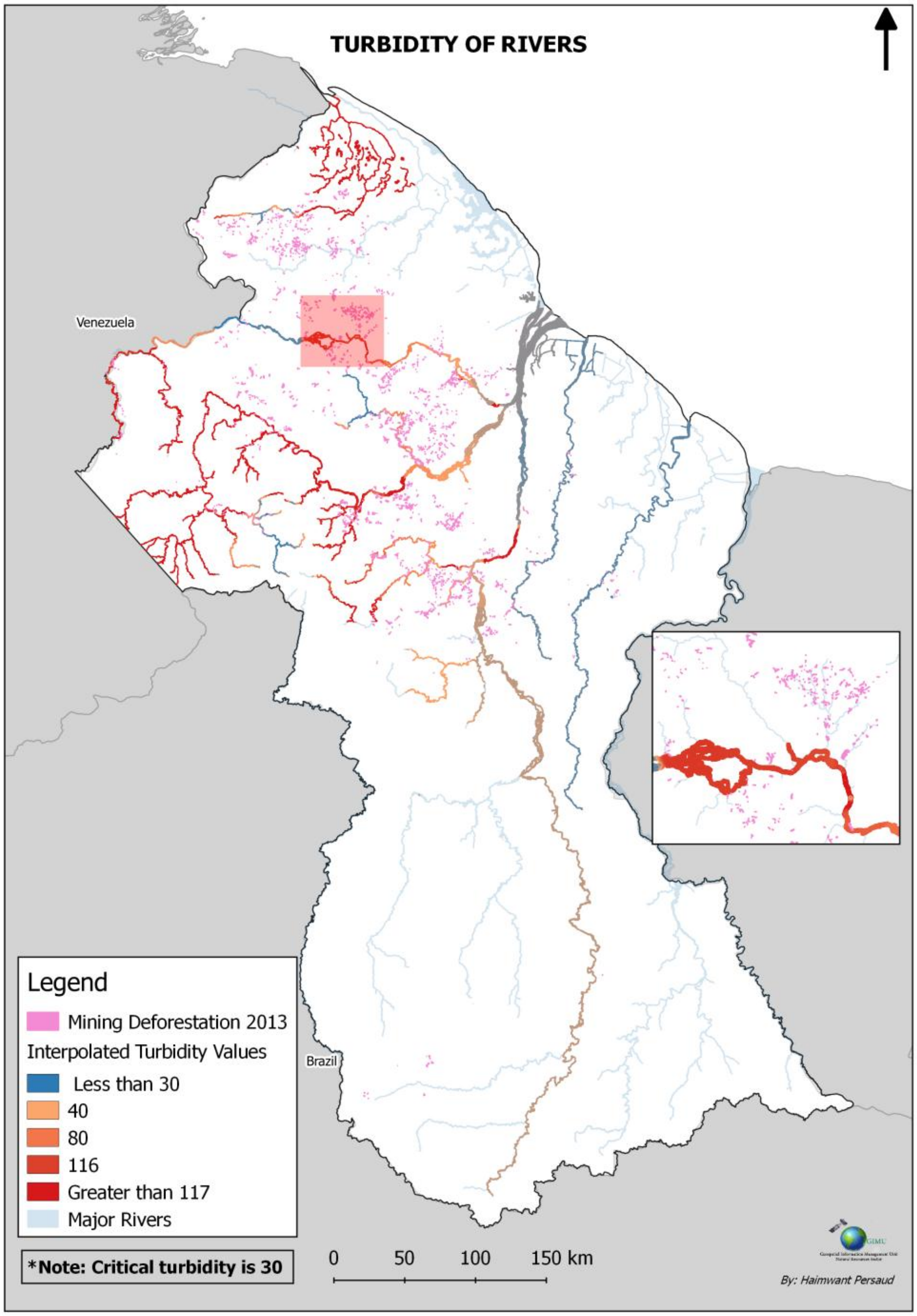
Large quantities of surface water is pumped and irrigated for large-scale rice and sugarcane production along the coastal belt in Guyana. At the Guyana Sugar Cooperation (GUYSUCO), effluent from the washing and processing is drained into holding ponds and an effluent treatment facility to allow for degradation before it is released into the environment. However, since the surrounding areas of many GUYSUCO sugar estates are prone to flooding, surface water contamination is still an issue, which eventually causes eutrophication and pollutes the various drainage systems on the coast. Other activities such as livestock farming and fish ponds also contaminate aquatic systems in the coastal regions (Parsram, 2010).

SURFACE WATER – INLAND

MINING AS A PRESSURE ON SURFACE WATER

Pressures on inland rivers are mainly due to mining and related activities. Mining is an important sector, see Chapter 1, and contributes significantly to the GDP in Guyana but it is a major source of surface and ground water contamination and degradation of rivers and streams in several regions. Dredging and other types of mining operation, such as hydraulicing using surface water, cause hydrocarbons to be released and increase sediment loads in rivers and streams. These suspended solids increase surface water turbidity and alter river geomorphology in many mining locations, see Figure 5.7. Furthermore, mercury used in the processes during the amalgamation of gold, is released into the air and rivers contaminating aquatic life and river sediments (Parsram, 2010). Although improvements were made, effluent generated by mining activities still gets into waterways resulting in high levels of suspended solids usually above the critical level of 30 NTU from small and medium-scale mining activities and in some cases tailings are either discharged directly or seep into waterways (CI Guyana *et al*, 2014; Lowe, 2006).

Figure 5.7 Map showing turbidity values of river interpolated with 2013 deforestation results from mining. *Source MNR, 2016.*



Other activities such as bauxite mining, improper disposal of sawmill wastes; tourism related recreational activities and to a lesser extent agriculture also contaminated these freshwater sources reducing the quality of surface water (Parsram, 2010; UATEC, 1998). The extent of the degradation from mining is not fully known and existing data were very limited and scattered from literature sources. However, mining in Guyana has resulted in a number of known impacts in a few areas such as, the major tailings failure and discharges of residual cyanide into the Omai River from the OMAI Gold Mines Limited (OGML) in 1995, tailings dam breach at Linden Mining Enterprise (LINMINE) discharged decant water with a pH of 4.5 into local stream and Demerara River, sedimentation in the Berbice River from the canal at the Aroaima Bauxite project, release of mercury via the washing process in small-scale gold operations, and river and missile dredging that increases turbidity of water in Mining areas (NDS, 1996)

GROUND WATER – COASTAL AND INLAND

POPULATION GROWTH

As populations grow and economic activities increase, the need for water is expected to increase. While Guyana's population as a whole has been relatively stable over the last 50 years, there has been some level of internal migration from one Administrative Region to another. Added to this, populations in some regions may increase depending on the activities within or surrounding these areas, for example, Region 9 has been experiencing continuous growth over the past 30 years. The 2012 national census reported the population of Region Nine has increased from 12,868 in 1980 to 24,212 in 2012 (BOS, 2014). This may be a direct result of the development of the region, as well as, the development of the Linden-Lethem road and therefore access to the northern coast of South America. It can be assumed that once the Linden-Lethem road has been paved and access made easier, there will be more persons in transit and permanently reside within Lethem and other communities in Region Nine.

GROUNDWATER WELLS

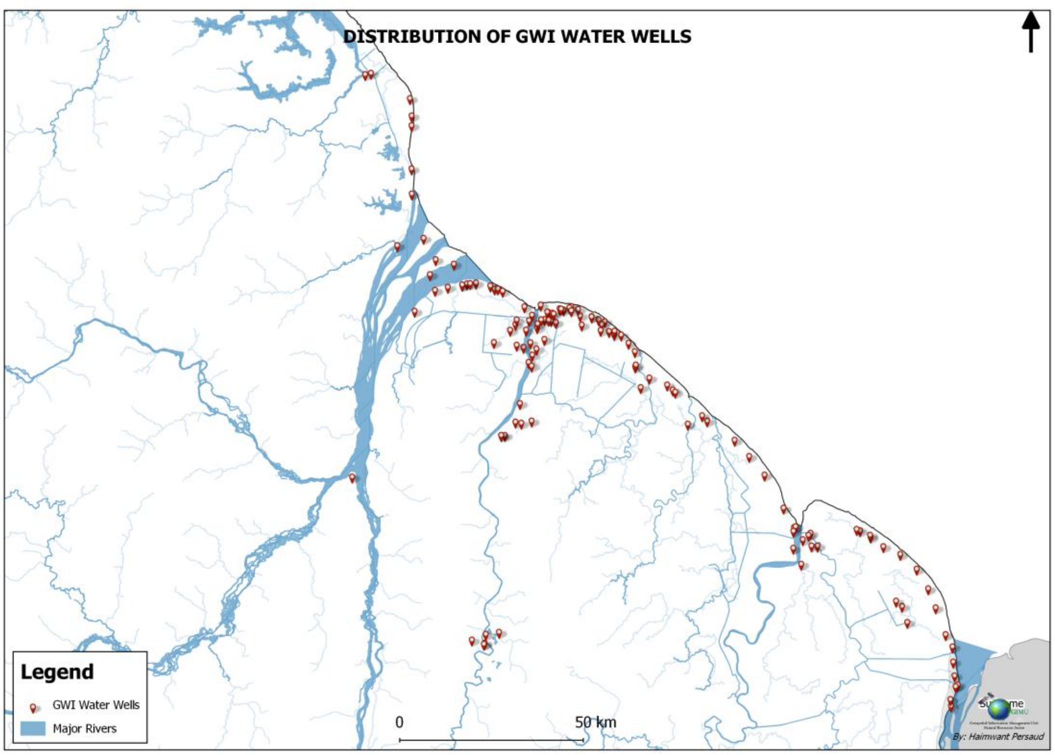
Water-intense industries, particularly those with private wells that are not adequately monitored, can severely compromise the potential of the coastal aquifers. There is poor enforcement and monitoring of private water users within Guyana which may result in over exploitation of the aquifers. In addition to this, there is little incentive for industries to employ water conservation measures.

Transboundary Waters Assessment Programme (TWAP) has recognised the coastal aquifers as being trans-boundary with neighbouring Suriname's coastal aquifers. The A-Sands aquifer of Suriname has experienced saline intrusion as a result of over abstraction (Hutchinson, 1990). While there is limited information to confirm the trans-boundary nature of the aquifer, it is imperative that abstraction rates be adequately managed to avert the result experienced by Suriname.

The Hydrometeorological Office (Hydromet) has reported that there are 17 registered private wells along the coast of Guyana for which they have limited data for 15 of these wells. However, it is generally known that there are several more private wells particularly within water-intensive industries that are neither registered nor monitored on a regular basis.

According to the Second National Communication (SNC), Guyana is projected to experience higher temperatures and lower precipitation leading to overall water shortages for domestic, industrial and agricultural uses (GoG, 2012), see Chapter 2 for more information. The projected decrease in rainfall is expected to mainly impact the northern half of Guyana including its vulnerable coastal zone. Moreover, the country's coastal population is heavily dependent on ground water resources to service its domestic, commercial and industrial needs, with the exception of Georgetown. Based on data available from GWI (2016), the ground water sources for the coastal areas are one hundred and twenty five (125) wells distributed across Administrative Regions 2, 3, 4, 5 & 6, Figure 5.8.

Figure 5-8: Location of Guyana Water Inc. (GWI) managed wells along the coast of Guyana. *Source: MNR, 2016 with data from GWI.*



LAND USE PLANNING

Poor land use planning can have several implications socially, but more so when inappropriate activities are placed within critical areas such as the recharge areas for an aquifer. Activities, such as agriculture or housing within the recharge area of the coastal aquifers, for example, can have a significant impact on the quality of water abstracted on the coast. This is particularly important given the characteristics and properties of the coastal aquifers and is exacerbated by the lack of information about the aquifer, particularly the recharge rate and therefore how long it would take a pollutant to travel from source to abstraction point along the coast of Guyana.

A similar issue is also reflected inland, especially where agricultural activities occur including livestock, crops, and aquaculture farming. Given the shallow water table of the inland aquifers, the risk of pollution is greater, and the impact is aggravated by the ease of access by residents of the communities in the areas.

CLIMATE CHANGE AND ENSO

Several projections have been made related to the impacts of climate change, primarily the change in weather patterns, particularly, to more intense conditions, for example, stronger wet periods or longer dry periods. These can have a significant impact on recharge for the aquifers as shorter more intense rain periods result in saturation of the soil and increased runoff rather than continued infiltration to recharge the aquifer while longer dry periods result in less recharge to the aquifer for an extended period while abstraction continues and may even increase due to the dry period. Outside of climate change, weather conditions such as the El Nino Southern Oscillation (ENSO) has a similar impact on the recharge of the coastal and inland aquifers of Guyana.

Extended dry periods were recently experienced in the Administrative Region 9 resulting in several waterfalls and creeks becoming dry and rivers being reduced to a trickle, allowing for walking across. The reduced access to water resulted in several actions including the cleaning and increasing the depth of hand-dug wells, drilling of additional wells, rationing of water, and several plans in place to address the impacts of the shortage (The Guyana Chronicle, 2016), refer to Chapter 2 for more information.

AGRICULTURE

Surface water, via a series of canals which are fed by a reservoir (locally called a conservancy), is the main source of water for agricultural purposes. However, in the event of extreme dry periods and when the conservancy is low, famers may have to resort to using groundwater to reduce loss of production. Even though there has been no reported case of this being an important pressure to aquifers in Guyana, a contingency plan should nevertheless be in place to cater for any eventuality. Agriculture is likely to have a greater impact on the quality of the aquifers both along the coast and inland. Agricultural activities have increased over the past five years inland to include livestock farming of sheep, cattle, goat, pigs, and poultry. Soya and rice are the primary crops harvested inland (mainly in Administrative Region 9) and tilapia (*Oreochromis niloticus)* and tambaqui (*Colossoma macropomum*) for the aquaculture farms. The waste generated from these operations, if not managed properly, can have a significant impact on the shallow inland aquifers.

STATE AND TRENDS OF SURFACE WATER

Guyana's rivers can be characterized as either black water (acidic, with high carbon dioxide and low oxygen content) or white water (turbid, with low carbon dioxide, high silica, and low acidity). Black water can be found upstream of most of the main rivers, however, as these rivers flow through mining areas and towards the coast, their characteristics change to white water (UATEC, 1998).

The Essequibo, Demerara, Berbice and Corentyne Rivers and their tributaries are the main sources of fresh surface water resources both inland and on the coastal belt of Guyana. The Essequibo River drains the largest area in the country stretching from the most southward point to the north with the Atlantic on the coast; this is followed by the Cuyuni, Mazaruni and Potaro rivers, which are major tributaries of the Essequibo and are historically impacted by runoff from gold mining activities. The Demerara and Berbice rivers also drain from the south, bringing freshwater to the coast, refer to Table 5.4. These rivers are affected historically by domestic, mining, industrial and agricultural waste discharges (UATEC, 1998).

Table 5.4 Annual Flow of Selected Rivers in Guyana. *Source: UATEC, 1998*

River	Gauging station	Drainage area (km^2)	Maximum discharge (km^3/year)	Minimum discharge (km^3/year)	Mean discharge (km^3/year)	Period of record
Essequibo	Plantain Island	66 563	252.72	4.58	70.16	1950-1969
Cuyuni	Kamaria	53 354	170.12	0.31	33.54	1946-1968
Mazaruni	Hillfoot	20 720	130.70	1.79	36.13	1961-1968
Potaro	Tumatumari	6 203	70.15	1.38	16.46	1946-1954
Demerara	Saka	4 040	14.10	0.37	3.52	1950-1967
Berbice	Itabru	5 102	13.16	0.05	1.26	1960-1968
Canje	Reynolds Bridge	277	0.27	0.05	0.08	1969

Given the vastness of Guyana's surface water resources, ecosystem conditions and the differing environment and activities, the water quality across the country will vary. Importantly, consistent spatial and temporal data on key environmental parameters are critical to determine specific states and trends of the resource. Aside from the US Army Topographic Engineering Centre's assessment in 1997/1998, there has been a lack of sufficient data on water resources and attributes. This is extended to a lack of information on water extraction and rates by regions, usage and rate of recharge in Guyana. There is need for the collection of water quality data from freshwater inland and coastal rivers in a comprehensive but also consistent method and for integration of data into one national database system.

A number of institutions such as the EPA, GGMC and the Hydrometeorological Department collect surface water quality data. However, these institutions respond to differing mandates and are responsible for different areas of the country, thus, in the absence of a coordinated approach to data collection, duplication may occur. Moreover, extensive temporal analyses of the information collected were not undertaken to provide informed assessment based on trends.

For the development of this report, existing data from the GGMC's Environmental Management Division and the Environmental Protection Agency, Water Quality Unit were obtained, processed and analysed. The GGMC data were a compilation of results from surface water monitoring points along a number of rivers in the six (6) mining districts in the country for the period 2008-2015, and the EPA data were a compilation of baseline data extracted from key Environmental Impact Statements (EIS) across geographic regions. It is important to note that there were a number of data gaps, as such, the results presented in the following sections should be used only for reference and taken in the context of:

1. GGMC surface water monitoring points were not spatially or temporally standardized across the mining districts and resulted in the representation of the data by the main rivers even though samples were taken at varying points along the rivers over the period.
2. Monitoring of mining districts were more responsive than institutionalized and sampling at the same area or points were not consistent across the period (2008 – 2015).
3. The results and the analysis, as presented, should be taken in the context of temporal and spatial parameters for the period (2008-2015) instead of concluding on geographic trends of water quality in those areas.

SURFACE WATER – COASTAL

STATE OF SURFACE WATER QUALITY – COASTAL

In populated areas such as Georgetown and areas along the coastal lowlands, surface water contamination occurs from inadequate waste disposal and from chemicals used in the production of rice and sugarcane. Contamination of surface water results in degraded quality. The quality of surface water is a growing concern, with biological and chemical contamination most prevalent along the coast where population density and land use practices are changing. Sewage systems within Georgetown are inadequate with disposal into nearby canals and waterways then into the Atlantic Ocean. During the wet and dry seasons susceptibility to contamination is higher; open-ditch sewers and septic tanks may flood during the wet seasons and during dry seasons, there may be insufficient flow to flush and dilute the contaminants. Other agricultural, industrial and more recently tourism on the coast also affect water quality and can lead to serious health issues in Guyana, if not mitigated immediately (UATEC, 1998; Parsram, 2010). There are limited data available for water quality on the coast; however data analysis from records collected showed that there are changes in turbidity, pH, conductivity and low levels of dissolved oxygen in surface water. In addition, iron rich soils and runoff from agricultural practices change water chemistry along the coast (UATEC, 1998; Parsram, 2010).

Based on the baseline data presented in a number of EIS and extracted by the Water Quality Unit of the EPA, the average turbidity recorded in 2005, was 110.17 NTU, with pH at 4.17, and dissolved oxygen at 7.85 mg/L, for samples collected at Supply, East Bank Demerara. In 2006, the average turbidity recorded at Providence was 20.25 NTU, for an inland canal with a pH of 6.91 and dissolved oxygen 2.01 mg/L. The average turbidity for six (6) sample locations in Georgetown in 2008, was recorded at 9.99, with a pH of 6.46 and total dissolved solids 10.76 mg/L.

The EPA in 2006, conducted an assessment of the Demerara Watershed and examined the state of water quality along different sections of the Demerara River. The study assessed fifteen (15) water quality parameters from upstream of the town of Linden, Region10 to the Demerara Bar saltwater offshore of Guyana's coastline and those were (EPA, 2006):

pH	Turbidity	Total Ammonia
Dissolved Oxygen	Alkalinity	Ionised Ammonia
Temperature	Carbon Dioxide	Unionised Ammonia
Conductivity	Hardness	Phosphate
Salinity	Nitrite	Silica

This study was used to supplement the water quality baseline data extracted from a number of EIS prepared for project activities along the coast and provide an understanding of the water quality along the coastal and near coastal areas. The results present an idea of the state of the surface water body at a specific time and cannot be used to infer conclusions on trends.

The 2006 assessment of the Demerara Watershed concluded that two (2) types of environments exist in the Demerara River based on pH levels - freshwater and brackish (or estuarine). In freshwater environment, the pH averaged 4.5, and in brackish waters pH averaged 6.2 due to the mixing of freshwaters with ocean waters, which is at pH 8.0 or higher. Based on the results of the assessment, it was determined that the brackish environment begins downstream of Wales, West Bank Demerara. Dissolved oxygen (DO) averaged 5.0 mg/L throughout the areas assessed and water temperatures at that time (of the survey) ranged from a low of 26^{o}C upstream at Yararibo (Linden) to a maximum of 30^{o}C downstream near the Harbour Bridge.

Further, it was determined that the conductivity levels in the Demerara River during the time of the assessment was high with 200 μS/cm in freshwaters, while in the brackish section, conductivity averaged 620 μS/cm. Average salinity for brackish water, measured after slack tide was 0.4% (Ocean water is 3.5%). It was noted that from Yararibo to downstream of Bonasika, the river water was clear with turbidity ranging from 0 to 3 NTU. In the brackish waters, turbidity increased from 2.0 to 82.0 NTU indicating the presence of algae, sediments, suspended solids and domestic and industrial wastes.

The study further concluded that in the freshwater section of the Demerara River, nitrite averaged 0.2 mg/L, which was relatively high and total ammonia averaged 0.4 mg/L while it was 0.2 mg/L in the brackish areas. The study found anomalies with high ammonia values measured at many stations, tributaries and point sources (Bauxite Mining locations, region from Clemwood to downstream Dora, stations next to poultry and pig farms). It was noted from the study that these values were all due to anthropogenic inputs (from non-point sources and point sources), which were run-off from agricultural fields, and municipal and industrial discharges along the river. Phosphate was found to be an average of 0.0 mg/L (i.e. non-detectable with the test method utilized) in both freshwaters and brackish waters, and silica averaged 3.0 mg/L throughout the Demerara River.

STATE OF SURFACE WATER QUANTITY – COASTAL

Heavy precipitation provides large amounts of surface runoff, creating very high stream density (the ratio of streams per surface area), and where conducive, ground water recharge.

A small amount of the surface water resources is trapped by a long low earth embankment to form large shallow dams locally called conservancies. The conservancies are located in the upper stream catchment areas and comprise water-retaining embankments and structures. There are four large human-made conservancies which provide continuous supplies of surface water. The Abary conservancy on the Abary River, also called Mahaica Mahaicony Abary (MMA), has a total capacity of 609 million m^3 and has been designed to provide irrigation to about 17, 500 ha; The East Demerara Water conservancy (EDWC), which dams the Maduni River and Lama creek, has a capacity of 16 million m^3 and has been designed to provide irrigation to about 34, 500 ha. It also supplies potable water to Georgetown, to augment the groundwater supply. Ten per cent (10%) of surface water is used for potable water supply against 90 per cent groundwater; The Boerasirie conservancy collects the flow from the Boerasirie River, Warimia Creek, Jumbi Creek and the South Durabana Creek which has a total capacity of 166 million m^3 and has been designed to provide irrigation to about 36, 000 ha. The Tapakuma conservancy dams the water from three inland lakes on the Essequibo Coast and releases it as needed for irrigation. It has a total capacity of 18 million m^3 and has been designed to provide irrigation to about 12 000 ha.

In addition, the four main rivers (Demerara, Essequibo, Berbice and Corentyne) that flow to the coast and into the Atlantic Ocean also provide large and continuous quantities of surface freshwater resources (UATEC, 1998; Parsram, 2010; AQUASTAT, 2015).

SURFACE WATER – INLAND

STATE OF SURFACE WATER QUALITY – INLAND

Inland surface water resources are expected to be in a pristine state, given the low level of activities within this region and are mainly utilized by Amerindian communities for domestic purposes. In the absence of comprehensive assessment on the quality of inland surface water and unavailability of data, existing reports and data from the GGMC were used to provide representation of the state of inland surface water resources. GGMC through its monitoring activities of the six (6) mining districts compiled a database with results of water quality analyses along major rivers and creeks over the period 2008 to 2015. The parameters assessed were turbidity, pH, dissolved oxygen, total dissolved solids, conductivity and temperature. Even though there were data gaps across this period per river and by parameters, as far as possible, data were used where there was consistency for a least a three-year period.

Turbidity is a key parameter assessed by GGMC since the surrounding water bodies and the water quality therein can be affected by unmanaged discharges from mining operations. Turbidity refers to particles found in the water body and is an indicator of water clarity. Turbid water can appear murky or coloured and while some freshwater systems naturally contain high suspended solids as a result of erosion and run off after rainfall, elevated turbidity over time due to discharges from mining activities can affect the quality of water for aquatic and any surrounding human life. High turbidity will contribute to higher water temperature and lower dissolved oxygen in the aquatic systems. Legislatively, turbidity levels should not exceed the critical level of 30 Nephelometric Turbidity Unit (NTU), however, this limit is often exceeded in areas of predominant small and medium-scale mining operations.

