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Green State Development Strategy VISION2040

GUYANA

GREEN ECONOMY MODELLING STUDY

Informing the Green State Development Strategy- Vision 2040: An Initial Analysis of Selected Green Economy Investments in Agriculture, Forestry, Energy and Road Infrastructure

Summary for Policy Makers

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A *Summary for Policy-Makers* is prepared by Simon Lobach on the basis of the original technical modelling report by Andrea Bassi.

FOREWORD

Guyana has long sought to diversify its economy and capitalize on the benefits of economic stability and job creation. However, the high dependence of the Guyanese economy on the production and export of a limited number of agricultural products and extractive industries – specifically bauxite, gold, sugar, rice and timber¬ – has not only made the country extremely vulnerable to global fluctuations in commodity prices, but also triggered socio-economic problems like unemployment and emigration.

With a growing number of youths entering the labour market and an unemployment rate of 12%, Guyana is one of the Caribbean nations most affected by skilled labour-force migration. The so called 'brain drain' threatens to hamper the future economic development of the country.

Today it is crucial that all efforts are put together to build a prosperous economy that works for the interest of the people, addressing the challenges of unemployment, emigration and economic stagnation, while at the same time ensuring that this economic growth is sustainable and respectful of the country's vast natural wealth. One of Guyana's most valued national endowments is its forest area, which covers 87% of the country's territory and is essential to the conservation of species and ecosystems. This rich biodiversity area serves as a natural carbon sink and plays a key role in adapting to and mitigating the impacts of climate change, for example by reducing risks from natural hazards for the low-lying coastal areas of Guyana and the livelihoods they support.

The timing for a shift in the country's growth strategy is auspicious, coinciding with the recent discovery of substantial oil reserves, the recent debt reliefs under the Highly Indebted Poor Countries initiative, and the entrance into the Caribbean Single Market and Economy. The Government of Guyana has an historical opportunity for using this economic windfall for the building of a sustainable development path that ensures future opportunities for the people of Guyana to thrive in non-oil sector markets, when petroleum resources come to an end.

It is in this context that the Partnership for Action on Green Economy (PAGE) has been providing analytical and technical support to guide the development of the "*Green Economy Modelling Study*". The study is intended to be a summary for policy-makers that resulted from broad public private engagement, followed by intensive consultation processes with expert groups. The priorities identified have been selected as the most effective investment sectors to deliver on the associated targets to the *Green State Development Strategy: Vision 2040* (GSDS) and the Intended Nationally Determined Contributions (INDCs). In that regard, systems dynamics modelling provides a credible decision-support tool for implementing the GSDS over the long term.

The study serves to inform the actions of the Government of Guyana to achieve the emissions reduction commitments of the country under the climate agreement. It will also effectively support the main objectives of the GSDS, such as increasing economic diversification and growth, social inclusiveness, and sustainable management of natural resources. Specifically, the modelling study provides evidence of how green policies can have positive economic, social and environmental impacts in four of the country's main economic sectors. For example, investments in more sustainable agricultural practices and energy efficiency, as well as investments in Reduced Impact Logging (RIL) and the construction and maintenance of a sustainable transport road infrastructure; result in increased annual GDP growth, higher carbon sequestration, price premiums, higher yields, economical savings and more job opportunities for the Guyanese people.

On the basis of the initial feasibility findings of the *Green Economy Modelling Study*, it is therefore hoped that policy-makers will have the impetus and confidence to invest and pursue the identified green economy initiatives, as well as continuous capacity building in the country. It is in this context that PAGE expresses its full support to Guyana in its new beginning and forward steps towards reframing economic policies and practices around sustainability to advance the 2030 Agenda.

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LIST OF ACRONYMS

BAU	Business As Usual
EE	Energy Efficiency
GDP	Gross Domestic Product
GE	Green Economy
GEMS	Green Economy Modelling Study
GHG	Greenhouse Gas Emissions
GRIF	Guyana REDD Investment Fund
GSDS	Green State Development Strategy
GuySuCo	Guyana Sugar Corporation
GYD	Guyanese Dollar
HA	High Ambition
ITTO	International Tropical Timber Organization
LA	Low Ambition
LCOE	Levelized Cost of Electricity Generation
O&M	Operations & Maintenance
PAGE	Partnership for Action on Green Economy
PV	Photovoltaic
RAP	Recycled Asphalt Pavement
REDD	Reducing Emissions from Deforestation and forest Degradation
RIL	Reduced Impact Logging
SCC	Social Cost of Carbon
SD	System Dynamics
SDGs	Sustainable Development Goals
UN	United Nations
USD	United States Dollar

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This Study informs the elaboration of the *Green State Development Strategy: Vision 2040*, which is expected to become the main policy tool for ensuring that Guyana's development pathway increases economic diversification and growth, social inclusiveness, and sustainable management of the natural resources, in line with the objectives formulated under the Sustainable Development Goals (SDGs). Through the Strategy and the recommended policy instruments, such as the establishment of the Natural Resource Fund, the income generated by the public sector from the newly discovered oil reserves can be reinvested in green policies, which will benefit all Guyanese, including future generations.

Guyana's Green Economy Modelling Study (Guyana's GEMS