Mean turbidity values for the period 2008 to 2015 for main rivers within mining districts ranged from low (within the 30 NTU limit) to above the critical level but below 100NTU and exceedingly high (above 100 NTU), see Figure 5.9. Turbidity levels were recorded along the Kurupung and Siparuni Rivers below 30NTU, specifically ranging from 4.74 in 2008 to 21.9 NTU in 2014. No data were available for the other parameters (pH, dissolved oxygen (DO), conductivity and total dissolved solids (TSS)) for the Kurupung River. Mean values of pH – 5.19; DO -5.59 mg/L; TSS – 7.65 mg/L and conductivity – 14.85 μ/S were only available for 2013 for the Siparuni River.

The Kuribrong, Issano, Potaro, Puruni, Essequibo and Mazaruni Rivers recorded instances of turbidity levels below 30 NTU and along with the Cuyuni River high turbidity but below 100 NTU. In 2014 and 2015, turbidity levels were above 100 NTU for the Cuyuni River. Even though the turbidity levels fluctuated over the period 2008 to 2103, a minor increase can be observed over the period 2008 to 2015, refer to Figure 5.10.

Figure 5.9 showing mean turbidity values over the period 2008 – 2015 for rivers monitored by GGMC. *Source: GGMC, 2016.*

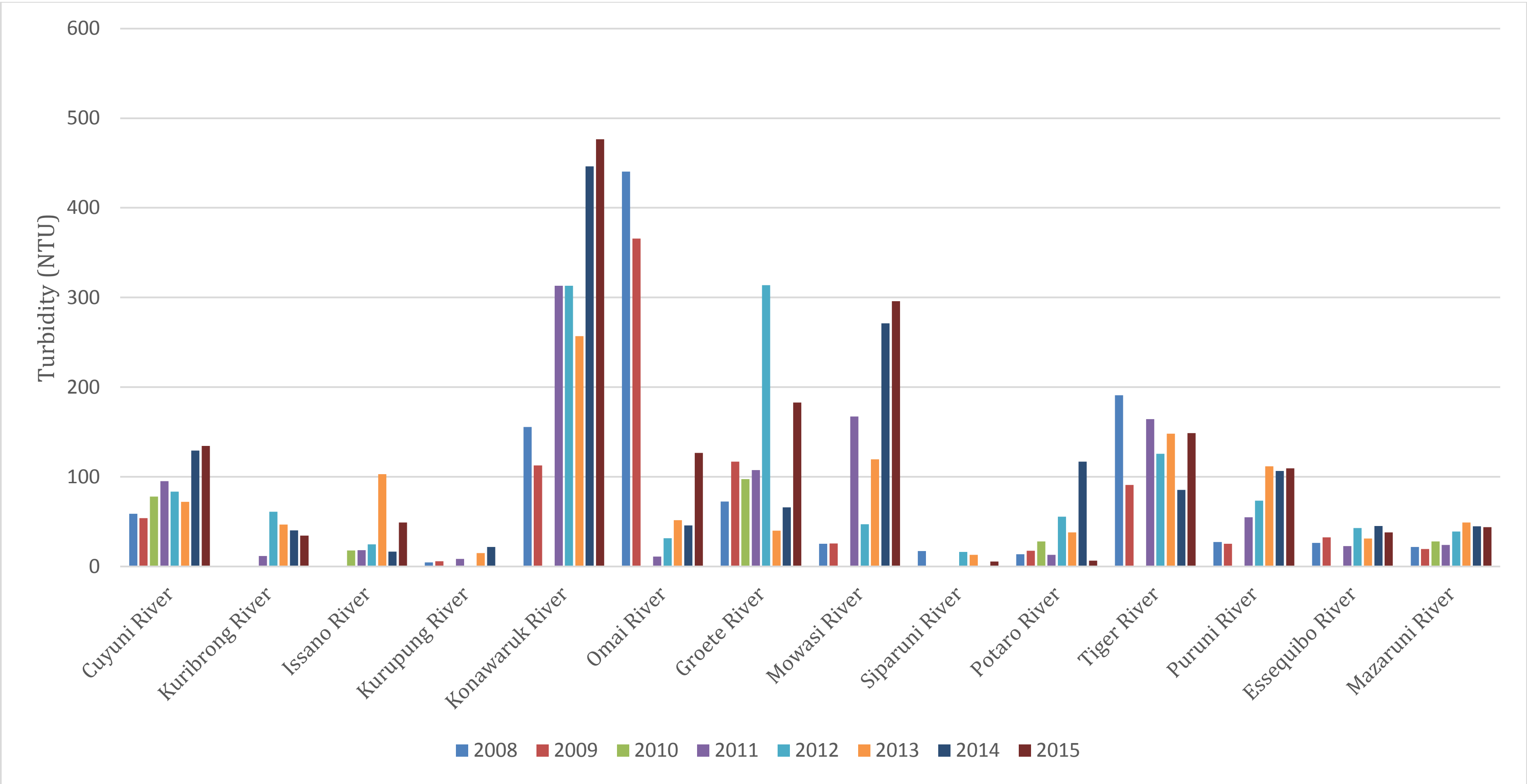
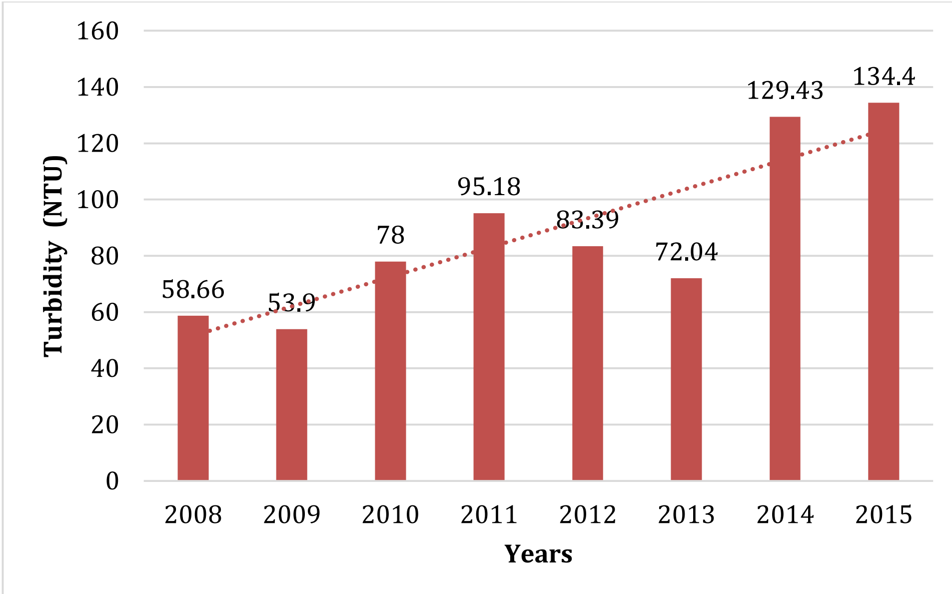


Figure 5 – 10 showing mean turbidity values for the Cuyuni River. *Source: GGMC, 2016*

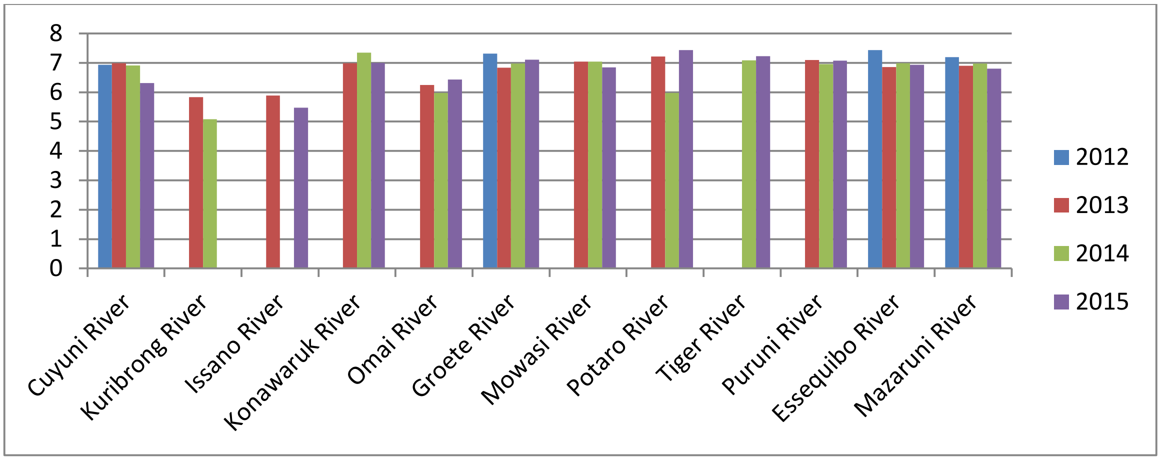


The Konawaruk, Omai, Groete, Mowasi and Tiger Rivers have all recorded exceedingly high levels of turbidity over the 2008 -2015 period. Mean values are as high as 476.44 NTU and 313.75 NTU in the Konawaruk and Groete Rivers respectively. The quality of the water over the years especially in those areas and to some extent the Cuyuni, Mazaruni and the Potaro Rivers have been continuously degraded due to discharges from mining activities within the mining districts.

Additionally, contaminants such as caustic soda from bauxite production, cyanide, sulfuric acid, hydrochloric acid, and mercury in gold production are pollutants of concern in freshwater systems close to these activities. The Essequibo, Mazaruni, Cuyuni, Barima, and the Barama Rivers and associated tributaries could be impacted by these chemicals. There are many documented cases of mercury spills into interior streams from gold-mining. Cyanide contamination from gold production operations has occurred in the Omai and Essequibo Rivers after a breach of the tailings dam in 1996. The Demerara River and the Upper Berbice and associated tributaries may be chemically impacted from caustic soda (sodium hydroxide) and high-suspended solids from soil erosion resulting from deforestation activities (AQUASTAT, 2015; UATEC, 1998; Parsram, 2010).

Inland rivers in Guyana with black water are expected to be acidic with low dissolved oxygen. However, with the exception of the Siparuni, Issano and Kuribrong Rivers, all other rivers recorded average pH values between 6.31 and 7.44, see Figure 5.11. It is highly probably that the neutral to slight alkalinity of these rivers correspond with their high to elevated turbidity levels.

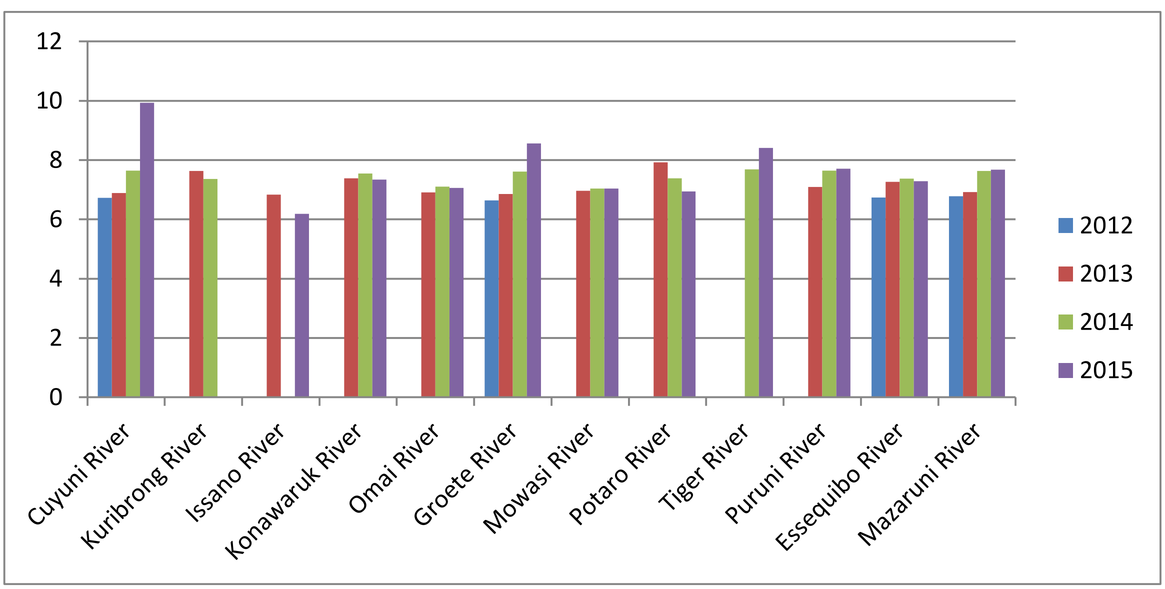
Figure 5.11: Mean pH values for the period 2012to 2015 for major rivers. *Source: GGMC, 2016*



Dissolved oxygen and total dissolved solids are important parameters to determine water quality since these influence the state and health of the system. Exceedingly high or low levels of DO can significantly affect aquatic life. Both DO and TDS levels are generally influenced by environmental factors including temperature, anthropogenic activities which may release effluent into the surrounding water bodies, time of day, season, depth, altitude and rate of flow of the river system.

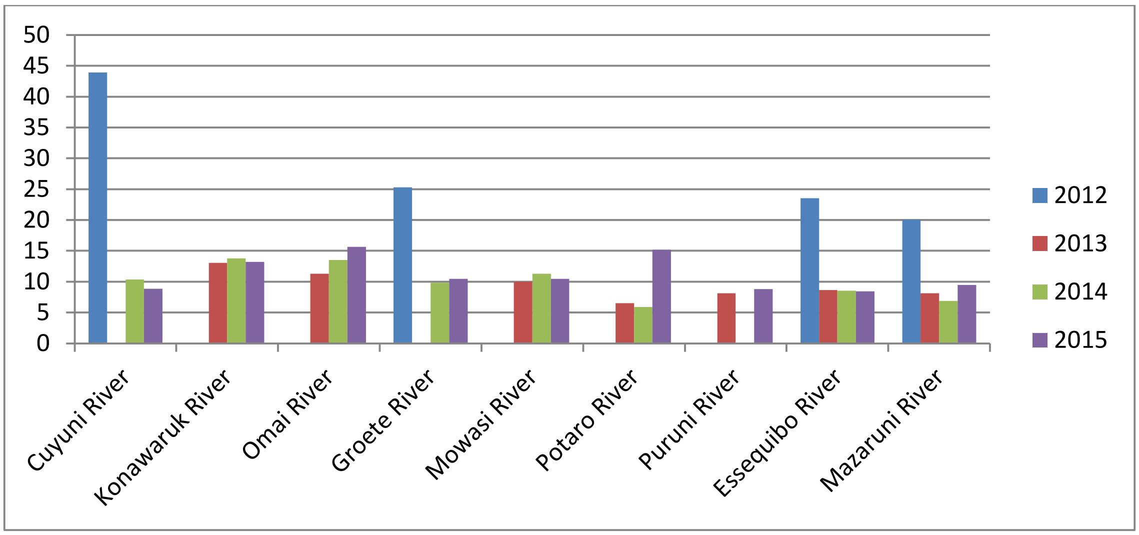
DO recorded over the period 2012 to 2015 showed fluctuations across the river systems ranging from 6.19 mg/L the lowest recoded in the Issano River to 9.93 mg/L the highest recorded in the Cuyuni River in 2015, see Figure 5.12.

Figure 5.12: Mean values of dissolved oxygen (mg/L) for the period 2012 to 2015 for major rivers found in the mining districts. *Source: GGMC, 2016.*



The average DO level recorded in the Cuyuni River in 2015, was the highest (9. .93 mg/L) in comparison with the other river systems across Guyana's mining districts, at a pH of 6.31. Moreover, the Cuyuni River recorded high mean turbidity value (134.40 NTU) in 2015, but the Konawaruk River, an area known for extensive mining, recorded the highest mean turbidity (476.44 NTU) and neutral pH (7) with a DO at 7.34 mg/L for the same year. Consequently, the Cuyuni, Groete, Essequibo and Mazaruni Rivers all showed high mean TDS in 2012, Figure 5.13 and sharp decline in 2013, which fluctuated thereafter, until 2015(based on available data).

Figure 5.13: Mean TDS (mg/L) for the period 2012 to 2015 for major rivers found in the mining districts. *Source: GGMC, 2016*



STATE OF SURFACE WATER QUANTITY – INLAND

Specific data on the quantity of surface water resources in Guyana is not available. However, the National Land Use Plan (NLUP) (2013) prepared by the Guyana Lands and Surveys Commission (GL&SC) used the annual per capita water resource availability as a measure of Guyana's water scarcity or water surplus. It was found that Guyana has a vast water surplus with an annual per capita water availability of 314,963m^3 and it was noted that there is continually *"plentifully available fresh water with enormous (>400,000 litres/min) quantities available for eight (8) months of the year (wet seasons) and large (4,000-40,000 litres/min) to very large (40,000 – 400,000 litres/min) qualities available for four (4) months of the year"* (GL&SC, 2013). There are a number of exceptions to surface water availability, and these include, the coastal plain backlands, Rupununi Savannahs, Pakaraima Mountains and further south of the country due to recorded seasonally abundant quantity of water. In general, the coastal frontlands were found to be fresh water scarce but contained large quantities of brackish to saline water (GL&SC, 2013).

STATE AND TRENDS OF GROUND WATER

GROUND WATER – COASTAL

It is important to preface this section with a number of critical observations that emerged during the process of preparing the State of Environment Report. First and foremost, there is significant lack of information including supporting data on Guyana's groundwater aquifers. There has not been a thorough assessment of the aquifers of Guyana since the initial drilling of the coastal aquifers, and as such, there is no information to verify what was collected and estimated over fifty years ago.

Further, while there may be some data available, in particular, abstraction rates, these are inconsistent and of poor quality to allow for in-depth assessment of trends and as a result limit the knowledge of the state of the aquifers. In addition, a number of private wells were found along the coast but not all private wells are registered with the regulatory body, the Hydrometeorological Office (Hydromet) and these wells are not adequately monitored nor information provided for verification due to lack of resources (financial and human capacity).

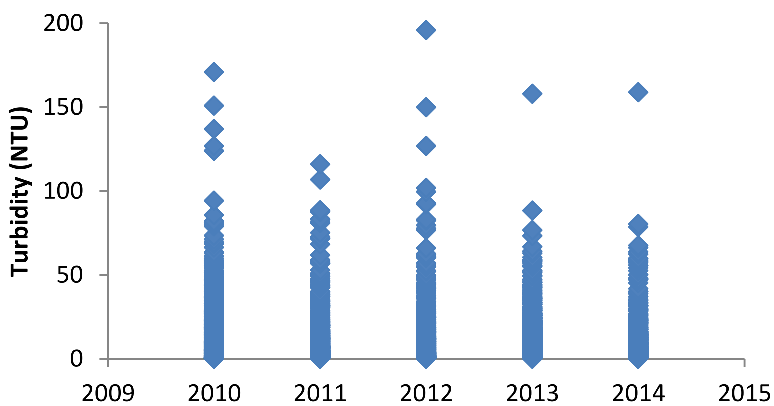
Moreover, the Guyana Water Incorporated (GWI) has the overall responsibility for the supply of water for domestic use throughout Guyana of which the main source of water is abstracted from groundwater sources with a small portion coming from surface water sources via dammed reservoirs or conservancies, as they are locally called. However, it is the Hydrometerological Office that is responsible for the management of water resources in Guyana. As a consequence of the fragmented distribution of responsibilities of water resources in Guyana, limited data currently exist. A comprehensive study of the aquifer has not been completed within the last 25 years and there are contradicting reports on whether the levels of the coastal aquifers are declining or not. These have not been substantiated by comprehensive studies.

STATE OF GROUND WATER QUALITY – COSTAL

Worts Jr. (1963) reported the quality of water of the coastal aquifers to increase in quality with the depth of the aquifer. The first layer, the "Upper Sands" aquifer was abdoned shortly after its initial drilling as a result of retrieving water with high concentrations of sodium and chloride which was reported in 1913. The "A-Sands" aquifer is considered a better quality of water but has an high concentration of iron. The "B-Sands" aquifer is an even higher quality but use is limited as a result of the depth of the aquifer. Water quality data was provided by the GWI for the period 2010 and 2014, and included samples taken at well sites, as well as, points along the distribution system. It should be noted that borehole monitoring is ad hoc by GWI and as a result the data collected from each ground water well were not consistent across the assessed period. Parameters analysed by GWI are pH, turbidity, iron, and total and faecal coliform.

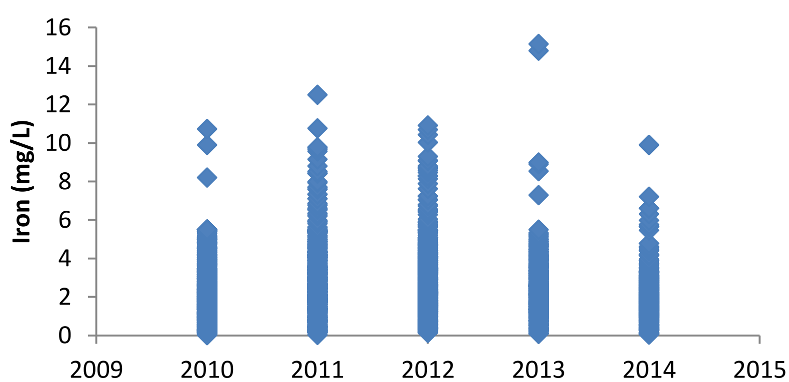
Turbidity readings were generally low, though not within the World Health Organisation (WHO) standard of less than 5 NTU, with a few extreme cases. An average of 11.36 was recorded, with readings ranging from 0.13 to 204 NTU during the five year period. It was noted that areas within the recharge area had a lower turbidity, below 5 NTU, while those along the coast were above the WHO limit. This may be attributed to the well condition, as well as, the state of the distribution system. The annual average decreased over the five year period from 15.06 NTU in 2010 to 9.49 NTU in 2014. This is reflected in the concentration of records below the 50 NTU mark and with outliers decreasing over time. (See Figure 5.14)

Figure 5.14: Turbidity readings for the coastal aquifers for the period 2010 – 2014. *Source: GWI, 2016.*



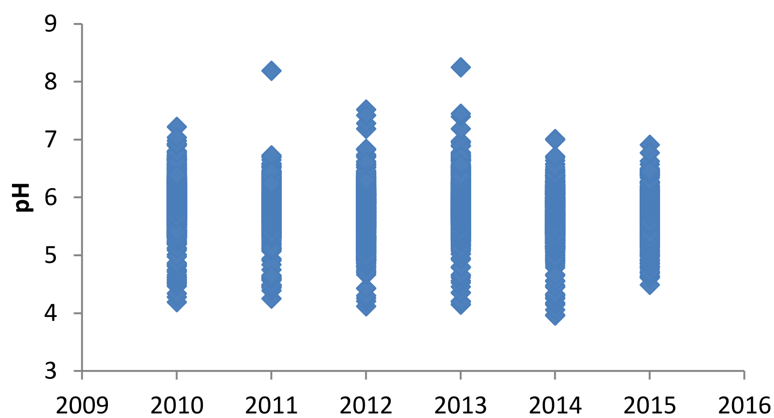
Guyana's coastal aquifers are noted for having a high iron content that is visible at the end point. This was reflected in the data provided by GWI for the period assessed. Iron content ranged between 0.01 mg/L along the East Bank Corentyne, Berbice to 92 mg/L along the East Coast Demerara for the data provided, with an average of 2.54 mg/L which is above the WHO recommended limit of 0.5 mg/L. (Figure 5.15)

Figure 5.15: Iron readings along the coast for the period 2010 – 2014. *Source: GWI, 2016.*



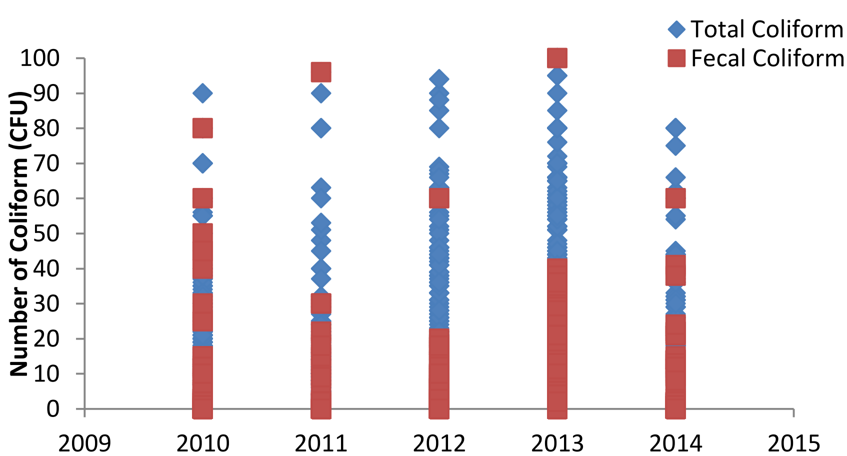
Guyana's surface waters are generally mildly acidic and this is reflected in the pH of the coastal aquifer where the pH readings ranged from 3.96 to 8.25 with an average of 5.77. The lowest reading of pH was recorded in Kuru Kururu, which is within the recharge area of the aquifer and may be attributed to the acidity of the interaction with the acidic surface waters. The highest reading was recorded along the East Coast of Demerara at Success. These show an elevation of the pH, which may be attributed to the subsurface chemical interactions during transit, from recharge to discharge area, and storage. (Figure 5.16)

Figure 5.16: pH readings for the coastal aquifers for the period 2010 – 2014. *Source: GWI, 2016.*



The presence of coliform, total or faecal, is not acceptable under WHO standards given the health impacts of this. A total of 2440 samples were recorded for Total Coliform of which an average reading of 14 Coliform Forming Units (CFU) were identified ranging from 0 to Too Numerous To Count (TNTC). The presence of Faecal Coliform was less noted with an average occurrence of 1.28 CFU ranging from 0 to TNTC. The presence of these may be attributed to the breakages within the distribution system.

Figure 5.17: Total and faecal Coliform presence recorded for the coastal aquifers for the period 2010 – 2014. *Source: GWI, 2016.*



STATE OF GROUND WATER QUANTITY– COASTAL

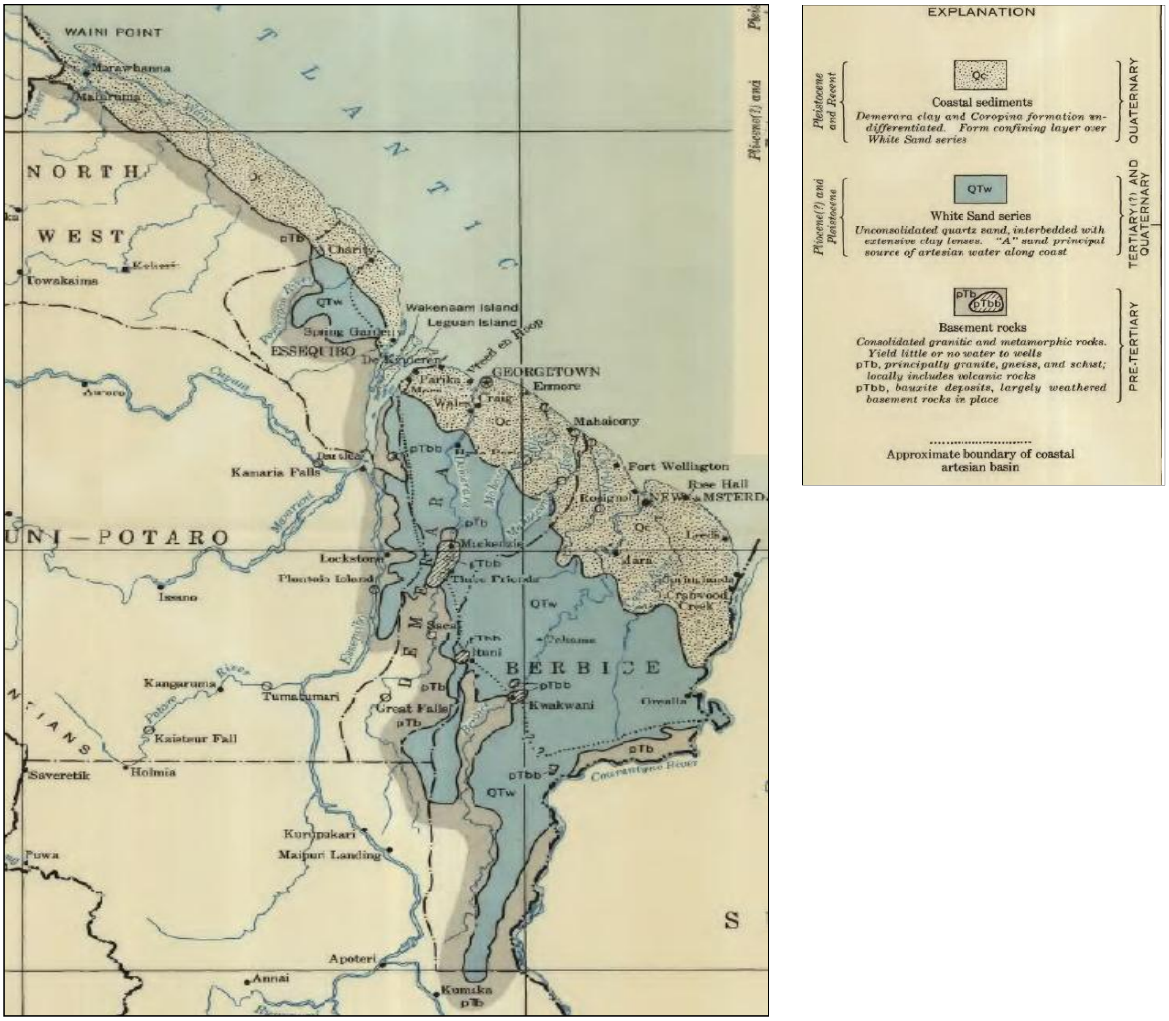
The coastal aquifers of Guyana cover an area of approximately 18,000 km^2 with a recharge area of approximately 13,000 km^2 with an estimated rainfall recharge of 2,500 mm per year (Worts Jr., 1963).

The 'Upper Sands' aquifer was first drilled in 1781 and reached a peak discharge of 458 $m^3\ d^{-1}$ in 1913 but was soon abandoned due to salinization. Mercado (1997) posited that the saline content of the 'Upper Sands' may be the result of over abstraction and thus saline intrusion from the aquifer's connection to the Atlantic Ocean, however, works from Worts Jr. (1963) and Edwards, et al. (1997), suggest that this may be the remnants of the Ocean from when the sea was much higher.

In 1913, the 'A Sands' aquifer was drilled with an initial yield of 1,636 $m^3\ d^{-1}$. By 1956, the 'A Sands' aquifer had more than 200 wells and a yield of 2,600 $m^3\ d^{-1}$(Worts Jr., 1963). This aquifer continues to be the main source of potable water along the coast today with a yield of 347,382 $m^3\ d^{-1}$ (Franklin, 2013). The 'B Sands' aquifer was first drilled in 1962 (UATEC, 1998), however, use of this aquifer has been limited primarily due to the depth of it.

Worts Jr. (1963) and Edwards, et al. (1997), further posited that the heavy build-up of clay along the coast would prevent recharge from rivers within this area, suggesting recharge to the coastal aquifers would come mainly from the recharge area. Figure 5.18 below shows the estimated recharge areas.

Figure 5.18: Estimated recharge area and extent of the coastal aquifer basin (*Source: Worts Jr., 1963)*



EXPLANATION Figure 5.18.

Qc: Coastal Sediments - Demerara Clay and Coropina Formation undifferentiated. Form confining layer over White Sand series. **QTw: White Sand series** - Unconsolidated quartz sand, interbedded with extensive clay lenses. "A" Sand principal source of artesian water along coast. **pTb/pTbb: Basement rocks** - Consolidated granitic and metamorphic rocks. Yield little to no water to wells. pTb, principally granite, gneiss, and schist; locally includes volcanic rocks. pTbb, bauxite deposits, largely weathered basement rocks in place.

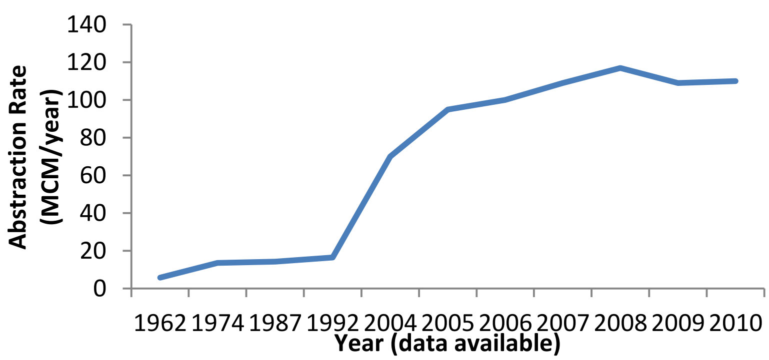
The US Army Topographic Engineering Center, in 1998, reported the falling ground water levels from 4.5 metres about ground level (agl) in 1913, when the A-Sands aquifer was first drilled to 14 metres below ground level (bgl) in 1993. Groundwater levels collected by GWI along the coast ranged from less than 1 metre bgl in Berbice to 35 meters bgl in Georgetown. Groundwater levels varied throughout the coast with minimum and maximum levels for each of the five Divisions identified by GWI (Franklin, 2013). (see Table 5.5)

Table 5.5: Groundwater levels for the five Division identified by GWI. *Source: Franklin, 2013.*

Divisions	Location	Groundwater level (metres below ground level)	
		Min	Max
1	Essequibo Coast Wakenaam Island, Essequibo Leguan Island, Essequibo	7.24	16.16
2	East Bank Essequibo West Coast Demerara West Bank Demerara	7.65	27.89
3	East Bank Demerara Georgetown, Demerara East Coast Demerara	12.85	35
4	West Coast Berbice West Bank Berbice East Bank Berbice	1.91	8.91
5	Canje, Berbice Corentyne, Berbice	0.98	11.91

Abstraction rates are expected to increase over time, as such, this has been the case of the coastal aquifer of Guyana since its initial penetration in 1781. Franklin (2013) reviewed the abstraction rates for a forty-year period between 1970 and 2010, which showed, given the limited data available, a 50% decrease in abstraction during the first 20 years from 74.69 million m^3/year in 1972 to 36.50 million m^3/year in 1992, and a 200% increase for the last 20 years to 106.6 million m^3/year (Franklin, 2013).

Figure 5.19: Calculated annual abstraction rate for the years data were available between 1970 and 2010. *Source: Franklin, 2013*



The decrease recorded between 1970 and 1990 may be attributed to a decline in data collection which was observed throughout the country, and across various sectors, subsequent to Guyana gaining independence. This entails that there may have been a natural steady increase over the 20 year period, but as a result of limited data, a decrease is shown and a significant increase in the subsequent 20 years.

GROUND WATER – INLAND

Approximately 10% of Guyana's population lives in the inland regions of Guyana which comprises tropical forests and savannah vegetation. Groundwater in these areas is accessed via relatively shallow wells penetrating unconfined aquifers. In the absence of an assessment of the inland aquifers of Guyana, little is known about the properties of the aquifers or their potential storage. The International Groundwater Research Association Centre (IGRAC) has gathered information on aquifers globally but has collected limited information for Guyana particularly inland.

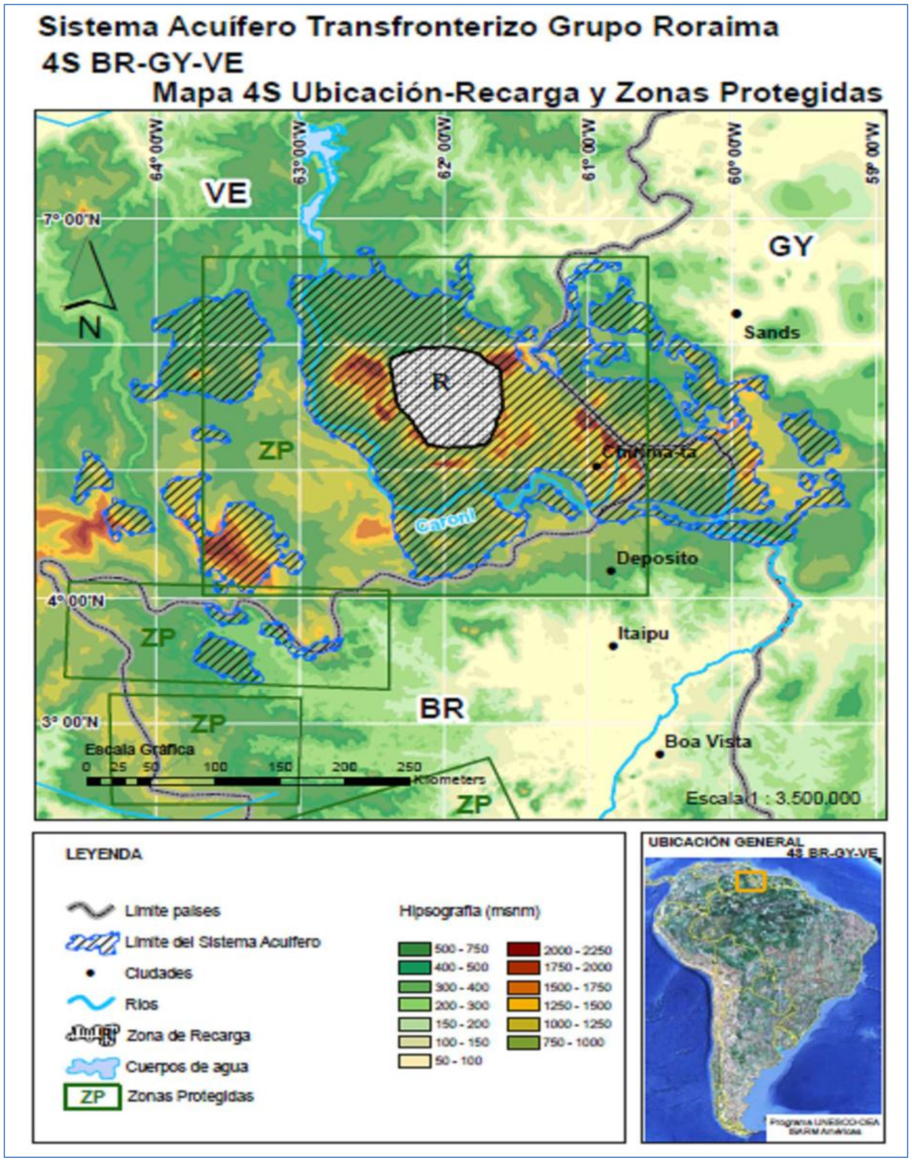
Further, access to the inland aquifers by residents of these areas is generally by means of shallow wells, however, how many of these existing shallow wells are not known. Even more so, monitoring of these wells was not conducted and therefore limited information is known, in particular, the interaction of the well with various activities and its impact on the communities or the aquifer. The limited information on characteristics of the aquifer means Guyana is unable to identify or project how aquifers would behave under various climate change projections particularly ENSO given their shallow nature.

STATE OF GROUND WATER QUALITY – INLAND

TWAP (2015) noted that there appears to be some decline in the quality of the Boa Vista-Serra do Tucano-North Savannah aquifer, with elevated natural salinity in Brazil but this has not been verified. Additionally, the TWAP notes that Brazil has reported that pollution from households and municipalities currently takes place. This is also a potential risk on the Guyana side of the aquifer, particularly with the increase of agricultural activities within Administrative Region 9, refer to Chapter 1 for more information. There are at least three major agricultural activities within Region 9, aquaculture, livestock and crop farming, which increase the potential of pollution of the shallow aquifers of this region. In addition to this, the sanitary practices of the region may also contribute to polluting the aquifer. The primary form of sanitation is pit latrines which can be a major contributor of pollutants to the aquifer. Unfortunately, no monitoring of the aquifer is undertaken to ascertain its current quality and to measure trends.

In the case of the Grupo Roraima Aquifer, there is little information. However, given the topography of the area and low population density, it is unlikely that the quality of this water would be poor as a result of anthropogenic activities. (Figure 5.20)

Figure 5.20: Recharge area for the Grupo Roraima aquifer. *Source: TWAP, 2015.*



Very little information is available on the Boa Vista - Serra do Tucanoo - North Rupununi aquifer with the exception that there is no legal framework between the two countries or is any under preparation for the management of the aquifer. While there are national institutions in place, these are not fully operational (Transboundary Waters Assessment Programme, 2015).

STATE OF GROUND WATER QUANTITY – INLAND

This aquifer covers Administrative Regions 7 and 8 with a per capita of 0.4 and 0.5 persons/km^2. The two regions have an accumulative population of 30,470 residents (BOS, 2014)

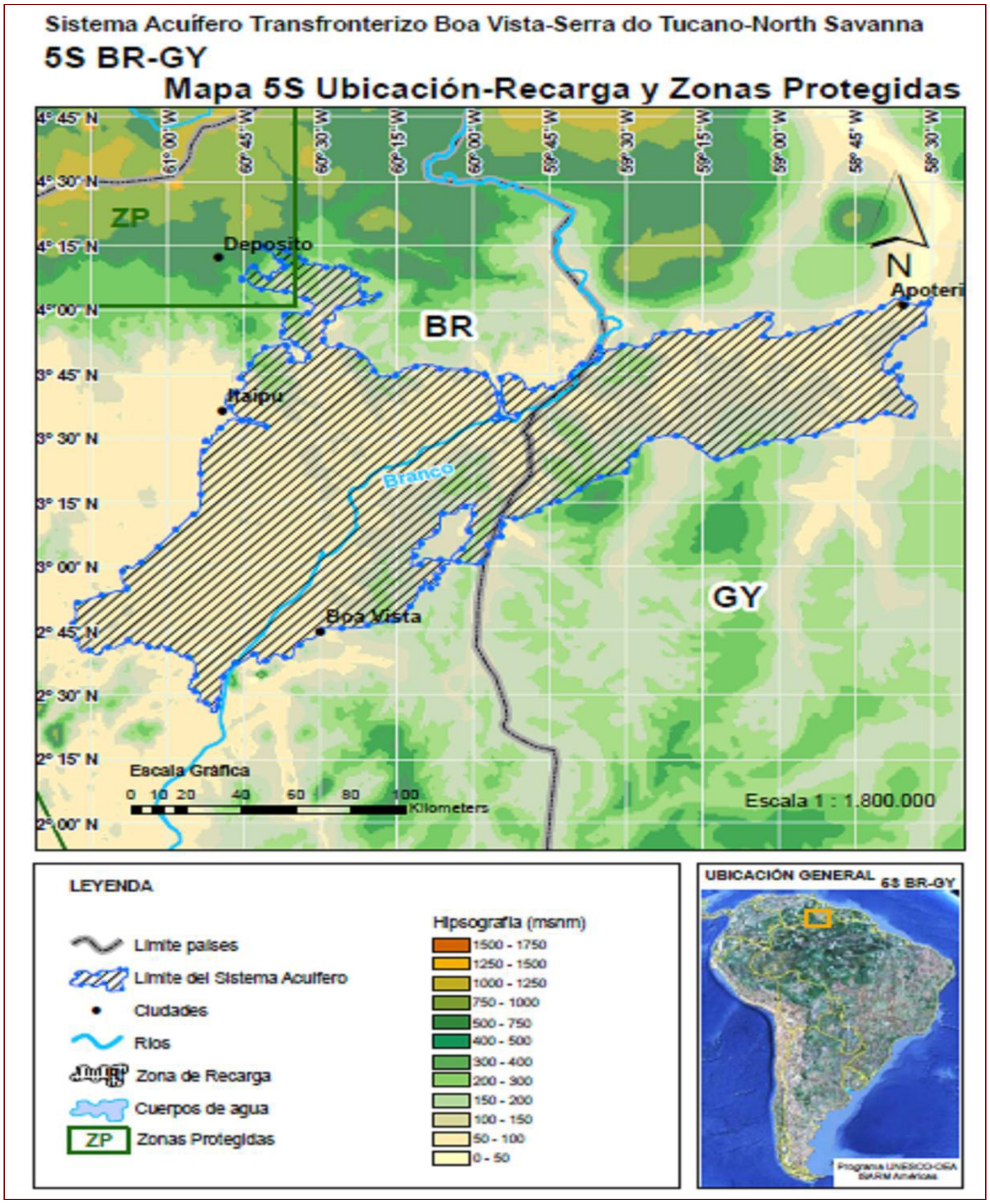
The aquifer falls within the tropical dry region of Guyana and received approximately 2,400 mm of rainfall per year. Given the topography of the region, the main source of recharge has been cited as runoff while the main form of discharge is via groundwater flow into another aquifer.

Guyana has no legal and institutional framework in place or arrangement with the trans-boundary countries for the management of the aquifer. This aquifer is accessed by residents of Region 9 from several villages including Lethem, MocoMoco, Nappi, Dadanawa, and Good Hope. Region 9 is composed of more than 24,000 residents and a per capita of 0.4 persons/km^2 (BOS, 2014).

The limited information on the Boa Vista-Serra do Tucano-North Savannah and the GrupoRoraima aquifers is not sufficient to quantify the resources of the aquifers.

The **Boa Vista-Serra do Tucano-North Savanah aquifer** is a multilayered hydraulically connected unconfined aquifer. The aquifer is a composition of Arkosic sandstones, conglomerates, and siltstones. This is primarily utilised by residents within Region Nine. It has an approximate area of 6,784 km^2 shared between Guyana and Brazil with the greater portion within Brazilian territory. The depth of the aquifer has not been reported to TWAP. The main source of recharge for the aquifer is via precipitation. This aquifer is within a tropical dry climate with a single major rainfall period and receiving approximately 1,500 mm of rainfall per year. (Figure 5.21)

Figure 5.21: Recharge area for the Boa Vista-Serra do Tucano-North Savanah aquifer. *Source: TWAP, 2015.*



IMPACTS ON FRESHWATER RESOURCES

ECONOMIC

Limited and reduced access to groundwater resources result in the use of surface water sources which usually require treatment. Treatment of surface water can be expensive and is heavily dependent on the quality of the raw water that determines the required type of treatment.

The coastal aquifers are considered to be a very good source of potable water supply, however, the GWI has several water treatment plants along the coast which treat for the naturally high iron content of the aquifers. This cost may be considerably lower than treating surface water and more so than mitigating a polluted groundwater resource. Because of the usually slow recharge rate of aquifers, pollution today may not be observed for months or even years after. As a result, the cost of treatment may not have been considered and treatment delayed until financial resources are available. With this in mind, the pollutant may continue to spread throughout the aquifer increasing the cost and potentially reducing the usability of the aquifer over time if mitigation measures are not sufficient or possible given the nature of the pollutant.

Along the coast of Guyana, many persons purchase drinking water from private producers. While these are easily accessible, they represent additional costs to residents along the coast. Conversely, if the heavily dependent inland groundwater sources utilised by the hinterland population becomes polluted or declines, access to privately produce bottled drinking water in those regions will not be as easily accessible. Although bottled water can be transported from Georgetown to those regions, the costs may be far more and it may be easier to import from neighbouring states such as Brazil.

HEALTH

The Boa Vista-Serra do Tucano-North Savannah is also under pressure from pollution given its shallow water table and the increase in agricultural activities within Administrative Region 9. The aquifer is exposed to pollution, as well as, from municipal wastes particularly in the absence of a regulated sanitary landfill where most wastes are released directly into the environment. Pollutants may also be transported via hand-dug wells which are used as a source of water for communities within Region 9. If not closely monitored, this could result in citizens consuming contaminated water from groundwater sources.

One of the major health issues that still pertain today in some inland communities is acute diarrheal diseases (ADD) (MoPH & PAHO, 2016) as a result of contamination of potable water sources, Table 5.7. In the absence of adequate groundwater supplies inland, residents may resort to using creeks and rivers nearby that may require treatment before consumption that would not be easily accessible given the topography of the region. As a result, residents may consume contaminated water and may be exposed to various water borne diseases.

Table 5-7 Environment-related Diseases (NDS, 2006)

TRANSMISSION	DISEASES
Water-borne	Cholera, dysentery, gastroenteritis, and typhoid
Food-borne	Dysentery, gastroenteritis, and infectious hepatitis
Soil-borne	Hookworm

Along the coast, private drinking-water producers are not adequately regulated and therefore a poor public supply system results in residents purchasing water from private distributors which are not adequately regulated and therefore the quality of their produced water may be questionable.

SOCIAL

In Guyana, groundwater is predominantly used for potable water supply. Pollution or decline in the volume of water could result in conflict particularly inland since residents generally dig individual wells. If it is believed that one person is consuming more than necessary, especially during a drought period, this may cause some level of conflict among residents.

Along the coast, since there is one public supplier, conflict over usage would generally occur if there is an extreme drought period, which limits the surface water sources used for agricultural purposes. The Food and Agriculture Organisation (2015) fact sheet on Guyana notes that agriculture accounts from approximately 1.363 billion m^3/year water usage. This is primarily accessed via the various conservancies along the coast. However, should these fall below the allowable limit and ration or a complete cut off is necessary and the alternative is to access groundwater, it is easy to see how great an impact this may have.

Conflicts may also arise along the coast between the public supplier and private users of the aquifer system as it relates to over abstraction for the groundwater resource. The Hydromet Office has reported data on 15 of 17 registered wells.

The information provided includes a one-time abstraction rate, which is not monitored and is assumed to have been at the initial use of the aquifer, years for which have not been provided. Given the known deficiency in the data provided, the figures reported present a modest estimate of 15.35 million m^3/year of water is being consumed by private wells. This is in addition to the estimated 126.8 million m^3/year (2012) abstracted by GWI (Franklin, 2013).

ENVIRONMENTAL

Freshwater, estuarine and marine surface water in both coastal and inland areas carry out major ecological processes and functions. Surface water throughout Guyana serves as important ecosystems by providing a medium for habitat, food, and reproduction for aquatic life forms especially fishes, macro-invertebrates, plants, mammals, birds, herpetofauna, microbes and drinking water for humans.

The increasing population density places major threats to our surface water resources with contamination from sewerage, grey water, agricultural runoffs, industrial wastewater, piping (extraction based on high demands) and chemicals from mining of gold and bauxite. These contaminants degrade water quality and quantity making it unsuitable for habitation by aquatic organisms and also provide conditions for disease outbreaks. Recent studies of the Demerara showed that water quality has been degraded because of waste inputs from the high population density in Georgetown. Also, bauxite companies release wash wastewater and more recently waste oil, which affects the water chemistry and organisms (UATEC, 1998; Parsram, 2010). The OMAI Gold Mine Ltd (OGML) cyanide spill in the Essequibo and Omai Rivers in 1995 caused high mortality rates in fish and other organisms such as mammals, reptiles and birds for miles for several days. Similar fish kills were observed in the Upper Mazaruni River and Lamaha Canal, Georgetown, where the top predator species were found dead in large numbers. In the latter case, the cause is still unknown but may be attributed to some form of contamination, which as a result can cause the ecosystem in those areas to become unstable and can affect aquatic life (AQUASTAT, 2015).

The Boa Vista-Serra do Tucano-North Savanna has a very shallow water table resulting in a high natural vulnerability (Transboundary Waters Assessment Programme, 2015) to pollution. Because of the shallow nature of the aquifer, it is likely to be connected to the many creeks and rivers that drain the region. As such, pollution of the aquifers may interact with these rivers further polluting them and exposing wildlife to pollution. The same may be said for the GrupoRoraima aquifer system. Because of the nature of the coastal aquifers, a change in its quality or quantity is less likely to have an impact on surrounding wildlife, however, as with the case of the Suriname A-Sands aquifer, there is a possibility of the aquifer being threatened by saline intrusion as a result of over abstraction.

RESPONSES

POLICY

The Government of Guyana through a Cabinet decision in 2015, has decided to resuscitate the National Water Council (NWC) as stipulated under the Water and Sewage Act 2002. Subsequently, recommendations were made regarding the members to the Council and for the convening of the Water Council, however, to-date the council is still to be established. One of the main functions of the Council is the preparation of a National Water Policy for the country and in support of its work; consideration is being given to establish a Water Agency as the administrative and operational body responsible for integrated water resources management. Further, an Integrated Water Resource Management Unit within the Ministry of Communities to collaborate with the Water Council and Agency is also being proposed[47].

In support of water resources management, the Guyana Water Incorporated (GWI) has established a Water Resource Unit that focuses on water use and monitoring of extraction of the resource. This initiative has served to improve the data collection system and to provide vital information for agencies with a mandate for water management. Additionally, the GWI has sustained a public awareness campaign, using social media to sensitise households on the need to conserve water and to protect water resources. Households have already embarked on initiatives such as rainwater harvesting.

LEGISLATION

A number of laws and regulations provide the overarching legal framework for the water sector, both surface and ground water and the mandates of the governing institutions and these are elaborated below:

The Water and Sewerage Act (2002)

The Water and Sewerage Act (2002) is an important recent piece of legislation that facilitates the development of a National Water Policy for Guyana. When fully implemented, this Act will enable the establishment a new legal, institutional and regulatory framework within which the salient issues regarding water resources management can be adequately addressed. The Act further allows for the introduction of national water standards and a National Water Council to spearhead the water resource management policy. Specific issues covered are water supply and connection, water regulations, wastewater and sewerage matters, drought orders and hydrometeorological matters.

[47] Ministry of Communities, May 2016

The Environmental Protection Act (1996)

The Environmental Protection Act (1996) is an act "*to provide for the management, conservation, protection and improvement of the environment, the prevention or control of pollution, the assessment of the impact of economic development on the environment and the sustainable use of natural resources*" (EP Act, 1996). It is best described as the umbrella legislation that mandates the undertaking of a number of measures to safeguard the environment and its resources, including water resources. In particular, Section IV deals with the execution of environmental impact assessment and Section V deals with prevention and control of pollution l-both of which are necessary tools to mitigate watershed degradation. For example, Part IV (19) 1 states "*A person shall not discharge or cause or permit the entry into the environment, of any contaminant in any amount, concentration or level in excess of that prescribed by the regulations or stipulated by any environmental authorization".* Further, the EP Act has allowed for the development of regulations, including the water quality pollution abatement and control and hazardous wastes disposal, which will help safeguard water systems in Guyana.

The Environmental Protection Regulations, made under the Environmental Protection Act, were gazetted in 2000. These Regulations, among others, govern Water Quality and Hazardous Waste Management. The Water Quality Regulations protects Guyana's water resources by controlling discharges of wastewater into any of the coastal and inland water bodies or land. The Water Quality Regulations provide for minimizing the contamination of potential and existing water supply sources. The Hazardous Waste Management Regulations protects Guyana's environment from hazardous waste generated including industrial waste, clinical wastes from hospitals, etc. The Regulations examine the generation, treatment and disposal of hazardous waste and allows for the management of chemical wastes including persistent organic pollutants.

The Mining Act (2005)[48]

The amended Mining Act has been made in light of the growing number of environmental defaulters who contribute to contamination of rivers, creeks and other waterways affecting various life-forms. These laws encompass mercury use, mine reclamation, mine effluents, contingency planning, mine waste and tailings management. The statutes set out by the legislation include compliance with a number of practices, failure of which may result in penalties. In particular, the law strictly prohibits:

- The use of mercury during primary stages of mining operations such as in sluice boxes, hammer mills or ball mills;

[48] Information sourced from Bynoe, P. and Bynoe, M. (2006) Report on An appraisal of the Environmental Impact Assessment Process and Procedures, as well as the Permitting Systems in Guyana.

- The discharge of amalgamation tailings (black sand or fluids which contain mercury) into water bodies;
- The discharge of fluids in excess of 30 nephelometric turbidity units NTU or 100 total suspended solids (TSS);
- The burning of amalgam in open air; and
- Settling ponds less than 20 metres away from rivers or other waterways.

The law also seeks to ensure that:

- All miners submit an environmental impact assessment and an environmental management plan outlining measures to be undertaken to ensure environmental compliance;
- Waste dumps are away from surface waters;
- Sites are restored following the completion of mining activities. This includes (i) ensuring that mine sites are chemically hazard-free (ii) reclamation plan must be completed prior to commencement of mining (iii) site must be restored to visually reproductive state (iv) and mine titles must be relinquished once all requirements are met;
- Emergency-accident response mechanisms are established in the event of tailing dam failures, chemical spills and other possible eventualities; and
- Environmental monitoring is done to ensure compliance with legislations. In the event that chemical limits are exceeded, all operations must cease until restoration has been completed.

Moreover, the Mining (Amendment) Regulations 2005, Part XXVII Protected Areas, has stipulations for mining activities near parks or protected areas.

Another important initiative of the Guyana Geology & Mines Commission (GGMC) is the EPA-GGMC Draft Code of Practice for Sand and Loam Mining, which requires, among other things, an environmental authorization from the EPA prior to being granted medium-scale mining permits or large-scale mining licenses from the GGMC. While the Draft Code of Practice calls for a buffer zone, the unit of land licensed to many operators is insufficient for realizing such a goal. Operational issues addressed include environmental management measures and progressive reclamation or closure.

East Demerara Water Conservancy Act

The East Demerara Water Conservancy Act (1998) has established the East Demerara Conservancy for the purpose of making better provision for the supply of water, and to provide for the management of the Conservancy through the establishment of a Board of Commissioners. Importantly, the Board has established under this Act controls the surface water supplied to the Georgetown Municipality and many Coastal NDCs.

PLANS

Over the years, the Government of Guyana (GoG) has developed a number of plans and programmes to manage its environmental resources, inclusive of water and key plans with considerations for water management are elaborated below:

Integrated Coastal Zone Management Plan

The Integrated Coastal Zone Management Plan (2000) aims at fostering a more coordinated and integrated approach to management of the coastal zone. One of the key objectives of the Plan is to promote and support sustainable development of coastal resources. Associated actions include installation of automatic and telemeter equipment at weather stations, purchase of equipment for upgrade of weather stations, purchase and installation of a tide gauge, computerization of data for surface and groundwater hydrology, and development and implementation of a programme for collection of data for a water balance study of groundwater aquifers.

To date, many of the actions identified to address the issues regarding water resources under the ICZM have not been implemented due to serious capacity constraints, particularly financial and human resources. The lack of implementation is further exacerbated by a lack of integration of programmes that collectively seek to address water resources in Guyana.

National Forest Policy and Plan

National Forest Policy and Plan (1997, 2000 and 2011), which is essentially a five-year strategy for the forestry sector. The overall objective of the National Forest Policy is to promote conservation, protection, management and utilization of the nation's forest resources, while ensuring that the productive capacity of the forests is maintained or enhanced. Thus, the Plan promotes sustainable use and management of Biological Diversity in the forestry sector and therefore proposes a range of activities land use, forest management, research and information, forestry training and education, and forest administration and governance. More importantly, the National Action Plan for Combating Land Degradation (2006) identifies as one of its key objectives the protection and rehabilitation of watersheds given the fact that the country's forests purify the nation's water supplies and ensure environmental stability.

The National Action Plan for Combating Land Degradation (2006)

The National Action Plan for Combating Land Degradation (2006) basically seeks to build upon and integrate other initiatives in an effort to realise the objective of sustainable land management. The prescriptive elements of the Plan include the need for: (i) rational planning and management of land resources; (ii) harmonization and rationalization of legislation to remove overlaps, and promote effective coordination, information exchange and institutional synergies;(iii) sustainable management of drainage basins and watersheds; and (iv) Early Warning Systems and Emergency Plans to mitigate drought, floods and other natural disasters.

Guyana Climate Change Action Plan[49]

Guyana Climate Change Action Plan outlines strategic measures to be taken to respond to the threat of climate change on water resources. These water conservation measures are expressed metering, the use of time-runs where the water supply may be staggered according to regions or sectors in the domestic/industrial sector; cautious development of new artesian wells in the interior regions for anticipated population migration from the coast; introduction of efficient control and management practice for water reservoirs network, especially that for agriculture use; and introduction of scientific monitoring and management of irrigation and drainage systems.

Additionally, the GoG is currently in the process of planning to map the aquifers in the Administrative Region 9 and to collect hydrological data for the Region to better prepare and plan for the drought-like conditions experienced by the Region during 2015-2016[50].

INTERNATIONAL OBLIGATIONS

In addition to the national policies, strategies and action plans, plus legislation, Guyana is signatory to a number of international laws, protocols, agreements and declarations that place obligations on the government to manage water and land based resources.

These are identified as:

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[49] For more information see http://www.hydromet.gov.gy/documents/Guyana_Climate_Change_Action_Plan.pdf
[50] Ministry of Communities, May 2016.

(a) United Nations Framework on Climate Change (UNFCCC).

(b) Kyoto Protocol (and its successor).

(c) Convention on Biological Diversity.

(d) United Nations Convention to Combat Desertification.

(e) United Nations Law of the Sea Convention.

(f) International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).

(g) Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region.

(h) Protocols to the Cartagena Convention SPAW LBS Oil Spills.

(i) Convention for the Control of Transboundary Movements of Hazardous Wastes.

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CHAPTER 6

Biodiversity

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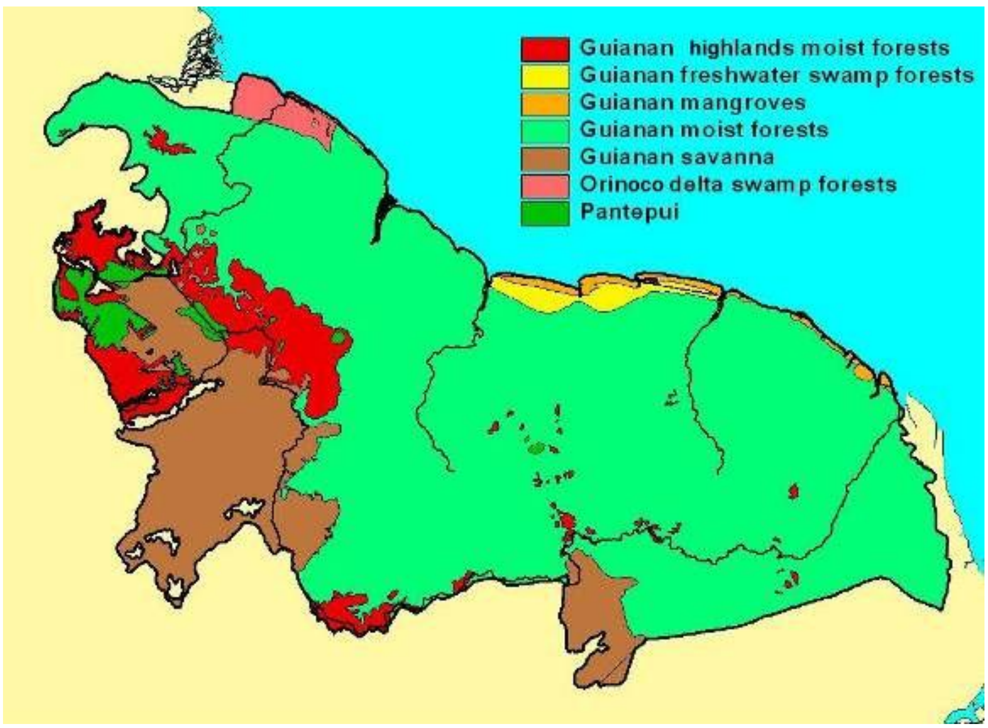
INTRODUCTION

Guyana's borders span two of the world's most biodiversity rich zones: the Amazon region and the Guiana Shield, an ancient granitic dome that protrudes from the lowland basin and separates the Orinoco and Amazon watersheds. WWF-Guianas identified five terrestrial and four freshwater ecoregions in Guyana. Two ecoregions must be added to these: Guyana's portion of the Guianan mangroves has been significantly restored over the last decade; and, the Atlantic Ocean marine ecoregion that is part of the North Brazil Shelf Large Marine Ecosystem.

Figure 6.1: Terrestrial Ecoregions of the Guiana Shield. *Source WWF-Guianas (2007)*



Guyana's land cover is more than 80% forest and the largest terrestrial ecoregion is the Guianan Moist Forest. This ecoregion is species rich with some local and regional endemism. It is viewed as a convergence zone for speciation as it comprises species from other regions such as the Orinoco Basin.

The Guianan Highland Moist Forest Ecoregion is the second largest ecoregion in Guyana and is found near the western and southern borders at elevation ranges between 500 to 1500 m above sea level. Biodiversity is high in this ecoregion with significant endemicity across a wide range of taxa.

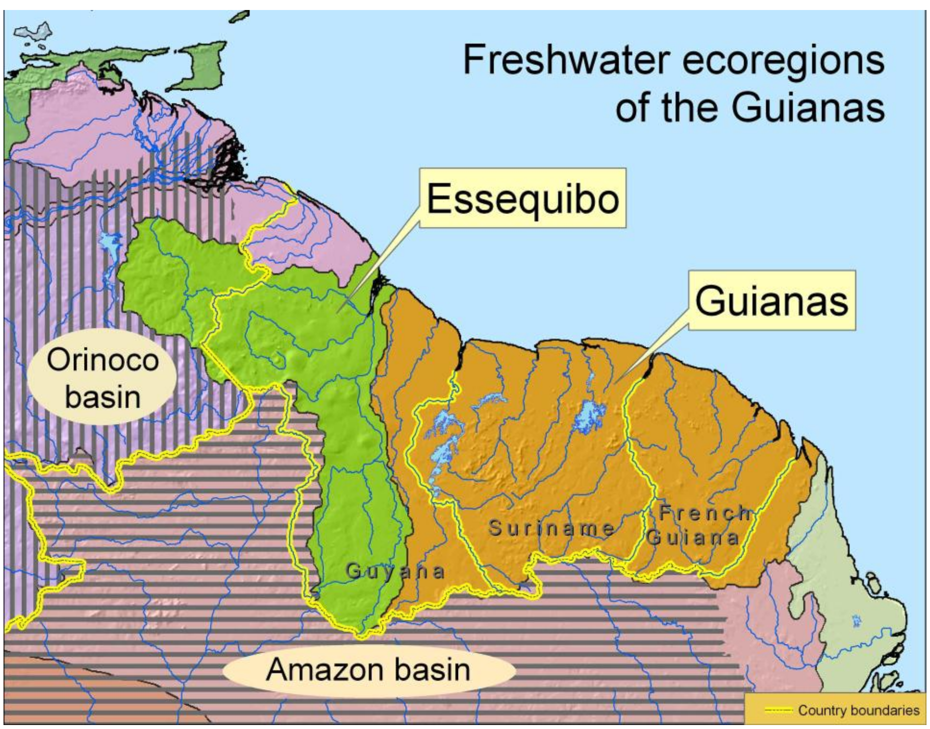
The Pantepuis Ecoregion is found between 1000 and 3000 m above sea level and is characterised by the flat or tabletop mountains. Biodiversity in this ecoregion is relatively low but endemicity is significantly high with thirty-three per cent endemicity among vascular plants.

The Orinoco Delta Swamp Forest is located to the north western portion of the country and is characterised by the inundated forest of moderate diversity with a number of species endemic to the region. This ecoregion forms part of what is considered to be one of the largest intact wetlands areas on the planet.

The Guianan Mangroves Ecoregion is found in the intertidal zones and is characterised by a dominance of mangrove species. Diversity is relatively low and there is little endemicity in this ecoregion but a significant range of species, some of significant commercial value, utilise these areas as breeding and/or nursery grounds.

The singular non-forest terrestrial ecoregion in Guyana is the Guianan Savannah Ecoregion which lies to the southwest of the country and spans lands associated with both the Amazon and Essequibo Basins. The savannahs are grass and shrub-lands of moderate diversity and low endemism.

Figure 6.2: Freshwater Ecoregions of the Guiana Shield. *Source WWF-Guianas (2007)*



The Essequibo Basin Ecoregion is the largest freshwater ecoregion in Guyana with headwaters in all highland regions and the Rupununi Savannah. Considering hydrology and biodiversity, the Essequibo may be roughly broken into several sub-regions: the upper-Essequibo draining from the southern highlands to above the Rupununi River; the Rupununi River; the Middle Mid-Essequibo from the Rupununi to the confluence with the Cuyuni-Mazaruni; the Cuyuni-Mazaruni Rivers; and, the Lower Essequibo below the confluence with the Cuyuni-Mazaruni.

The Amazon Basin extends significantly into the western side of Guyana both in the areas of the Highlands and the Guianan Savannahs.

The Orinoco Delta is a mix of fresh and brackish water streams in an interconnected network. These streams are completely isolated from any other basin in Guyana and are likely to have at least one species of fish that is locally endemic.

The remainder of the freshwaters of Guyana is a small portion of the Guianas Ecoregion and covers all drainage basins from the Demerara going east.

The marine ecoregion of Guyana is part of the North Brazil Shelf Large Marine Ecosystem. Guyana's territory extends just over nineteen kilometres from the shore, with its Exclusive Economic Zone extending to three hundred and twenty kilometres. The continental shelf extends on average 113km from the shore line with the narrower areas being west of the Essequibo River. Moving outwards from the land, the sediments on the shelf changes from soft mud to mud, and then to a sandy mud, followed by sand and finally corals. Water colour also changes from brown near the shore to green mostly above the sand and then to blue above the corals. The continental slope begins at approximately 100m depth. The fish and crustacean diversity in the region is of significant economic value and some face significant pressures by this. Some globally endangered species have been encountered in this region in recent years.

Guyana has high species diversity which is supported by the diversity of ecoregions, ecosystems within those regions, habitats within those systems, the high primary productivity in the neotropics and interconnections between the Amazon and Guianan systems. The diversity of species in the broad taxonomic groups are documented in the Table 6.1 below.

Table 6.1: Species diversity by Taxonomic Groups.

Taxon	Approximate number of species	Source
Plants	8000	EPA (2010)
Fungi	1200	EPA (2010)
Algae	44	EPA (2010)
Mammals	224[51]	Hollowwell and Reynolds (2005)
Birds	815[52]	Braun et al (2007)
Reptiles	179	EPA (2010)
Amphibians	130	EPA (2010)
Fishes	922	Personal conversation with Elford Liverpool based on ongoing research.

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[51] Hollowell and Reynolds (2005) reports 222 species. *Physeter microcephalus* (Sperm whale) and *Kogia breviceps* (Pigmy Sperm Whale) were observed in Guyana's Atlantic waters in December 2014 and January 2015 respectively.

[52] Braun et al reports 814 species. A *Rissa tridactyla* (Blacked legged kittiwake) was observed on the Guyana coast after this publication was issued

Arthropods	1673	EPA (2010)
Other Invertebrates	30	EPA (2010)

PRESSURES ON ECOSYSTEMS

OVERHARVESTING

MARINE

The marine ecosystem is among the least studied and therefore data on overharvesting is limited. The main biodiversity components harvested from the ocean are fish and crustacean and these harvests are not well monitored. Data from various assessments (CRFM, 2009; CRFM, 2007; CRFM, 2006; CRFM, 2004; FAO, 2005) at the national and regional levels indicate that most of the assessed species were fully or over exploited, or data was insufficient for conclusions to be drawn.The harvest of juveniles of many target species as target or by-catch is of particular concern as it significantly impacts the recovery of the stocks.

TERRESTRIAL

Whereas there are some assertions of overharvesting of terrestrial biodiversity (EPA, 2010), empirical evidence is lacking. The major offtakes are for the wildlife and bush meat trades. While the international trade in wildlife is well regulated, there are no systems in place to monitor harvest at the source and losses along the chain of custody. Nonetheless, there is no evidence that species in the trade have required significantly increased efforts to make quotas for export. Rather, the harvest of many species has been regulated by demand.

Hunting is completely unregulated in Guyana at this point. Species targeted by hunters therefore face significant pressures and those that are heavily selected for and also have a low fecundity, e.g. Powis and Tapir, are under the greatest threat.

FRESH WATER

Harvest of fresh water species is completely unregulated with the exception of the Arapaima (*Arapaima gigas*). This species had been significantly affected by overharvesting because of the quality of the meat until the Communities of the North Rupununi determined that they will work towards its recovery and the Arapaima Management Plan was approved in 2002. Other food fishes such as the Haimara (*Hoplias aimara*), Pacu (*Myleus pacu*), Lukanani or Peacock Bass (*Cichla spp.*), Arowanas (Osteoglossum bichirossum), and tiger fish (*Pseudoplatystoma fasciatum*) have all faced significant harvesting pressures in the Rupununi and areas accessed for mining in particular. In the south Rupununi the increased harvesting pressures result from increased demand, accessibility and harvesting effectiveness (Bernard, 2011). Whereas the international trade in some species in the demand by aquarists is regulated, there is not regulation of harvest or local trade.

DEFORESTATION

Guyana is classed as a High Forest cover, Low Deforestation (HFLD) country (>80% forest cover; <0.1% annual deforestation) and has a robust regulatory system for the harvest of products from state forest. Gold mining has long been the main driver of deforestation largely because Guyana's mining efforts are led by medium and small-scale operators whose operations require clear cutting of forest and who are never made to practice land reclamation/restoration. As a result, large tracts of land are laid bare and habitats for a wide range of species are lost. Riparian areas and areas along major forest trails are especially impacted by mining and human settlement.

Coastal forest which were home to predators like the Harpy Eagle (*Harpia harpyja*) have long been removed. Mangrove forest which were affected along with the rest of the coastal forest are now in recover due to a managed reforestation programme. (Refer to Chapter 4 for more detail.)

HABITAT LOSS AND/OR FRAGMENTATION

MARINE

The lack of empirical data from this region is the greatest obstacle to our understanding of the levels of habitat loss and fragmentation. Industrial trawling, especially will the use of sledges, is believed to be causing significant damaged to the benthic zone of the ocean and thereby destroying habitat critical to ecosystem stability.

TERRESTRIAL

Habitat loss and fragmentation is largely driven by mining, transportation and agricultural expansion. Much of the coastal forests of Guyana were lost hundreds of years ago when the land was first settled by Europeans and agriculture became the main economic activity. In the last half century, there has not been any significant change to the coastal forest systems for agricultural purposes and much of the most recent housing development has been on lands previously transformed for agriculture. Agricultural expansion into the savannahs to establish large-scale farms is however very recent and is beginning to transform the ecosystems there. Plans for the development of soya bean plantations indicate sustained pressures into the near future.

Mining with the associated loss of forest cover has resulted in significant habitat loss and fragmentation in ecoregions such as the Guianan Highland Moist Forest. Mining has removed natural corridors and isolated patches of habitats. There is significant history of this in both gold and bauxite mining operations, but sand and rock mining also contribute to this in some areas. An assessment of the abandoned mines in

Linden powerfully illustrates how the bauxite mining operations which had contributed significantly to the economy in the past, directly impacted terrestrial habitats, both during and after mining.

Expanding interior road networks and increased traffic volumes on these roads, both driven largely by the extractive sectors, are likely having untold negative impacts in previously intact habitats. Data from the Guyana Forestry Commission and Guyana Geology & Mines Commission show increased mining and forestry operations but there is inadequate monitoring to provide data to substantiate the impacts. Refer to Chapter 4 for more detail.

FRESH WATER

Habitat loss in freshwater systems is largely associated with river mining operations in the Mid-Essequibo and Cuyuni-Mazaruni sub-regions of the Essequibo Basin and parts of the Berbice River Basin and the Orinoco Delta in the north western portion of the country. The main habitat loss is the benthic zones because the material is removed, processed and stockpiled in areas other than where originally moved from. In the process the pelagic zone is degraded significantly also. Similar impacts are seen where sedimentation occurs, as a result of water with high levels of suspended solids being discharged from mining areas. Sediments in such cases, blanket the benthic zone and destroy the habitats.

FOREST & SAVANNAH FIRES

Uncontrolled fires cause significant habitat loss where they occur. Forest fires are uncommon in much of the country except in the secondary forest on the white sands and forest with heavy leaf litter. Savannah fires are more frequent during the dry periods and could be sparked by multiple sources of ignition.

There is a general misrepresentation that the slash and burn agriculture practiced by Amerindian communities is largely responsible for habitat loss by fire. This is true only in the sense that it's a potential source of ignition. Slash and burn is a traditional technique used in land preparation for small-scale farms. It is never applied to large-scale farms and is done in such a way that the burning is contained to the desired area (Rodriguez, 2011).

POLLUTION

Pollution in all forms relevant to human activities in Guyana places significant pressures on ecosystems and species. Primary data is however missing for much of the ecosystems because of the lack of effective monitoring. Without comprehensive monitoring of pollution in ecosystems, unacceptable levels of pollution cannot be identified and addressed before they become crises.

MARINE

The Atlantic Ocean serves as a source of food from fisheries and as a medium for transportation of people and goods within Guyana and internationally. Additionally, it receives discharges from land-based activities directly (discharge of sewage from coastal communities) and indirectly (material suspended or dissolved in river waters flowing to the ocean). There is no sewage treatment in any location in Guyana and at multiple locations, including points in Georgetown, raw sewage is pumped directly into the ocean (See Chapter 3 for more details). Sewage in aquatic ecosystems is known to cause eutrophication and hypoxia, introduces hormones and antibiotics to the ecosystems and changes the community dynamic.

Land-based sources of pollution are also significant but not quantified. The population centres are almost exclusively coastal and there is no sewage treatment. Raw sewage is pumped into the ocean at several locations via canals and from trucks which clear septic tanks of homes and businesses. Poor solid waste management practices place a significant volume of solid material into the ocean (see Chapter 2 for greater details). These wash up at various beaches including areas in Georgetown. Whereas sediments and heavy metals from mining in the upper reaches of major rivers may not make it to the ocean at significant concentrations, runoff from coastal agriculture likely makes it to the ocean carrying agricultural chemicals.The precise impact of all these on the biodiversity in Guyana has not been studied to-date.

FRESH WATER

Pollution in freshwater systems on the coast, including the network of manmade canals, is mainly from improper solid waste disposal, domestic and industrial effluents and agricultural runoff. Solid waste dumped directly or washed into waterways from the surface, litter the bed of water bodies blocking light, obstructing normal ecological functions and releasing harmful chemicals as they break down (Huang et al, 2014; Alam and Ahmade, 2013; Nartey, Hayford and Ametsi). Organic and inorganic effluents and runoff transform ecosystems, causing eutrophication and poisoning the food chain (Anderson, D. *et al* (2002) - see Chapter 3 on waste management for additional information.

In interior locations, freshwaters are generally polluted by sediments and mercury from small and medium-scale mining (Lowe, 2006). Small and medium-scale mining operations on land, generally discharge tailings in or near water courses. River mining operations destroy the benthic habitats and discharge sediment laden effluent directly into rivers. Sediments also flow into waterways from eroding bare ground mainly near roads. The sediments degrade the quality of the ecosystem by reducing light penetration and visibility through the water. This reduces primary productivity, food availability for a range of species and vision in the water (Mol and Ouboter, 2004). Consequently, species migrate from the polluted habitats or are eliminated from the system.

Mercury released into the aquatic systems from gold mining on land and water enters the food chain in its elemental form and as methylated mercury where the biological and physical conditions exist. Mercury bio-accumulates and is biomagnified in food chains and this has been well documented in aquatic food chains in Guyana. Research by various groups have repeatedly confirmed that in rivers polluted by gold mining, fish at lower levels of the food chain have lower concentrations of mercury in their muscles than those higher up (Miller et al. 2003; Alofs, et al. 2014; Legg *et al* 2015).

On August 19, 1995, a break in the tailings pond dam at Omai Gold Mines in the Middle Essequibo resulted in over four hundred million gallons of cyanide laced waste flowing into the Omai River then to the Essequibo River. This killed almost all animal life in the Omai River in the vicinity of the point of impact, downstream to the Essequibo, and likely killed a significant number of organisms at the confluence of the Omai and Essequibo rivers. The carcasses of dead fish were carried by the strong currents of the Essequibo for several miles downstream and likely had secondary impacts on the ecosystem along the way. Studies of the Omai and Essequibo rivers in 1998 and 2003 found that the Essequibo showed signs of being fully recovered while the Omai was recovering (Da Silva, P. 1998; Bernard, C. 2003).

CLIMATE CHANGE AND VARIABILITY

Climate change in Guyana has been observed in increased temperatures, varying weather patterns, extreme drought and extreme flooding; refer to Chapter 2 for additional details. The effects of increased temperatures on biodiversity are not documented. Within the last decade, unseasonal rains resulted in a rapid rise in the water levels in the Rewa River causing it to overflow its banks and flood into seasonal ponds. Many fish followed in preparation for spawning but the rains were short-lived and waters swiftly receded. This did not provide the fish with enough time to reproduce and move back to the main channel (Bernard, 2011). Consequently, a significant number of fish died in drying ponds. At the University of Guyana's Turkeyen campus, a similar event of out of season rains caused flooding of the grounds and resulted in the death of thousands of subterranean larva of an unidentified beetle species[53]. Recent extreme droughts have placed significant pressures on biodiversity in usually wet areas. Recent droughts from 2015 to 2016, caused drying in the ponds and lakes in the Rupununi such that it endangered the lives of a number of Arapaima, a species under protection in Guyana because of low populations and high human demands. On two separate occasions, over fifty individual Arapaimas had to be rescued from drying ponds and placed into larger

[53] Based on Coordinating author's personal interaction.

bodies of water. The impacts of extreme flooding events such as the 2005 flood on the coast, is not as well documented in ecosystems not heavily impacted by humans. The 2005 flood however, had significant impacts on agricultural biodiversity and on coastal species that were either displaced from their habitat, or drowned (ECLAC, 2005).

INVASIVE SPECIES

The EPA's Invasive Alien Species Assessment Report (2011), reported thirty one (31) species as listed on the Global Invasive Species Database. An assessment of the same database in 2016, found twenty one (21) alien invasive species as being present in Guyana. Seventeen (17) of these occur in terrestrial systems and four (4) in freshwater systems. Six (6) are plants and fifteen (15) are animals: four insects, one non-insect invertebrate, four fish, three reptiles, one bird and one mammal.

The precise impacts of these species are not well understood as there has been no focused study on invasiveness of species in Guyana. The EPA highlighted four (4) species in Guyana as being among the one hundred (100) most invasive species in the world. Analysis of stakeholder interviews conducted by the EPA identified three plants - antelope grass (*Echinochloa pyramidalis*), water hyacinth (*Eichhornia crassipes*) and wattle (*Acacia mangium*) – and four animals - rock pigeon (*Columba livia*), the small Asian mongoose (*Herpestes javanicus*), the red-eared slider (*Trachemys scripta elegans*), and Johnstone's whistling frog (*Eleutherodactylus johnstonei*) - as the invasive alien species of concern in Guyana (EPA, 2011).

Among the invasive fish is the Tilapia (*Oreochromis mossambicus*) from Africa which was introduced for fish farming on the coast. Though this species is known to be highly invasive in some territories and though it has been introduced to Guyana for more than fifty years with no significant control mechanisms in place, it has not invaded natural waters. The species in known to be found in manmade and at times highly polluted canals on the coast where they thrive.

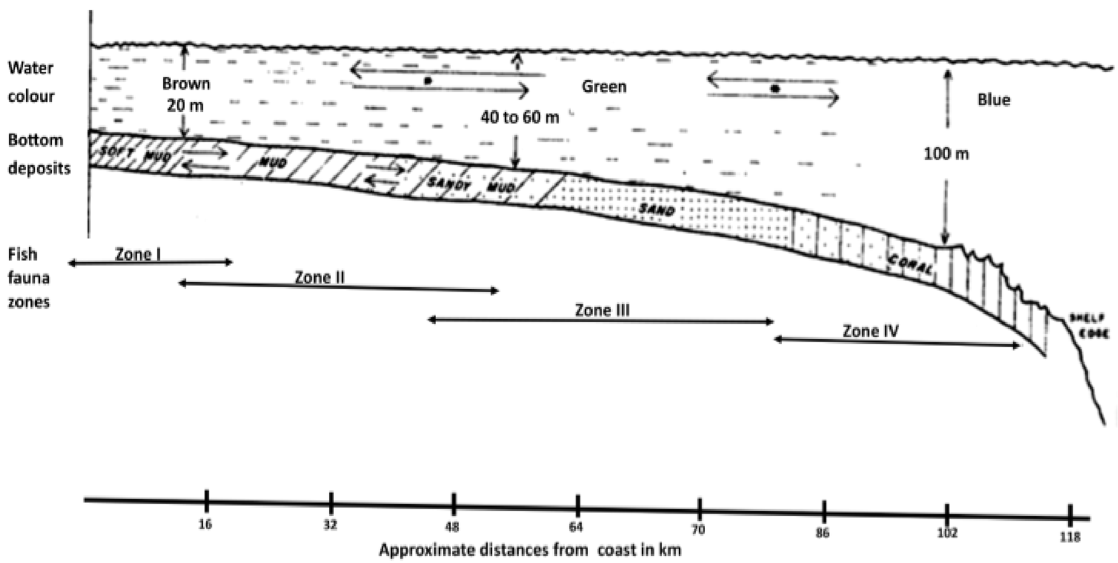
STATE OF ECOSYSTEMS

Guyana's ecosystems are largely intact and functional, with a very low rate of destruction/degradation and conversion. The WWF-Guianas ecoregions of the Guiana Shield report of 2007 provided a useful approach to considering the state of ecosystems which is fully utilised here. They have identified broad zones referred to as ecoregions which consist of multiple ecosystems. WWF has utilised the definition of an ecoregion offered by Dinerstein et al (2000) which states that *"an ecoregion is a relatively large unit of land or water that contains a distinct assemblage of natural communities sharing a large majority of species, dynamics, and environmental conditions"* (WWF, 2007). This approach is applicable here because it allows for the consideration of the state ecosystems at a level that is pragmatic.

MARINE

The marine ecoregion is one of the least studied and is influenced by the outflow of sediments from the Amazon. While fauna diversity has received some attention, there is very little information available on the flora in the marine environment.

Figure 6.3: Illustrates section through Guyana's continental shelf showing faunal and physical zones of the region. Not to scale and only for one season (arrows indicate movements during seasons). *Modified from illustration published in Lowe-McConnell (1962).*



Rosemary Lowe-McConnell surveyed the marine environment over Guyana's continental shelf between 1957 and 1959 with an emphasis on demersal fishes. She also documented the invertebrate species encountered. The study identified four overlapping fish faunal zones characterized by bottom substrate, water quality and water depth. Two hundred and thirteen (213) fish species from seventy two (72) families were documented. Sciaenidae, Carangidae and Pomadasyidae were the most diverse families.

The most abundant species were *Micropogon furnieri* (croaker), *Macrodon ancylodon* (bangemary) and *Cynoscion virescens* (seatrout) which were found closer to shore along with *Dasyatis guttata* (Long-nose stingray) and *Urotrygon microphthalmum* (Smalleyed round stingray), *Narcine brasiliensis* (electric ray), *Narcine brasiliensis* and *Diplobatis pictus* (electric rays).

Several species of invertebrates were documented in zones close to shore including *Eunice antennata* and *Onuphis magna* (polychaetes), *Sipuncules multisulcatus* (sipunculids), *Renilla reniformis* (sea pansies), *Tropiometra carinata* (featherstars); *Astropecten marginatus*, *Luidia clathrata* and *L. aternata* (starfish species) and shrimp species: *Penaeus aztecus*, *P. schmiti*, *P. brasiliensis*, *P. setiferus* and *Xiphopenaeus brasiliensis*.

The deeper waters were dominated by carangidaes including *Vomer setapininis*, *Chloroscombrus chrysurus*, *Hemicaranx amblyrhynchus*. *Lutjanus aya* (red snapper), *Coryphaena hippurus* (dolphin), *Holocentrus ascensionis*, *Upeneis masculatus* and *U. pavus* (red mullet), *Carcharhinus acronotus* (blacknose shark) and *Rhinobatos percellens* (guitarfish) were found just before the edge of the continental shelf. *Scyllarides aequinoctialis* (squat lobster), *Stomolophus meleagris* (jelly fish) and several species of crab including *Portunus spinicarpus*, *P. spinimanus*, *Callinectus ornatus*, *Lupella forceps*, *Hepatus sp*, *Dromia erythropus* were also found in deeper waters.

Also known to inhabit the Atlantic of Guyana are four species of marine turtles - *Lepidochelys olivacea* (Olive Ridley), *Chelonia mydas* (Green Turtle), *Eretmochelys imbricata* (Hawksbill) and *Dermochelys coriacea* (Leatherback). These species are known to nest in on the beaches at the Shell Beach Protected Area.

Twenty seven (27) species of birds in Guyana are known from the marine environment. Among these are the shearwaters, storm-petrels, Brown Pelican (*Pelecanus occidentalis*), Brown Booby (*Sula leucogaster*), Magnificent Frigate (*Fregata magnificens*), Osprey (*Pandion haliaetus*), Skuas, Gulls, Terns, Black Skimmer (*Rynchops niger*) and Greater Flamingo (*Phoenicopterus ruber*).

Guyana's marine mammals are not well studied. The West Indian Manatee (*Trichechus manatus*) is known to venture into the Atlantic Ocean from time to time. In recent times, two (2) species of whales have been observed in Guyana's waters. A male *Physeter macrocephalus* (Sperm Whale) was observed in December of 2014 and a male *Kogia breviceps* (Pygmy Sperm Whale) was observed in January 2015. Unfortunately, both whales were entangled in fishing gear and met their demise as a result.

All of the regulated fisheries in Guyana takes place in the marine environment and this has placed significant strain on the biodiversity and the habitats. Several species face significant pressure from over harvesting and other are affected by the impacts of the fishing activity on the habitat. The full impacts of all the pressures on the marine ecosystem is not known and the therefore the true state of the environment is not known. In so far as the ocean continues to be productive and support the livelihoods dependent on it, it could be determined to be at least in fair state.

TERRESTRIAL

Guyana's terrestrial ecosystems are divided into six (6) ecoregions; five (5) forest types and one (1) savannah type. Despite some significant pressures exerted on these ecosystems, they are largely intact and functional.

GUIANAN MOIST FOREST

The Guianan Moist Forest in Guyana covers 30% of the ecoregion type in the Guiana Shield. It is a part of the Tropical and Subtropical Broadleaf Forest Biome. The ecosystems are mainly lowland forest of varying kinds which are characterised by soil types (e.g., Dakama forest on white sands), species dominance (e.g., Mora forest) and flooding regime (e.g., Low evergreen seasonally flooded forest and riparian forest). This ecoregion also includes areas of grassy savannahs generally referred to as Guyana's intermediate savannahs. Coastal forests across most of the country were cleared centuries ago for settlement and agriculture. This region therefore includes a significant portion of the agricultural biodiversity of Guyana. The soils are mainly such as kanhapludults, kandiustoxs and quartzipsamments.

This ecoregion contains much of Guyana's species diversity. Whereas the entire ecoregion has not been studied, data available indicates that some of the country's diversity centres are within this ecoregion. Of the species known from Guyana: the Iwokrama Reserve (1.7% of Guyana's area) is home to approximately 20% of the plant, 50% of fish, 45% of amphibians, 45% of reptiles, 60% of birds and 60% of mammals; the Kanuku Mountains (2.8% of Guyana's area) is home to 20% of the plant, 15% of fish, 15% of amphibians, 15% of reptiles, 50% of birds and 70% of mammals; and, the Kaieteur Park (0.3% of Guyana's area) is home to 15% of the plant, 20% of fish, 40% of amphibians, 35% of reptiles, 25% of birds and 25% of mammals. That diversity includes a range of endemic species of flora and fauna. It also includes a range of endangered or threatened species such as the Jaguar (*Panthera onca*), Harpy Eagle (*Harpia harpyja*) and Sun Parakeet (*Aratinga solstitialis*).

Six of eight of Guyana's proposed or established protected areas, including the Iwokrama Reserve, are located wholly or partially (in a significant way) in this ecoregion. These afford significant protection to the wide range of critical species and habitats found there.

Much of Guyana's population and economic activity is based in this ecoregion: Agriculture on the coastal plain and intermediate savannahs; gold and diamond mining in the foot hills of the Pakaraima and Acarai mountain ranges; bauxite mining on the white sands; forestry distributed in various zones; and, ecotourism a various locations. These have brought significant pressures on the ecoregion. In contrast with the exception of the areas that were cleared during early settlement to facilitate housing and agriculture and the areas under gold mining ecoregion, the ecosystems are intact and fully functional.

Deforestation is highest in this ecoregion but still negligible on the larger scale. Genetic diversity has been and continues to be degraded, but no species has been documented as lost to date from this region. The Harpy Eagle (*Harpia harpyja*) represents a good case of loss of range which diminishes genetic diversity. Early records of the species place it in coastal forest where the silk cotton tree (its nesting tree) was common. Today, the species is restricted to area under protection in the Iwokrama Reserve and the Kanuku Mountains.

Box 6.1 - Butterfly biodiversity of the Iwokrama forest and Norht Rupununi

A total of 4699 butterflies were caught using hand-netting and fruit-baited traps within the Iwokrama forest and North Rupununi District, June 2007-Aug 2008. These butterflies were surveyed in three habitat types i.e. savannah, forest and ecotone. Butterflies caught were subdivided into six families with the largest family being the Nymphalidae, followed by the Pieridae, Hesperiidae, Lycaenidae, Riodinidae and finally by the least populated group, the Papilionidae. These families were divided into approximately 200 species. Although all six butterfly families were found within all three study sites the distribution of butterfly families were affected by habitat that was defined by different floral compositions, season and altitude. One family which exhibited some degree of habitat preference was the Hesperiidae; 50.97% of all Hesperiids collected were found in the grass rich Savannahs. Additionally, 54% of Pieridae were found in the ecotone environment. These butterflies (Genera Phoebis, Aphrissa and Rhabdodryas) were observed migrating, as is their nature in large numbers through this habitat at certain times of the year. They were also observed "mud puddling" next to small bodies of water, possibly to obtain nutrients e.g. salts and nitrogenous compounds as a precursor for mating. In both the forest and the savannah, Pieridae and the Hesperiidae were found in greater abundance in the flat land, whereas Nymphalidae and Papilionidae were present in greater relative abundance on the sloping terrains, in both the forest and savannah. In the forest, more Lycaenids and Riodinids were found on the slope but more were found on the flat land in the savannah. Butterflies such as Lycaenidae, Nymphalidae and Papilionidae, were found in greater abundances in the wet season, and Hesperiidae, Pieridae, Riodinidae, were found in the dry season. It was noted that the occurrence of many of these butterfly groups was influenced by the availability and vegetative and reproductive phenologies of the flora (host and food plants).

GUIANAN HIGHLAND MOIST FORESTS

The Guianan Highland Moist Forests in Guyana covers approximately 60-70% of the ecoregion type in the Guiana Shield. It is part of the Tropical and Subtropical Moist Broadleaf Forests Biome differentiated from the Guianan Moist Forest principally by elevation. The region is located near the mid-western and southern borders of Guyana, and approaches the top of the Guiana Shield. Its topography of the region consists largely of steep inclines with few moderately flat regions. The Guianan Highland Moist Forest are dominated by montane and steep forests with some mixed forest at the lower elevations and patches of savannahs and swamp/marsh forest on predominantly udorthents soil. Swamp/marsh forests are especially significant in the southern highlands.

The diversity of flora in this ecoregion is high. The natural barriers of elevation, steep gradients and other physical parameters have resulted in isolation in some taxa which is a precursor for speciation which has led to a significant degree of endemicity in this ecoregion (ter Steege 2000). Whereas the faunal diversity is moderate, endemicity is also high for the reasons above.

There is no data available on areas wholly within this ecoregion to illustrate the diversity of life, however two areas that have been fairly well studied have significant portions in this ecoregion: the Konashen Community Owned Conservation Area (COCA) covers an area of 6,250 km2 (2.9% of Guyana) and the Roraima mountain and surrounding lands. The Konashen COCA spans Guianan Moist Forest and Guianan Highland Moist Forest and is home to approximately 40% of plants, 15% of fishes, 20% of amphibians, 20% of reptiles, 40% of birds and 10% of mammals known from Guyana. Additionally, over 200 species of ants, 73 species of katydids and 50 species of dung beetles are known from the area (there are no reliable national estimates on the groups). The Roraima area spans the same ecoregions as Konashen in addition to the Pantepuis. The Guianan Highland Moist Forest area of Roraima is home to approximately 49 herps (amphibians and reptiles combined), 251 birds and 31 species of mammals.

This ecoregion is not heavily populated and the settlements are all Amerindian communities with a few mining camps. Gold mining at the lower elevations places the greatest pressure on the ecosystems. As a whole, the ecoregion has largely intact and functional ecosystems with localized disturbances from mining.

PANTEPUIS

The Pantepuis in Guyana covers approximately 10-15% of this ecoregion type in the Guiana Shield. It is part of the Tropical and Subtropical Moist Broadleaf Forests Biome and represents the peaks of the mountains in the Guianan Highlands. In Guyana, the Pantepuis are exclusive to the mid-western region. The Ecoregion is characterized by isolated sandstone plateaus at the peaks of tabletop mountains. Huber (1997) identified four main vegetation formations in the Pantepuis, montane forest, tepui scrub, alpine meadows and open rock vegetation. GLSC (2013) places these into montane/steep forest and upland savannah. The dominant soils in this ecoregion are udorlhents and Endoaqualts.

Species diversity in this region is relatively low and but endemism is significantly high as the habitats are fairly extreme and require specific adaptations for survival. Across the Guiana Shield, approximately 33% of the vascular plants of this ecoregion are endemic.

For Mount Roraima the fishes in Guyana are not well studied. Amphibians and reptiles on the other hand have been fairly well documented and records show approximately nineteen (19) species in this ecoregion of which four (4) are endemic to the Guiana Shield. An estimated thirty-seven (37) species of birds are found in this region of Roraima, six (6) of which are endemic to the ecoregion and another five (5) are endemic to the Guianan Highlands but are also found in the Guianan Highland Moist Forests. Mammalian species diversity decreases with increased elevation at Roraima and only thirteen (13) species are found in the Pantepuis region. One (1) species is endemic to this region.

ORINOCO DELTA SWAMP FOREST

The Orinoco Delta Swamp Forest in Guyana covers approximately 55-60% of the ecoregion type in the Guiana Shield. It is part of the Tropical and Subtropical Moist Broadleaf Forests Biome. It is located in north eastern Guyana and is characterized by inundated forests on hydraquents and medihemists soils. The vegetation comprises coastal swamp/marsh forests and mangrove forests.

Species diversity in this ecoregion is moderate and includes a range of endangered and endemic species. The biodiversity of the entire region has not been assessed, however the Shell Beach Protected Area falls partly within this ecoregion and that area has been extensively studied. Also, a WWF study of wetlands provided insight in to the species diversity of more inland areas. Shell Beach accounts for approximately 0.57% of Guyana area and is home to approximately 15% of plants, 10% of amphibians, 15% of reptiles, 25% of birds and 10% of mammals found in Guyana. The swamp forests comprise diversity from both the Orinoco and Amazon River Basins. The area is abundant in palm trees (*Mauritia flexuosa* and *Euterpe oleraceae*) and has three species of mangroves. The ecoregion has the highest diversity of bird species in the country with over 200 species of coastal and migratory birds recorded including scarlet ibis (*Eudocimus ruder*), caribbean flamingo (*Pheonicopterus ruber*), harpy eagle (*Harpia harpyja*) and various species of parrots and macaws. Tapirs (*Tapirus terrestris*), deer (*Mazama americana*), jaguars (*Panthera onca*), howler monkeys (*Alouatta seniculus*) and other large mammals are also commonly found in the area. Shell Beach Protected Area, located on the northwest coast of Guyana, is the nesting ground for four species of endangered marine turtles: the Leatherback (*Demochelys coriacea*), Hawksbill (*Eretmochelys imbricata*), Olive Ridley (*Lepidochelys olivacea*) and Green Turtle (*Chelonia mydas*).

Oil exploration and extraction activities is the greatest threat to the region along with human population pressures and species exploitation. *Euterpe oleraceae* and *Mauritia flexuosa* are heavily exploited species.

GUIANAN MANGROVE FOREST

Guyana has very good representative stands of both riverine and coastal mangroves. Six (6) of the ten (10) Regional Administrative Districts in Guyana have an association with the coastline and each has various extents of coastal and riverine mangroves on hydraquents and kandustults soils. Often referred to as 'courida' by many coastal inhabitants, this was once a major vegetation type along much of Guyana's coast. Most of the literature recognizes three (3) major species of mangroves that occur in Guyana; the black mangrove (*Avicennia germinans*), the red mangrove (*Rhizophora mangle*), and the white mangrove (*Laguncalaria racemosa*). Research by Tom Holowell (2000) has suggested that the species *Rhizophora racemosa* occurs in the Barima-Waini region of the country. In addition, herbarium records show the possible existence of a fifth species, *Rhizophora harisonii*. However since the collection of this single specimen no further collection of this species has been recorded. It should also be noted, although there is no known recent verification based on herbarium or field observations, that 'The World's Mangroves 1980-2005' report that *Avecennia schaueriana* is also present in Guyana FAO (2007). Among the main mangrove associates present in the mangrove forests of Guyana are the buttonwood mangrove, *Conocarpus erectus* and the Nypa Palm, *Nypa fructicans*. Given the apparent uncertainty of the presence of some species of mangroves in Guyana, there is therefore a great need for further research to be done to confirm or ascertain the presence and determine the extent and distribution of these other mangrove species in Guyana.

Mangroves in Guyana occur in both mixed and monospecific stands. Most of the monospecific stands are of *Avicennia germinans* and such stands are found in many areas along the coast as mainly fringe type mangrove forests and basin type mangrove forests. There are mixed stands which are also found along the coastal and riverine areas. The dominant species in the mixed stands vary from location to location. Along the coast, the dominant species is *Avicennia germinans* and in some instances the dominant species is *Laguncularia racemosa*. In riverine areas the dominant species is usually *Rhizophora mangle*.

Mangroves currently run along approximately 290km of Guyana's 430km coast and line many of our rivers, refer to Figure 6.4. The current estimate of mangroves in Guyana is approximately 226Km^2 (22,632 hectares) (GMRP, 2012). The current extent of mangroves has shown a declining trend over the past years as is shown in the figure 6.5 below.

Figure 6.4: Distribution of Mangroves in Guyana. *Source: MNR, 2016*.

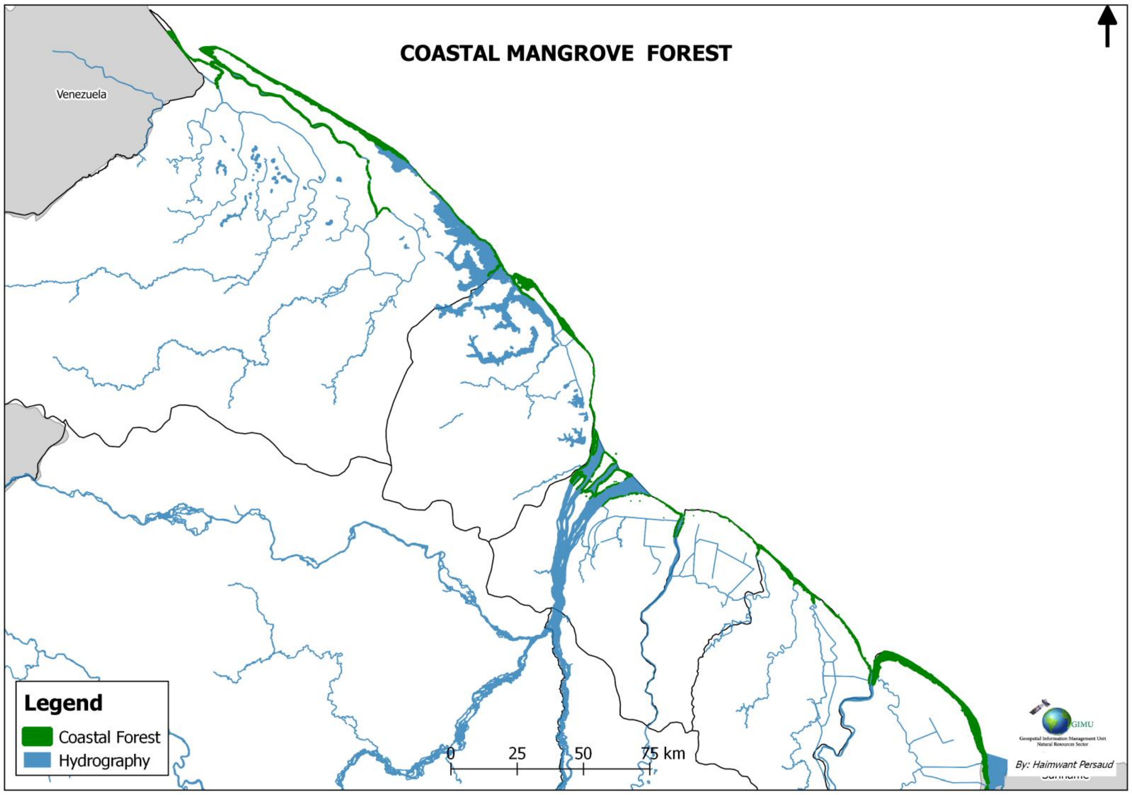
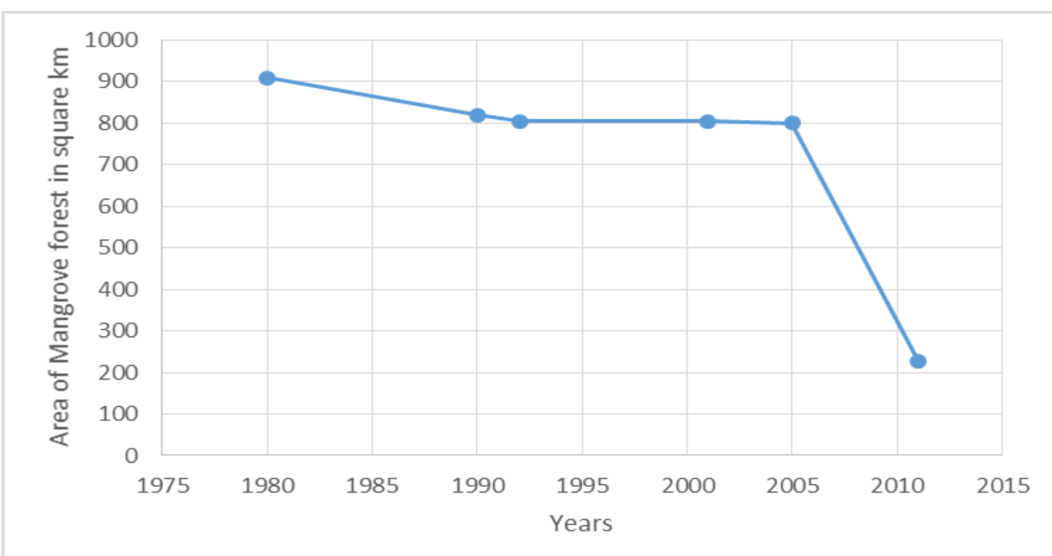


Figure 6.5: Trend in the area covered by Mangrove Forests in Guyana between 1980 and 2011. Data from GMRP.

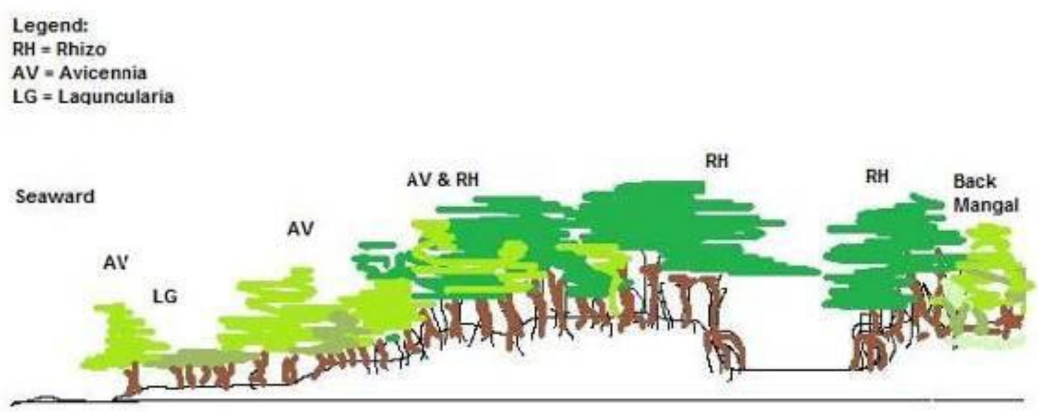


In recent decades, the mangrove belt has been severely depleted and the natural cycle of erosion and recovery is apparently at disequilibrium. Although the cycle mechanisms are poorly understood, it is generally assumed that heavy damage by humans, the loss of old groynes (constructed during colonial times but largely left to disintegrate since then), and increases in sea level and wave energy are the principal factors explaining the depletion. Whatever the cause, the protection of mangroves is a major concern (GoG, 2010a). Given the decline in the extent of mangroves in the country, their protection and conservation and the protection of the coast by mangroves have become a major concern for the Government of Guyana. Recognizing the need for a greater understanding and appreciation of the roles that mangrove ecosystems play, inclusive of economic contributions to livelihoods, coastal protection and biological and cultural diversity, their role in carbon sequestration, their efficiency in coastal protection, their biological and cultural diversity and their links with coastal fisheries, a conscious effort is being made to address concerns of threats to this ecosystem (GoG, 2010b). However, there are still instances of continued degradation and loss, transformation and conversion to other uses of this vital ecosystem due to varying levels of awareness and understanding, management and law enforcement.

With the inclusion by the Government of Guyana of climate change considerations in public policy, there has recently been enshrined in the Low-Carbon Development Strategy (2009), a central focus on forest conservation, inclusive of the protection of the mangrove belts along the coasts and estuaries. More specifically, the Sea and River Defence Policy calls for alternative solutions to traditional hard engineering options including the re-establishment of mangroves for effective flood defence and to protect environmental resources (NMMAP, 2010)

In Guyana, *Avicennia germinans* predominates along the seaward coastal areas whereas, *Laguncularia racemosa* decreases in dominance and presence on the seaward side but increases in dominance and abundance towards the landward side, see Figure 6.6. The presence of *Rhizophora mangle* is highest along riverine edges and declines as one proceeds toward inland areas and also along coastal seaward areas. Monospecific stands of *Avicennia germinans* are found along the seaward coast. As one moves inland, the progression changes to mixed stands of *Avicennia germinans* and *Laguncularia racemosa*. Riverine areas have mixed stands with *Rhizophora mangle* as the dominant species. The soil types found in this region are Hydraquents and Kandustults.

Figure 6.6: Zonation patterns and composition of mangrove forests in Guyana. *Source: NMMAP, 2010*.



GUIANAN SAVANNAH

The Guianan Savannah in Guyana covers approximately 15-20% of the ecoregion type in the Guiana Shield. It is part of the Tropical and Subtropical Grasslands, Savannas and Shrublands Biome. It is located in southeastern Guyana, in an area within the Roraima formation and characterized by extensive savannas and shrubs on predominantly ustchrepts, kanhaplustults and endoaquepts soils. There is low endemism.

The Rupununi Savannahs consist of mixed savannah and moist forest along with scattered mountains and fresh water river systems. The diverse ecosystems supports over 9000 species including over 2000 vertebrates and species considered endangered at the global scale. The South Rupununi Biodiversity Assessment Team documented 241 plant species (including 41 rainforest tree species), 139 species of water beetles, 150 species of ant, 302 species of birds, 34 species of reptiles, 25 species of amphibians (with 1 potentially new species), 36 species of bats, and various species of large mammals (including jaguar, tapir, giant armadillo, nine banded armadillo, giant anteater, white lipped peccary, red brocket deer, collared peccary).

The floodplain of the Rupununi River is inundated when the Amazon and Essequibo rivers and its tributaries overflow during the rainy season, resulting in an increase in the diversity of the aquatic species in the area. Important threats in this ecoregion are poor soil and fires.

AGROBIODIVERSITY

In general, agricultural biodiversity (agro-biodiversity)[54] is the result of interactions among genetic resources, the environment and the management systems and practices used by farmers developed through natural selection and human intervention. It encompasses a number of dimensions including genetic resources for food and agriculture (plant, animal and microbial and fungal genetic resources); ecosystem support services for agriculture (nutrient cycling, pest and disease regulation, pollination etc.); abiotic factors (climatic and chemical factors); socio-economic and cultural factors (traditional and local knowledge to maintain and manage systems and sustain livelihoods).

Guyana has made considerable efforts to develop the agriculture sector to maintain its national food security needs. Agriculture contributes approximately 20 per cent of Guyana's economy, 40 per cent export earnings and more than 33 per cent of employment (EPA, 2015). The agriculture economy is estimated to occupy approximately 1,740,000 hectares of land of which an estimated 200,000 hectares is specifically irrigated land (MoA, 2013) hosting a number of crops, inclusive of sugarcane, rice (traditional crops), non-traditional crops such as coconut, cassava, diverse orchard species, green vegetables, foraged botanicals and herbs (MoA, 2013; Paul, 2012). Crops of rice and sugarcane occupy 90,000 and 48,000 hectares, respectively, followed by non-traditional crops - 30,000 to 40,000 ha and showing upward trends and coconut - 25,000 hectares. Approximately 158,473 hectares of agricultural land are used for livestock (MoA, 2013; Paul, 2012).

There is a direct link between agriculture and food security and in turn the diversity of plants and animals used for food in the country and by extension the dependence of a large number of people on agricultural biodiversity for sustainable livelihood. Therefore, the stability of Guyana as a food secured nation is directly related to its tradition of sustainable use of plant and animal genetic resources for food and agriculture. Any threat to agriculture and its biodiversity therein, therefore, will result in a direct threat to lives and livelihoods. Safeguarding agricultural diversity (plant and animal genetic diversity) is not only critical for food security but also to sustain livelihoods.

[54] Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems (agro-ecosystems). In other words, it is the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels which are necessary to sustain key functions of the ago-ecosystem, its structure and processes (UNCBD, COP Decision V/5, appendix. www.cbd.int/agro).

AGRO-ECOSYSTEMS

The biodiversity associated with agricultural ecosystems is vital for plant stability and by extension sustaining crop production and livelihoods. The productivity of these ecosystems depends on a number of species such as soil micro-organisms, pollinators, predators of agricultural pests and the genetic diversity of crops and livestock. Agriculture ecosystems also serve as important habitats for a number of wild plants and animal species. Currently, very limited information exists, if at all, on agricultural ecosystems other than the genetic assessment of a number of species for crop and livestock production. Specifically, it was recorded that the Guyana Sugar Corporation (GUYSUCO) has a collection of invertebrate fauna found within the sugarcane agro-ecosystem, as well as, some rodents, and the Guyana Rice Development Board (GRDB) has limited documented evidence of the state of the invertebrate and avifauna encountered in the rice agro-ecosystem (EPA, 2009).

In particular, the understanding of pollinator species in agricultural ecosystems is limited to few export crops and non-crops and basic information of what species of insects, birds and small mammals for example, may be classified as pollinators. Studies to ascertain the economic value and the ecological importance of a number of local pollinator species, as far as, is known linking the yield of fruit crops with the population dynamics of pollinator species are yet to be conducted. Some limited assessments on bees have been conducted by NAREI although confined to the emerging honey-making business as a cottage industry. Additionally, the potential impact of environmental pollutants such as pesticides on economically important insect pollinator species may need some attention (EPA, 2009).

Information repositories have been developed by key institutions to manage and store taxonomic data. In particular, the herbaria at the University of Guyana and NAREI house species of cultivated and weed plants where over two-hundred and twenty-four (224) plant families have been preserved. NAREI maintains over forty-eight (48) families of rice weeds with the majority being from Poaceae (40) and Cyperaceae (18), the main rice weed families in Guyana (NARI, 1995).

It is important to note that shifting weather patterns, refer to Chapter 2, contributes to crop loss as a result of shorter periods of precipitation and extensive (longer) dry periods. Additionally, the use of agro-chemicals, inadequate management and control of crop diseases and soil erosion also contribute to loss of crops and the diversity of the agricultural ecosystems therein.

GENETIC DIVERSITY

PLANT GENETIC DIVERSITY

Rice and sugarcane crops have been the mainstay of agriculture industry; however, these traditional[55] crops are not endemic to Guyana. Therefore, varietal diversity and crop improvements are central for the sustainability of crops. According to an analysis of plant genetic diversity for food and agriculture in Guyana, genetic background of varietal diversity used for these two (2) crops is 100% dependent on the infusion of exotic germplasm. The varieties grown are climate tolerant, and produce high product quality and yields, as well as, resilience to a number of common pests (Paul, 2012). The report concluded that the genetic backgrounds of all commercially released varieties were created from diverse parental genotypes. It was found, in particular with rice varieties, that high yields and product quality were evident even from expansion into less productive ecologies (Paul, 2012). All sugarcane and rice diversity is derived from improved strains (introduced and shuttle bred) and maintained ex situ.

Continuous research into varieties of rice (*Oryza sativa*) is undertaken by the GRDB and in particular the Burma Rice Research Station (BRRS). However, according to Paul (2012), the BRRS is yet to source molecular genetic marker analysis technology. It was noted that while the research station uses bulk breeding, pedigree selection was the breeding method applied (Paul, 2012). While nurseries can be found on-station, additional pedigree nurseries for each station can be sourced from international research institutions such as ADRON (Suriname), Fondo Latinoamericano para Arroz de Riego (Brazil) and national rice breeding programme of India (Paul, 2012). Burma Rice Research Station has upgraded the characterization of forty-three (43) entries in its collection, including commercial varieties, based on these cross program exchanges. Each season more than 3000 pedigree lines are evaluated and selection of specific variety made based on performance for high grain yields, biotic stress tolerances, superior grain quality and high milling recovery (Paul, 2012). In the last year, the GRDB through its rice research station and extension offices released the GRDB 14 variety and the Aromatic Variety for cultivation (MoA, 2015). The station continuously runs trials across the country to test other varieties and once suitable are released to farmers. The Ministry of Agriculture anticipates that rice cultivation of GRDB 12, GRDB 13 and GRDN 14 varieties will continue to expand and more research into will be done into at least 500 varieties of rice accessed from international research institutions (MoA, 2015).

GUYSUCO employs a shuttle-breeding programme for sugarcane (*Saccharum officinarum*) where clones are breed and evaluated at multiple locations under diverse ecological conditions. Paul (2012) noted that a combination of pedigree and

[55] Traditional is defined in terms of crop production and contribution to GDP as a result of export.

bulk conventional breeding methods have been applied and on a seasonal basis pedigrees were generated from numerous parental clones used in experimental, b-parental and open poly-crosses. GUYSUCO has adopted a varietal selection programme of up to 90,000 single plant clones each season. Field nurseries have been established on most sugar estates which serve as the main source of 'seed clone' cuttings and field research is focused on practices that reduce environmental impacts and demonstrates tolerance to biotic and abiotic stresses (Paul, 2012). In the absence of molecular genetic marker or biochemical analysis technologies, biochemical traits such as juice analysis are used.

In recent years, crops of economic importance have grown to a majority of seventy (70) food plant species. NAREI has the overall responsibility to conduct research into these non-traditional[56] species and have done so for approximately thirty (30) of these crop species. Paul (2012) noted some of the key non-traditional food species were pineapple, plantain, pumpkin, papaya, hot pepper, coconut and cassava. Further, the manicole palm was also recognised as an important food species of which an export enterprise has been developed. The plant genetic resource report concluded that the diversity among the green vegetable crop species is estimated to comprise 50% of modern varieties and the diversity within the commercial stand of cabbage, pakchoy, sweet pepper and tomatoes is highly exotic (Paul, 2012). It was further noted that the local landrace diversity of carilla, ochro, squash, watermelon, bora, hot pepper, eggplant, and pumpkin continued to dominate in farming communities and vegetable farm cultivations (Paul, 2012). The infusion of imported modern (exotic) vegetable varieties was also observed.

Moreover, Paul (2012) concluded that the cassava (*Manihot esculenta*) represents the country's widest varietal diversity among all crop species[57]. The cassava diversity has been stable and faces no threat of genetic erosion, although, the crops especially in the south-western Rupununi savannahs have experienced unseasonal floods and extensive drought like conditions causing temporary shortage of the crop. Coconut diversity has been limited to the 'bastard variety' which is derived from naturally out-crossing populations of 'tall' and 'dwarf' varieties (Paul, 2012).

ANIMAL GENETIC DIVERSITY

The main animal species in the animal production system are Bovine, Avian, Ovine, Caprine, Porcine and Equine and few breeds within the animal species have been used for commercial and semi-commercial production. The livestock system ranges from extensive, semi-intensive to intensive and the common breeds used in

[56] These are defined as food plant species now contributing to Guyana's GDP through earnings from the export of these products.
[57] Paul (2012) also noted that possible trans-border varietal infusion could be possible for this species but the majority of the diversity remains locally generated with a high possibility of endemism.

production are listed in Table 6.2. In a report prepared by NAREI on the state of animal genetics in Guyana, it was found that little information has been collected and is available on the state of breeds within each animal species and their importance to food and agricultural production (NARI, 2004). The locally adapted breeds are responsible for the major livestock products in Guyana and provide food for the domestic market.

Table 6.2: Common breeds used in production. *Source: NAREI, 2004*

Animal Type	**Breeds/Breed Type**
Buffalo	Swamp Type
Beef Cattle	Zebu. Santa Gertrudis, Charolais. Hereford Creole
Dairy Cattle	Holstein. Friesian. Brown Swiss. Jamaican Hope. Jersey. Creole.
Sheep	Barbados Blackbelly, Virgin Island White Wiltshire Horn, Creole.
Goat	Creole, Nubian, Boer
Pigs	Large White. Landrace. Duroc. Non-descript
Duck	Pekin, Kunshan, Muscovy.
Turkey	American Bronze. Creole
Chicken	Commercial Hybrid. Creole
Geese	Local
Horse	American Thorough Bred. Quarter Horse, Creole
Donkey	Creole

Ducks, sheep beef and dairy cattle have been targeted for increased production, mainly through the introduction of improved genetics, for example, Boer breeds of goats, Dorper and Kathadin breeds of sheep and the Holstein, Brown Swiss and Jersey semen in dairy production systems (NARI, 2004). Mainly, an upgrading or crossbreeding system driven by private farmers is used in the absence of a structured system for breed development. The technologies applied include artificial insemination, particularly in cattle; limited artificial insemination in sheep and goats and performance recording in cattle, sheep, goats and ducks. Though limited, some genetic evaluation is undertaken for ducks, sheep and dairy cattle to allow farmers to secure seed stock of greater genetic potential (NARI, 2004).

It is worthy to note though, the utilisation of animal genetic resources is not restricted because of adequate number of animals, large landmass, adequate biomass and absence of significant disease among the animal population.

InSitu and ExSitu Management

According to the report on plant genetic resources for food and agriculture (Paul, 2012), insitu plant species diversity is associated and strongly manifested in farm cultivations and subsistence farming communities. It noted the plant genetic diversity found in farming communities represents the greatest diversity assembled in Guyana, accounting for more than 80% of the plant species diversity for food and agriculture for that reporting period (EPA, 2015).

NAREI collects and preserves threatened crop genetic diversity exsitu through traditional seed storage and vegetative field gene banks and conducts evaluation of land race varieties such as hot peppers and cassava, to conform claims based on traditional knowledge for harvest quality and agronomic characteristics (EPA, 2009). Further, NAREI has several ex situ field gene banks, inclusive of pineapple, avocado, cassava, yams, mango, West Indian cherry, passion fruit, cashew, coconut, citrus species, sorghum, corn, peanut, soybean accessions and an array of minor orchard crop species (EPA, 2009). The MoA and GRDB have collection in seed storage facilities, GUYSUCO has storage in greenhouses and field repositories and GRDB Burma station maintains over 816 local and regional rice accessions (NARI, 1995). Three local and two regional strains of azolla are maintained in the NARI Microbiology facility and numerous forage species are maintained at the Burma (Coastal ecozone) and Ebini (Intermediate Savannahs ecozone) Field Stations (NARI, 1995).

At NARI, some efforts have been made to evaluate and characterize grasses, forage legumes and rice germplasm. GUYSUCO has a plant breeding and selection unit responsible for the creation of new varieties of sugar cane, choosing the best possible clones and thoroughly testing and evaluating these clones for commercial extension. A new variety takes about 12 years to develop. Selections are based on: i) good agronomic characteristics ii) high yields iii) more sugar in stalk iv) medium fibre content and v) good millability (NARI, 1995).

FRESHWATER

Guyana's freshwater biodiversity is considered to be associated with the two freshwater ecoregions: the Essequibo (which includes several coastal and inland wetlands, and major tributaries of the Essequibo River such as the Mazaruni, Cuyuni, Potaro, Rupununi, Rewa and Kuyuwini Rivers) and the Guianas (which includes the Demerara, Berbice and Corentyne Rivers) (WWF-Guianas, 2007).

The rivers, streams, wetlands and other water bodies which comprise the system are home to 709 known species of fish including the arapaima (*Arapaima gigas*), lau-lau (*Brachyplatystoma filamentosum*), arowana (*Osteoglossum bichirrosum*), lukanani (*Cichla ocellaris),* and haimara (*Hoplias aimara*). Since the first overview of freshwater fishes in Guyana more than 100 years ago by Eigenmann (1912), we have known rivers in the Essequibo ecoregion were important centers of endemism (Vari et al., 2009).

Recent studies show that the freshwater fish diversity of Guyana is highly underestimated (Alofs, 2014; Maldonado-Ocampo et al., 2013; Netto-Ferreira et al., 2013; López-Fernández et al., 2012, and Taphorn et al., 2010). Many migratory birds, mammals (e.g. the giant river otter – *Pteronura brasilensis*), reptiles (e.g. green anaconda – *Eunectes murinus*; black caiman – *Melanosuchus niger*), amphibians and a variety of insects are also highly dependent on freshwater habitats for breeding, foraging or supporting the juvenile phase of their life cycle. The well-being of local people is determined by the health of these freshwater ecosystems, making their protection anthropogenic degradation a key priority.

THE ESSEQUIBO ECOREGION

Freshwater habitats in this area have thus far received more scientific attention than those of the Guianas ecoregion. Studies show that the area has high levels of diversity and endemism – not surprising given the incredible diversity of freshwater habitats and the relatively intact nature of the landscape (all of the current conservation areas in Guyana can be found in the Essequibo ecoregion). The integrity of freshwater habitats and biodiversity in areas of the Mazaruni, Cuyuni, and Potaro districts is affected small and medium scale gold mining operations, where high levels of turbidity, discolouration, changes in hydrology and mercury contamination are evident (Miller et al. 2003; Alofs, et al. 2013, WWF/EPA, 2014). In the south Rupununi, the threats are expanding. Erosion associated with mining results in reduced fish diversity, a shift in fish community composition and fewer suitable habitat areas for fish (Mol and Ouboter, 2004). Mercury bioaccumulates in the tissues of fish and other aquatic species, which means that local people are also affected since fish is a primary source of protein.

Wetland ecosystems, either permanently or seasonally flooded large open areas of lands, are an important component of the ecoregion. Seventeen (17) sites have been identified along the Essequibo coast, in the Moruca sub-district and north and central Rupununi savannahs (WWF-Guianas, 2012a). Though specific sites have not been identified, the southern Rupununi savannahs experience flooding during the rainy season which converts them to wetlands for many months of the year (WWF/GWC, 2013). In addition to having high levels of biodiversity (see table 6.3), these flooded landscapes enhance ecosystem connectivity, resilience and function. Flooding in the low-lying savannah areas of the Rupununi during the rainy season, for example, creates a complex hydrological connection between the Amazon and Essequibo river systems and allows for the exchange of fauna, particularly freshwater fishes, which increases diversity (de Souza et al., 2012, Lujan and Armbuster, 2011) and promotes gene flow (Lovejoy and De Araujo, 2000).

Table 6.3: Recorded species at wetland areas in the Essequibo ecoregion *(Source: WWF-Guianas, 2012a; * WWF/GWC, 2013. Note: ** 10 species likely new to science)*

Site	Number of Recorded Species				
	Mammals	Birds	Amphibians & Reptiles	Fishes	Aquatic Beetles
Essequibo Coast (Lake Tapakuma, Lake Capoey , Lake Mashabo)	11	102	11	44	
North West District (Moruca swamp, Assakata Lake and Wetlands, Baramani Lake, Almond Beach , George, Arnold Ponds)	23	158	32	18	
North and South-Central Rupununi(Surama Pond, Airstrip pond, Oma Pond, Devil Pond, Grass Pond, Shulinab, Sand Creek)	24	94	17	73	
Deep-South Rupununi Savannahs (Parabara and Kusad areas)*				145	139**

Extensive networks of rivers and streams, associated with different habitat types and elevational ranges, also harbour many species (see Table 6.4). The focus thus far has largely been on fishes; other invertebrates have been subject to fewer investigations.

Table 6.4 Number of freshwater fish species recorded in protected areas and areas in priority biodiversity regions *(Sources:[1]Montambault, J.R. and O. Missa (eds.)., 2002; [2]Alonso et. al., 2008; [3]Watkins et. al., 2004; EPA, 2007; [4]Kelloff, 2003; [5]Alofs et. al., 2014: levels of endemism in the region - estimated between 68-95%.).*

Protected and Priority Biodiverstiy Areas	**Sample Locations**	**No. of Recorded Fish Species**
Kanuku Mountains[1]	Catchments of the Lower Kwitaro River and the Upper Rewa River at the Corona Falls rapid.	113
Konashen - COCA[2]	Sipu River, Acarai Mountains, Kamoa River, Wanakoko Lake /Essequibo River, Essequibo River at Akuthopono and Masakenari Village.	113
Iwokrama[3]	Rivers in and around the Iwokrama forest including the Essequibo, Burro-Burro, and Siparuni drainages	420
Kaieteur National Park[4]		180
Upper Mazaruni[5]	Main upper Mazaruni River channel and its three main tributaries, the Kukui, Kako and Kamarang	39

The species and status of aquatic organisms in this region of Guyana, which includes the Demerara and Berbice Rivers and their tributaries and the tributaries of the Corentyne River which drains the New River Triangle, are poorly understood. However, what is known from collection efforts thus far, suggest high species diversity and pristine condition of freshwater habitats. Important human-made/semi-natural wetland areas lie along the coastline including the East Demerara Water Conservancy (EDWC), Mahaica-Mahaicony-Abary (MMA) Conservancy and Lower Canje Basin. The EDWC has substantial fish species including many carnivorous species such as the lukanani (*Cichla ocellaris*) and birds – the most unique of which is the Hoatzin or Canje pheasant (*Opisthocomus hoazin*). Maguari storks (*Ciconia maguari*), kingfishers, herons, ducks, swallows and flycatchers are also common (WWF-Guianas, 2012a). Large aquatic mammals such as the neotropical otter (*Lontra longicaudis*), giant river otter (*Pteronura brasiliensis*), west-indian manatee (*Trichechus manatus*), and capybara (*Hydrochaeris hydrochaeris*) are known to inhabit the EDWC (WWF-Guianas, 2012a). Biodiversity within the MMA and Lower Canje is comparable (see Table 6.5). Many terrestrial species are closely associated with the areas including the Brazilian tapir (*Tapirus terrestris),* jaguar (*Panthera onca*) and white-lipped peccary (*Tayassu pecari*).

Table 6.5: Recorded species at wetland areas in the Guianas ecoregion *(Source: WWF-Guianas, 2012a)*

Wetland Site	Number of Recorded Species			
	Mammals	Birds	Amphibians & Reptiles	Fishes
East Demerara Water Conservancy (EDWC)	9	99	8	26
Mahaica - Mahaicony - Abary (MMA) Conservancy	14	86	7	14
Lower Canje Basin	12	166	23	32

A recent study in the Upper Berbice River region uncovered 92 species of fish representing 7 orders, and more than 112 species of invertebrates (crab, shrimp, aquatic beetles and insects) have been recorded (WWF-Guianas/GWC, 2014; preliminary findings). As additional data emerges, it will likely add to the distinct species and assemblages. The upper Berbice drainage is thought to be isolated from other nearby basins (in particular the Essequibo and Corentyne) an important factor which contributes to unique groups of species. The health of these aquatic environments could be jeopardized in the future due to existing new development in the extractive sector as well as planned expansion into the Upper Berbice.

The Rupununi savanna, southwestern Guyana, experiences seasonal flooding that allows a connection between the Essequibo and Amazon Rivers that provides potential for ichthyofaunal exchange. This connection may be a corridor of dispersal for some species and a barrier toother species. De Souza, Armbruster and Werneke (2012) conducted extensive sampling in the Rupununi and Takutu Rivers and collected 433 species representing 41 families and 13 orders. Characiformes, Siluriformes, Perciformes and Gynotiformes were the dominant orders. The dominant families were Characida, Loricariidae and Cichlidae. Of the 343 species collected from the Rupununi River (predominantly from the Characidae, Loricariidae and Anostomidae families), 89 species were unique to the Rupununi. Whereas, of the 344 species collected from the Takutu River (primarily from the Characidae,Trichomycteridae, Loricariidae, Crenuchidae and Heptapteridae families), 90 species were unique to the Takutu. The two drainage systems had 254 species in common, mainly from the Characidae, Loricariidai and Cichlidae families.

Several new species were identified including *Cetopsidium soniae, Gelanoglanis sp, Hypostomus sp, Peckoltia sabaji,* and *Rhinodoras armbrusteri. S*pecies considered endemic include *Peckoltia braueri, Hypancistrus sp, Typhlobelus sp, Panaque sp,* and *Peckoltia cavatica.* There are several cognate species that have diverged morphologically from the common ancestor due to geographical separation.

Bicknell surveyed three sites from the Rupununi/Essequibo drainage and two sites from the Ireng/Amazon drainage during the low water season. The study recorded 53 species from 16 families representing 6 orders, predominantly Siluriformes, Characiformes and Periciformes. The most widely distributed species were *Pygocentrus nattereri* (red bellied Piranha) and *Prochilodus sp,* whereas *Cichla temensis* is found only in the Amazon drainage.

Other notable species in the Rupununi region include *Arapaima gigas*, *Ancistrus sp* and *Callichthys sp* (catfish species) and *Inia geoffrensis* (pink river dolphin) which was found in the Ireng area.

ORINOCO DELTA

The Orinoco Delta is an interconnected network streams of fresh and brackish waters. The freshwater component comprises permanent and seasonally flooded areas. The brackish water component is a mixture of intertidal mangrove swamps and coastal brackish water lagoons and is significantly influenced by the ebb and flow of tides from the Moruka, Pomeroon, Barima and Waini River systems and recharge from rainfall during the rainy season. Characiformes, Siluriformes and Perciformes were the main families observed in these wetlands. Lukanani (*Cichla ocellaris*), huri (*Hoplias malabaricus*), imehri (*Trachelyopterus galeatus*), haimara (*Hoplias aimara*), larima (*Pimelodus blochii*) and (*Erythrinus sp*) were also reported from this area. Aquatic birds include scarlet ibis (*Eudocimus ruber*), American flamingo (*Phoenicopterus ruber*), magnificent frigate bird (*Fregata magnificens*) and brown pelican (*Pelecanus occidentalis*). Resident aquatic mammals include river dolphin (*Inia geoffrensis*), the Neotropical and giant otters (*Lontra longicaudis* and *Pteronura brasiliensis*) and manatee (*Trichechus manatus*). The Spectacled caiman (*Caiman crocodilus*) is also found along these waterways.

Harvesting of timber and non-timber forest products, fishing, hunting, mining, farming, wildlife trapping, travel and tourism are the factors that influences the status of this ecoregion.

IMPACTS OF CHANGES IN BIODIVERSITY

The connection between biodiversity and human wellbeing is unquestionable, thus the state of biodiversity has direct bearing on the quality of the human existence. Relatedly, it has a bearing on the quality of the environmental services provided. Theoretically, we seek to balance ecological wellbeing with human wellbeing in order to realise long-term sustainable livelihoods. The extent to which this can be realised is in question, as assessments have thus far suggested that we have failed to merge human wellbeing with ecological wellbeing, and our major global ecosystems are being lost/degraded (Mainka, McNeely and Jackson, 2005). In cases where the harvesting/harnessing of ecosystems goods and services for improved human wellbeing has taken place in a weak or corrupt institutional setting, ecological wellbeing is lost with no commensurate improvements in human wellbeing – thus is the case of Haiti (Christensen, 2011).

In this section we consider the impacts of the state of biodiversity on several areas of human wellbeing by considering the state of each ecoregion grouping previously identified – marine, terrestrial and freshwater.

ECONOMIC

The main economic activity in Guyana that has been directly dependent on the state of the marine ecosystem is fisheries which contributed 1.8% of Guyana's GDP in 2014 (Bureau of Statistics, 2016). Uncertainties in relation to the status of some stocks and clear evidence of overharvesting of others have caused the introduction of a range of management measures including fleet reduction, defined fishing seasons (for some crustaceans) and defined fishing areas to reduce conflict over limited resources (Fisheries, 2006). All these have negative economic impacts which have not been quantified.

Other economic activities in the marine ecosystem – oil exploration and transportation for example - are unaffected by the state of state of biodiversity. Lack of knowledge of the system would have required oil exploration companies to invest more into primary research to determine the nature of the ecosystems they are putting at risk.

The terrestrial ecoregions support a range of economic activities including large and small scale agriculture, forestry, wildlife trade, mineral mining and quarrying and ecotourism. Low rates of deforestation, habitat loss and fragmentation and overall functional ecosystems provide tremendous support for these industries. The industries which are directly dependent on functional ecosystems contributed at least 21.8% of Guyana's GDP in 2014 (Bureau of Statistics, 2016). Mining and quarrying contributed 10.4% of GDP in the same year (Bureau of Statistics, 2016) but these are not clearly dependent on functional ecosystems except for issues of land stability and climate predictability.

Ecotourism is a growing industry in Guyana and is significantly dependent on terrestrial biodiversity. Birds feature in a major way in the industry, but also ecosystems such as the Kaieteur plateau and gorge and the rainforest of Iwokrama are of great importance. However, there is no disaggregated data available on this industry, but its contributions must be noted.

The economic cost of ecosystem degradation is not well studied in Guyana. However, the REDD+ based agreement between the Cooperative republic of Guyana and the Kingdom of Norway provided a quantification of deforestation. The monitoring and evaluation report in 2012 indicated an increase in deforestation largely due to mining and caused Guyana to loose US$20M in funds accessible under the agreement.

Biodiversity in freshwater systems is not fully exploited for economic benefits. Some species of fish including but not limited to Arapaima (*Arapaima gigas*), Lukanani (*Cichla ocellaris*), Pacu (*Myleus pacu*) and Tigerfish (*Pseudoplatystoma fasciatum*), are harvested on a commercial scale. With the exception of the Arapaima, the harvest and trade in these species are not regulated. Other species of fish, some species of caiman (principally *Caiman crocodilus*) and aquatic turtles (*Podocnemis sp.*) are traded internationally as wildlife. The absolute economic impact of these trade activities is not well documented for public consumption.

Functional freshwater ecosystems, in particular the wetland systems, are critical to natural detoxification of water and reduces the cost of water purification for human consumption. There are however no studies which quantified this economic benefit.

HEALTH

Guyana has consistently been ranked among the top countries in the region for fish consumption, with an annual *per capita* consumption of 57kg reported in 2011 (CARICOM 2011; Haughton, 2011). High levels of fish consumption presents both risk and benefits for human health, however the data for analysis of these are lacking in Guyana.

Guyana's terrestrial ecosystems support good health for the most part. However there is at least one issue that must be highlighted. That is the issues of vector borne diseases such as malaria, yellow fever, dengue fever, and the zika and chikungunya viruses which have been on the rise across Guyana. Vector borne parasites are known to increase as their vectors increase due to ecological imbalances which support their rapid reproduction. The human altered coastal ecosystems with improper drainage and overgrowth of brushes near human settlements create habitat for vectors such as mosquitoes. As does the mining ponds and obstructed rivers in the interior.

Whereas feral pigeons are known to carry disease causing agents in many parts of the world, and whereas Guyana has a growing problem with alien feral pigeons in the population centres, no evidence is yet available to link this species to human health in Guyana.

There is little data available on the health impact of freshwater biodiversity on human health, however two points may be noted. Firstly, we must appreciate the relationship of improperly functioning ecosystems and vectors of disease causing agents as articulated in relation to the terrestrial systems. We must also appreciate the link between health and consumption of fish which is a low cost form of proteins and are known to provide both risk and benefits for human health. In particular, the consumption of fishes in areas affected by mining with the use of mercury has caused a rise in the concentration of mercury in human tissues (Henry, 2013). No health epidemic has however been linked to this in Guyana.

SOCIAL

Beyond its economic benefits, fishing in the marine environment has a significant social context given that it is a major activity in many coastal communities. Both the harvesting and consumption of marine fish on the coast is of importance socially. Not only are these activities that communities form around, but the ability of communities to access and use the resources improves social justice.

Fisheries cooperatives are major institutions in the Guyanese landscape. The physical facilities used by these cooperatives support a number of micro-enterprises such as porting, fish processing, food supplies, fishing supplies and shoes and clothing supply.

Terrestrial biodiversity has multiple social impacts in Guyana. Communities living closer to nature from time to time retreat to natural ecosystems for purely social reasons. A much smaller group from the coastal region also engages in similar activity with notable frequency. In some communities, traditional lifestyles necessitate interaction with biodiversity of varying forms from the placement of significant buildings in specific ecosystems, to dependence on specific plants and animals for traditional practices including medicine. Some species of mammals and birds in particular, but to a lesser extent fish, amphibians and reptiles, are common as pets. Finches in particular are kept as singing birds, and although significant volumes of cash exchanges hand during ‘bird races’, the practice is significantly cultural in communities on the coast.

Hunting has always been part of the traditional life of the indigenous communities (together with general gathering of products from the plants and animals) but it is increasingly appealing to some affluent coast-landers.

All these are dependent on the functional terrestrial ecosystems which support critical species.

Fishing in freshwater bodies, whether manmade of natural, is a popular and growing Guyanese pastime. Only adult fishers, and usually the more affluent, are engaged in species targeted fishing. Most persons fish more opportunistically and capture and keep a range of species. The consumption of freshwater fishes by coastal communities is in significant instances more cultural than health related. In particular, the consumption of species of Hassa (*Hoplosternum spp* and *Callichthys callichthys*) is cultural for many families as better quality protein is more cheaply and readily available.

Freshwater ecosystems also have significant cultural appeal in folklore and in every day life. It is more common place in Guyana up to current time to utilise natural waterways for recreational activities. This is the thrust behind establishments such as the Splashmin Resort and the Lake Mainstay Resort. While different in their origin, both these location, and many others, attract scores of visitors on a weekly bases. The attractiveness of these areas especially to persons living on the coast, who only have access to manmade canals near their homes, is significantly based on fully function ecosystems which create the acceptable water condition for recreational activities.

ENVIRONMENTAL

Whereas there is no evidence from an assessment of the marine ecosystem, indications are that the state of its biodiversity supports satisfactory environmental services and goods.

Evidence of the environmental impacts of the terrestrial biodiversity is wanting also. From the evidence that does exist the following can be highlighted. Firstly, many alien and invasive species have integrated into the ecosystem and could be displacing native species especially near human settlements. Secondly, increases in large cat encroaching on human settlements and their taking of domesticated animals could be an indication of a shortage of prey animals for large predators. Thirdly, areas cleared for mining which are not reclaimed/restored are known to take significantly longer times to recover naturally and those dysfunctional systems have significant impacts on local and long distance migratory species as well as affect other ecosystems such as freshwater streams and lakes. Finally, functioning forest ecosystems are especially critical to regulation of the water cycle, land stability and carbon circulation.

Beyond the provision of habitat for a range of species critical to overall biosphere survival, functional freshwater systems are critical to detoxification of freshwater and general regulation of the water cycle. Most of the natural water bodies in Guyana possess a complement of species that allow for these function to be performed. Where freshwater systems are dysfunctional, it is usually where physical parameters such as suspended solids have exceeded normal ranges. In these cases there is no available data to fully analyse the overall environmental impacts.

RESPONSES

Guyana is a Party to a number of Multilateral Environmental Agreements (MEA) which contribute to the conservation and protection of the country's rich biological diversity. These MEA's shape the national sustainable development agenda, in particular, as it relate to the country's conservation efforts. Guyana became a Party to the United Nations Convention on Biological Diversity (UNCBD) in 1994. Since that time country has made significant efforts to meet its commitments to ensure conservation and protection of its natural resources. In support of the implementation of the UNCBD, Guyana acceded to the Cartagena Protocol on Biosafety in 2008 and the Nagoya Protocol on Access and Benefit Sharing in 2014.

Furthermore, Guyana became a Party to the United Nations Framework Convention on Climate Change (UNFCCC), refer to Chapter 2, the United Nations Convention to Combat Desertification (UNCCD) in 1997 and the Convention on International Trade in Endangered Species of Fauna and Flora (CITES) in 1977, all contributing to the conservation and protection of biodiversity.

Guyana has implemented a number of conservation actions over the years including the preparation and submission of five (5) national reports to the UNCBD for the periods 1994-1999, 2000-2003, 2004 – 2006, 2007 – 2010, and 2011-2014. An overview of key actions in recent years, at the national policy and strategic levels, as well as, the supporting institutional framework in response to biodiversity conservation is provided in the subsequent sections.

NATIONAL POLICY COMMITMENTS

Key policies related to biodiversity conservation and management have been developed and are being implemented. Recognising the importance of biodiversity conservation the GoG has taken steps to mainstream biodiversity across the sectors, especially the productive sectors such as agriculture, forestry, tourism, mining and fisheries. The UNCBD Fifth National Report (5NR) highlighted the extent of these mainstreaming efforts, in particular, the inclusion of biodiversity considerations in national policies. These policies all aim towards conservation of Guyana's natural resources, inclusive of sustainable utilisation of its components and include (EPA, 2015):

1. Policy on the access to genetic resources and fair and equitable sharing of benefits arising from their utilisation (2007)
2. National Forest Policy (2011)
3. National Land Use Policy (draft)
4. Biotechnology, Biosafety and Biosecurity Policy (2007)
5. National Integrated Water Resources Management Policy & Roadmap (2013)
6. Sea & River Defence Policy (2009)
7. National Policy on Inland Fisheries and Aquaculture (2012)

In its INDC submission to the UNFCCC in 2015, Guyana has committed to the conservation of an additional two (2) million hectares of forest through the National Protected Areas System and the pursuit of other effective area-based conservation measures under the UNCBD, including the protection of mangroves, conservancies, reservoirs and their watersheds, as well as, watersheds upstream of new hydro-power sites (GoG, 2015). This national commitment is in keeping with Guyana's policy objective for protected areas, that is, to achieve the UNCBD target of having at least 17% of the country's land and inland water under some form of protection by 2020 (EPA, 2015).

NATIONAL STRATEGIES AND ACTION PLANS

The country's sustainable development framework has been strengthened over the years through the preparation and implementation of key strategies and plans, especially those focused on or contain biodiversity conservation considerations and these include (EPA, 2015):

1. National Biosafety Framework (2007)
2. National Biodiversity Strategy and Action Plan (2012-2020)
3. National Strategy for the Conservation and Sustainable Use of Guyana's Biodiversity (1997)
4. Low Carbon Development Strategy (2010, 2013)
5. National Protected Areas Strategy (2002)
6. National Strategy for Agriculture in Guyana (2013-2020)
7. Climate Change Action Plan (2001)
8. Climate Resilience Strategy and Action Plan (2015)
9. Guyana's Green Economy Plan (draft)
10. Integrated Coastal Zone Management Plan (2000)
11. National Mangrove Management Action Plan (2010)
12. National Land Use Plan (2013)

13. National Forest Plan (2011)
14. National Protected Areas Systems Plan (2013-2015)
15. Fisheries Management and Development Plan (2006)
16. Marine Fisheries Management Plan (2013 – 2020)
17. Arapaima Management Plan (2014)
18. Action Plan for Implementing the Programme of Work on Protected Areas of the UNCBD (2012)

These strategies and plans collectively provide the framework for biodiversity conservation and management through improved management of Guyana's productive sectors such as forest, agriculture, and fisheries sectors. Further, the implementation of these plans, in particular, the national protected areas systems and action plan for implementing the programme of work on protected areas allow for the protection and maintenance the country's rich diversity and cultural heritage while facilitating social, environmental and economic development (EPA, 2015).

NATIONAL LAWS AND REGULATIONS TO SUPPORT BIODIVERSITY CONSERVATION AND PROTECTION

National laws and regulations were developed and legislated to support the various policies and strategies in order to ensure the protection of Guyana's environment and sustainable use and conservation of its natural resources and these include (EPA, 2015):

1. Access and Benefit Sharing Regulations (in draft)
2. Aquatic Wildlife Control Regulations (1996)
3. Biosafety bill and related regulations (in draft)

4. Environmental Protection Act, 1996
5. Environmental Protection Water Quality Regulations 2000
6. Forest Act 2009
7. Mining Act 1989 and related regulations
8. Protected Areas Act 2011
9. Species Protection Regulations 1999
10. Wildlife Management and Conservation Regulations 2013
11. Wild Birds Protection Act 1973
12. Wildlife import and export regulations (draft)
13. Wildlife Conservation and Management Bill

In recent years, the GoG has placed emphasis on the protection of specific species through the amendment and enactment of regulations. In particular, in 2010 the then Minister of Agriculture having responsibility for forestry at that time and in consultation with stakeholders including the GFC, amended the Forest Act 2009 to include "*Protected Trees*", specifically specifying that *"no bullet-wood tree or red, black or white mangrove trees shall be felled without first obtaining the permission in writing of an authorized forest officer not below the rank of an Assistant Commissioner of Forests".*

Additionally, in 2013 the Wildlife Management and Conservation Regulations made under the EP Act 1996 were enacted giving rise to legal protection of a number of CITES and International Union for Conservation of Nature and Natural Resources (IUCN) listed species as specified in the First Schedule of the regulations. These include species listed as critically endangered such as the leatherback turtle (*Dermochelys coriacea*), endangered such as the sun parakeet (*Aratinga solstitialis)* and vulnerable such as the large-leaved Mahogany (*Swietenia macrophylla)*.

More recently, the Parliament of the Cooperative Republic of Guyana passed the Wildlife Conservation and Management Bill. This Bill is intended to serve as the umbrella legislation for the regulation, conservation and management of wildlife in Guyana and builds off the Wildlife Import and Export Bill and the Wildlife Management and Conservation Regulations. It also provides for the implementation of the CITES provisions as required by Article VIII of the Convention. The Bill specifies a number of provisions, in particular, requirements for the importation and exportation of wildlife; transportation of wildlife; licensing of holding premises and the establishment, management and operation of wildlife rescue centres. It is expected that the bill will soon be accented to by HE. The President of the Cooperative Republic.

INSTITUTIONAL ARRANGEMENTS TO SUPPORT BIODIVERSITY CONSERVATION

Over the years the government, in meeting its commitment to the UNCBD, has strengthened the institutional and governance arrangements for the protection, conservation and sustainable management use of biological diversity. A key governance arrangement was the creation of the Ministry Natural Resources and Environment (MNRE) in 2011. The MNR's primary focus was on the harmonising of policy and management in the natural resources sectors to allow for better mainstreaming of conservation and environmental management. A number of natural resources related Agencies and Commissions were placed under the purview of the Ministry, including Guyana Geology and Mines Commission; Guyana Gold Board; Environmental Protection Agency; Wildlife Management Authority; Protected Areas Commission; National Parks Commission and Guyana Forestry Commission (EPA, 2015). This arrangement was recently revised with the National Parks Commission being subsumed under the Protected Areas Commission and the removal of the Environmental Protection Agency, Wildlife Management Authority and Protected Areas Commission from the purview of the MNRE. The MNRE has consequently been renamed the Ministry of Natural Resources (MNR) and the

Department of Environment has been form under the Ministry of the Presidency to accommodate the agencies mentioned above along with the Office of Climate Change.

Further, the enactment of the Protected Areas Act, 2011 paved the way for the establishment of the Protected Areas Commission (PAC). The functions of the PAC include establishing, managing, maintaining, promoting and expanding the national protected areas system. The PAC by extension monitors and regulates activities and the use of resources within protected areas; prepares, develops and effectively implements management plans in collaboration with stakeholders, including communities; conducts scientific studies and research; provides support and advice to communities towards the development of their protected areas; and promote public involvement in decision-making processes (EPA, 2015).

Moreover, the EPA is the National Focal Point for the UNCBD. The Agency was established by the Environmental Protection Act, 1996, which gives it the mandate for environmental protection. Natural Resources Management is a core programme area of the EPA. The EP Act 1996 specifically stipulates the functions of the EPA for natural resources management. According to the Act, the EPA has the mandate to *"manage the natural environment to ensure conservation, protection, and sustainable use of its natural resources; to coordinate a programme for the conservation of biodiversity and its sustainable use; to establish and maintain a national park and protected area system; and wildlife protection management programme*[58]*"* (EPA, 2015).

In the last year, and to support the implementation of the proposed Wildlife Conservation and Management Bill, an administrative institution will be a necessary requirement. The Bill therefore makes the provision for the establishment of the Wildlife Conservation and Management Commission, a body corporate to be governed by a board of directors. It is expected that the current Wildlife Management Authority will be transformed to provide the administrative function as stipulated in the Bill and to enforce its implementation, in particular, regulate international trade in wildlife, assess the level of trade and devise measures to effectively manage the trade in a sustainable manner.

KEY SECTORAL PROGRAMMES AND INITIATIVES

Conservation in Guyana is guided mainly by collaborative and adaptive management. In this regard, the government is working more closely with conservation NGOs, local communities and other stakeholders to partner in the process. A few specific initiatives to date include the passage of the Arapaima Management Plan and collaboration with the NRDDB and Iwokrama; the mangrove restoration project and its livelihood support programme; declaration of new protected areas by the GoG (Kanuku Mountain Protected Area and the Shell Beach Protected Area); community involvement in protected area planning, refer to Box 6.2; establishment of the PAC;

[58] EP Act 1996

creation of a National Protected Areas Trust; development plan for a National Protected Areas System and management plans for each protected areas (EPA, 2015; 2010).

Box 6.2: Community Involvement in Protected Area Planning and Development - The Case of the Kanuku Mountains, Guyana

Introduction

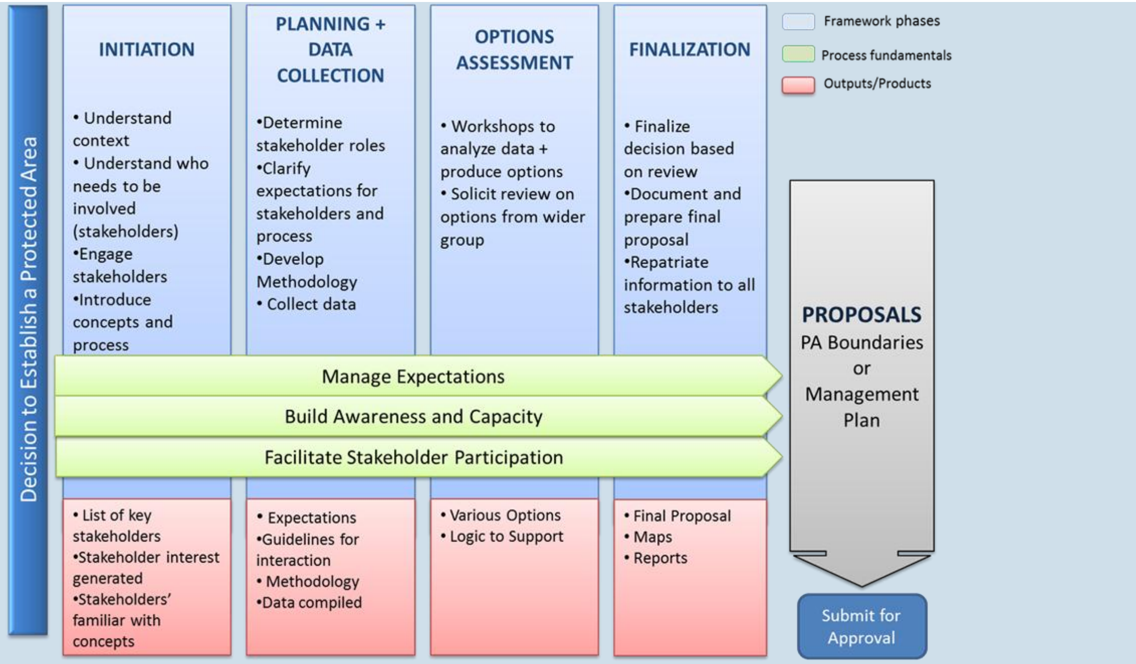
The success of protected areas depends greatly on strong collaborative relationships with people, particularly communities within and near areas under protection (Andrade & Rhodes, 2012; Holmes, 2013). Guyana articulated a policy of "parks with people", embracing a concept of meaningful community involvement in planning and management of protected areas (EPA, 2002). Early protected areas established in the country had little to no involvement of communities, particularly prior to their declaration. In order to demonstrate the stated policy and provide support towards the establishment of suitable legislation for protected areas, the Kanuku Mountains region was identified as one of two pilot sites in which a process that ensures meaningful community involvement in protected areas planning and management would be designed and tested.

The Kanuku Mountain Protected Area Planning Framework

The Government of Guyana mandated Conservation International Guyana (CI-Guyana) to collaborate with a diverse group of stakeholders[59] to design and test a participatory process for protected area planning in Guyana. The framework for the approach used comprises four sequential phases (see Figure 6.7) carried out each time for (1) boundary design and afterwards, (2) preparation of the management plan (CI-Guyana, 2014). The process involved the use of highly participatory and innovative methods particularly to ensure effective and informed participation of stakeholders in decision making throughout.

Figure 6.7: Planning framework for The Kanuku Mountain Potected Area

[59] This included communities that use the resources of the area, national agencies responsible for land and natural resource use and management, local and national government bodies, and civil society and private sector actors.



Results/outputs

This holistic approach to protected area planning and development has produced extremely positive results, notably the nurturing of interest among the local communities in the establishment and management of the protected area. The meaningful and informed involvement of the State, communities and other civil society stakeholders, in the process of planning the Kanuku Mountains Protected Area has helped secure high levels of support for the declaration of the area. The process allowed for understanding of potential conflicts around land and resource rights and management in an open and objective manner, involving direct discourse amongst groups with differing interests and priorities. This has significant bearing on the issues of land rights. Both the boundary design and management plan were approved by consensus, and there were no matters left outstanding that could affect the effective and sustainable management of natural resources. In fact, despite expressing strong reservations and concerns at the beginning of the process, the communities lobbied strongly for the declaration of the area in the end.

The Kanuku Mountain Framework was utilized for the development of the Shell Beach Protected Area and influenced the design of Guyana's protected areas legislation.

Challenges and Lessons

Consensus building in natural resource management is usually difficult because of diverse understanding of complex rights-based issues, and laws that are oftentimes inconsistent and/or conflicting. The process created an atmosphere for decision making by building consensus incrementally, through encouraging understanding of and respect for the varying points-of-view of stakeholders, and using such understanding to foster trust amongst stakeholders.

In the implementation of this process, a major challenge faced was addressing the concern of communities for security of land and resource ownership and use rights. Building consensus on the application of protected areas as a resource management mechanism to secure rights, access, benefits, and traditional use to and by communities, helped to address this concern. This could have only been possible through focused education and awareness efforts. These efforts also enhanced both the ability of the local communities to participate and the value of this participation to the process itself. Informed and knowledgeable communities – and other stakeholders – are much better able to contribute meaningfully to the success of protected areas.

A notable challenge is the significant up-front investment of resources necessary for success, especially the amount of time required. The effective participation of the wide cross section of stakeholders in decision making surrounding resource management relies heavily on trust being built between parties, and therefore cannot be rushed. This pays dividends in the medium to long term.

Conclusion

Long-term success of protected area management hinges on the effective participation of local people. The framework utilized in the Kanuku Mountains has helped establish a platform for successful management of the protected area in Guyana by ensuring effective participation of stakeholders, particularly local communities, in decision making regarding the area from initiation of the planning process.

Moreover, given the threat of climate change and sea level rise along with the fact that Guyana's coast is below sea level, it is especially important to ensure the maintenance of the mangrove forests. To achieve this, the Guyana Mangrove Restoration Project (GMRP) was launched with funding by the European Union (EU). The overall objective of the GMRP is to implement the National Mangrove Management Action Plan (NMMAP) and its aim is to mitigate the effects of climate change through mangrove reforestation and preservation. Through activities engaged under this programme, stretches of mangrove forests were restored along the coast and persons were educated on the importance of these forests.

Biodiversity monitoring is also a critical element to ensure conservation and a number of activities were implemented by stakeholders and partners, although, these were more reactive than proactive and within the specific mandates or interests of the institution and/or taxonomic groups:

1. The Conservation of Ecological Interaction & Biological Association (CEIBA) conducts research and monitoring on-site at its facility on the Linden-

Soesdyke Highway into butterflies and other pollinator species, dragonflies, amphibians, phenology of plant and animal pollinators and seed disseminators.

2. Limited research and monitoring of bird species found on Guyana's coast, especially in the Botanical Gardens, are undertaken by Guyana Amazon Tropical Birds Society (GATBS).
3. Research and assessments based on the introduction of new rice varieties are undertaken by the Guyana Rice Development Board (GRDB).
4. NAREI conducts assessments of threats to loss of *in situ* crop genetic diversity in order to implement preventative measures such as collection of threatened species and conservation of *ex situ* gene banks.
5. Monitoring protocols for the mangrove project have been developed and the Mangrove Action Committee is collaborating closely with the Ministry of Public Infrastructure (MoPI) which have responsibility for sea defences. Mangrove rangers have been employed and have received formal and practical training through attachments to both the GFC and the MoPI. Regional mangrove officers operate at the regional level to oversee the activities of the mangrove project in each region. At the community level there have been numerous community consultations from which community based mangrove committees have been established. This network serves to engage in monitoring, data collection, awareness and nursery components of the mangrove restoration programme.

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CONCLUSIONS

This State of Environment Report was developed through a participatory approach with involvement of multiple stakeholders and specifically led by authors and reviewers from government, non-government and academic institutions in Guyana with coordinating support from UNDP and external experts. It represents an effort to collect and systematize existing information on a series of key environmental issues that were prioritized in the framework of a multi-stakeholder process, using an integral environmental analysis tool known as DPSIR (see Introduction). It also presents these issues as critical points of action that can be studied and addressed in future opportunities.

INFORMATION

One of the first conclusions was reached during the early stages of this process and is related to data availability. There is an extensive lack of data in some of the most pressing socio-environmental issues the country is facing. While isolated pockets of data have been found among sector agencies and key institutions, these were disaggregated by location and/or available in incompatible or non-standardized format. Most, if not all, of the data sets were results of specific spatial and temporal monitoring/assessment activities making comparisons and trend assessments difficult. Even though extensive climate data were found, there were some considerable data gaps due to technical issues during data collection.

In some of the prioritized environmental issues, lack of data can hinder the ability to make environmental decisions that have effects on society´s economy, health and general well-being. This is the case for activities that have been part of Guyana´s economy for many years, such as mining, and for future activities such as off shore oil and gas development. In the case of the latter it is important to undertake more detailed marine assessments to ensure other environmental and social resources are not unnecessarily affected. In the case of the former, it is important to understand the precise scale of the impact of mining operations in order to minimize their impact on the environment, health and on other economic activities such as forestry.

Efforts to generate new data should be supported, particularly in research on sustainable land use in Guyana from the overall perspective of sustainable development and conservation. There is a need to provide some national priorities with regards to research needs so that academia, foreign institutions carrying on research in the country, green economy related research efforts can focus their efforts on generating data in areas under these selected national priorities.

Funding for research and development should be strengthened, especially since the University of Guyana is well placed to undertake additional research, on biodiversity in particular, to fill the knowledge gaps at the basic level. These include in particular floral, invertebrate studies and detail assessments in the marine environment. Research and development should be further promoted and strengthen in agencies such as the EPA, GGMC, GFC and the Hydrometeorological Services Department in order to support and inform decisions.

In addition to the production of new research and data, the efforts on information sharing should continue and become widespread. Exchange of current information between agencies for example and the effective use of this information exchange and geographic technologies and systems can be a powerful tool for environmental monitoring.

Developing, sharing and using information is also a key aspect to ensure sustainable development and to enable the use of development tools such as strategic environmental assessments. The strategic environmental assessment as a planning tool can be a valuable tool for decision makers. It can analyse situations where uncertainty regarding the results of policies or mega developments is relatively high. One case where the use of strategic environmental assessment can be an effective decision-making tool is the development of infrastructure in the Rupunumi Savannahs. The development of transportation infrastructure in this area can have a significant impact in the economy of Guyana. Using appropriate analysis tools such as the strategic environmental assessments for the planning of this development can go a long way in ensuring that the positive economic impacts are not shadowed by social exclusion and environmental degradation.

The promotion of sustainable production can be sustained through financial and economic instruments and the creation of special restoration funds. There is need to increase access to funding to support environmental management efforts especially in the extractive industries. Financial and economic benefits from resources such as gold, oil etc. could be redirected and invested in safeguarding Guyana's natural and human capital. To increase the effectiveness, a clear inter sectorial natural resource management strategy should be designed and implemented that can allow all government actors to align to it.

As an example, the EPA was assigned the prime responsibility for implementing the UNCBD, without adequate government-wide co-ordination, human capacity and resources to implement the necessary response measures in key sectors such as agriculture, energy, transport and others. The extent of overlapping responsibilities reduced the ability of any one institution to function to its maximum potential. Therefore, there is a need to coordinate multilateral environmental agreements in order to reduce duplication and encourage effective use of scarce resources.

GOVERNANCE

Guyana's environmental governance framework is characterized by a highly reactive or response oriented approach, mainly by actions from the State and Civil Society in response to environmentally related issues. In the absence of a formal national environmental policy, the environmental policy direction is mainly determined by the national direction stipulated by the Government of Guyana (GoG).

In the past, the policy approach was shaped priority issues in the mining and forests sectors and climate change as key drivers of environmental degradation. In recent times the GoG has commenced the reorientation of the country's environmental responses towards developing a Green Economy, building off and expanding on the LCDS. Moreover, while Guyana has enacted legislation to address environmental degradation and biodiversity conservation and management; their adequacy, effectiveness and enforceability have been challenging. The core principle of the Environmental Protection Act 1996 is the precautionary approach to environmental management, however, access to and availability of information to support the implementation of the requisite laws and regulations, as well as, decision making and managing the environment were found to be limited, mainly due to the lack of resources (human and financial). Limited human resources also impacted the extent of public education activities by the Environmental Protection Agency (EPA). On the other hand, the EPA mandated through legislation, has the overall responsibility to coordinate and implement such activities but its reach is restricted to the coastal regions and a few interior areas due to limited financial resources necessary for countrywide public awareness.

Guyana can benefit from a multi-faceted approach in place to develop and sustain this capacity for strengthened environmental governance. Available human and technical resource capacity is recognised as critical to the implementation of, for example, the UNCBD and UNFCCC. Human resource capacity development has been recognised as an urgent priority in Guyana, in all areas inclusive of biodiversity management and conservation, and therefore more emphasis needs to be placed on increasing the technical resource capacity in the key natural resources and conservation agencies and devising a strategy to retain the current capacity.

Guyana's environmental governance framework limits opportunities for impacted stakeholders to participate in environmental decision-making. Public awareness and education need to be strengthened and scaled-up through streamlining and coordinating efforts among government institutions, civil society and the private sector. Currently, opportunities to participate are mostly limited to those in risk of being significantly impacted by proposed development in the framework of the Environmental Impact Assessment.

An important issue to highlight regarding environmental governance is the need for long term stability in the institutional framework. Although the main environmental governance bodies such as EPA have been established for 20 years, changes occurring during the past 5 years with regards to the Ministry of Natural Resources and Environment, the Ministry of Natural Resources and the Department of Environment under the Ministry of the Presidency create instability and hinder instead of strengthening the very much needed efforts for better coordination between different government agencies.

SECTORIAL ISSUES

BIODIVERSITY

Guyana lacks a formal system to strategically integrate biodiversity into sectorial and cross-sectorial plans, programmes and policies and eventually the work-plans of sector institutions. However, over the years biodiversity issues have been considered in development planning across the sectors, in particular, forestry and mining. This level of mainstreaming, although limited, occurs on a case by case basis and, in particular, at the level of developmental project planning and collaboration.

The environmental impact assessment process is currently the only mechanism that facilitates, although limited, biodiversity integration into the sectors within the environmental management context. The Environmental Protection Act 1996 and its Environmental Management Regulations 2000 stipulate the legislative requirement for environmental authorisation for any new development activity that may have significant impacts on the environment and, as a consequence, may affect biodiversity. The sectors regulated are mining, forestry, agriculture, infrastructure, energy, tourism and fisheries. As a result of the EIA process there is strengthened collaboration among the sector agencies, in particular the forestry and mining sectors. This coordination has resulted in forestry permits and mining licenses being contingent on receiving environmental authorizations and by extension, there is increased regulation of development activities based on increased awareness among sector agencies on environmental issues, inclusive of threats to biodiversity.

Taxonomic data is currently restricted to accessible areas or limited. There is limited long term planning for taxonomic work. Research into various taxa and ecosystems occur on a needs basis and are highly response oriented for most institutions. Additionally, some taxonomic studies have been done on vascular plants and fungi but there’re limited or no information on lower plants and most invertebrates. Taxonomic data can be found on fishes, amphibians and reptiles and while these are geographically limited, for example, there is no knowledge of what pertains in the Upper Berbice, Upper Demerara Region, New River Triangle, Pakaraimas, for some taxa. Further, the marine environment is one of the least researched areas and requires substantial study.

CLIMATE CHANGE

Guyana has made considerable efforts to address the issues associated with climate change and is committed to implementing the UNFCCC. Climate change continues to be a priority issue for the GoG especially as it advances efforts towards the development of a Green Economy to sustain economic prosperity, environmental security and social well-being. Some strategies supporting this vision include the Climate Resilience Strategy and Action Plan for Guyana (draft), Low Carbon Development Strategy, and the Second National Communication to the United Nations Framework Convention on Climate Change, the National Integrated Disaster Risk Management Plan, and the National Adaptation Strategy to Address Climate Change in the Agricultural Sector.

Guyana's commitment has been further demonstrated in its Nationally Determined Contribution to the UNFCCC whereby the country has committed to transforming its energy profile by increasing its share of renewable energy by 100% by 2025 and expanding its system of protected areas through the conservation of an additional 2 million hectares.

The strengthening of the Hydrometeorological Services Department for improved climatological monitoring and forecasting and capacity building in the area of climate modelling should be a priority as Guyana is particularly vulnerable to climate events. For this same reason, over the past years the GoG has been promoting awareness of climate change, especially along the coastal regions to ensure some basic understanding of the issues.

WATER

An overarching operational and administrative organisation responsible for all water management matters should be established. Consideration is being given to set up a National Water Agency responsible for integrated water resources management and this should be explored further, in particular, as it relates to merging the water resource function (currently under the Hydrometeorological Services Department based on the Water and Sewage Act 2002) with the functions of the Water Council to allow for the establishment of the National Water Agency. An overarching institution is important so as to reduce the disconnect in the management of and access to information related to water resources and water quality, inclusive of overlapping functions and mandate.

In the short-term it is critical for the members of the National Water Council to be identified and appointed to allow for the establishment of the Water Council. The Council is charged, under the Water and Sewage Act 2002 among other functions, to develop the National Water Policy, which should be its immediate priority.

With regards to information, an effort was made during the production of this State of the Environment Report to systematize existing information previously gathered. This effort covers some particular gaps, but it also points out to the importance of not only collecting data but also of coordinating and maximizing data collection and processing financial and human resource efforts. Different government and non-government institutions gather data in different geographical areas and for different goals. It is important to systematize efforts in order to obtain better results for the same collective investment.

WASTE

Uncontrolled waste disposal and its associated pollution and health problems is a major concern at the national level. As it happens with other environmental areas or topics (as pointed out throughout the SoE Report), there is very little and fragmented information on waste characterization. The most recent waste characterization dates to 2010 and concrete studies as far back as 2004. With this data, the national authorities have had to extrapolate to estimate waste production at the national level.

The country has the “Draft National Waste Management Strategy” for the Cooperative Republic of Guyana 2013-2024 as well as the Draft Solid Waste Management Bill of 2014. The goal of the Strategy is to have ten (10) Regional Waste Management Plans in place aligned with the National Solid Waste Management Strategy. At the time of preparing the SoE 2016 the drafts were still undergoing public review processes. It is imperative to have the Waste Management Strategy up and running and to develop and implement the Regional Waste Management Plans with the most up to date information.

FORESTS, AGRICULTURE AND MINING

Guyana´s economy is strongly tied to production and export from the primary sector, particularly agriculture, forestry and mining. The continued development of these activities is an integral part of Guyanese society and fundamental for its economic and social well-being. This heavy dependence of the primary sector also speaks about the importance of sustainably manage the natural resources of the country.

The existing efforts to better coordinate the exploitation of natural resources should continue and deepened. This includes monitoring and enforcing efforts by government agencies to ensure that natural resources are used efficiently and sustainably.

During the review of existing documents and analyses it became clear that most existing scenarios consider that mining, forestry and agriculture will likely geographically expand in the near future. With it come a great opportunity to develop and also risks to natural resources and local and indigenous populations.

The possibility of expanding the geographical coverage of existing exploitations should not hinder efforts to conduct genetic research on agriculture and beef production, climate models and information production and analysis to decouple economic growth from the expansion of the development frontier.

This State of the Environment Report presents some first set of data on priority environmental issues that can be used in the future to develop more extensive State of Environment Reports for Guyana. By pointing out to existing gaps, it also sets the basis for additional work in different areas that have been prioritized during the consultation phase. It should be noted that the issues raised and prioritized during the consultation phase for the report coincide with the issues highlighted during the process for the development of the strategic plan of the MoNRE three (3) years ago. The main issues have been identified, now it is time to use existing information and analysis to continue improving the management of natural resources; and to focus research efforts in covering identified gaps.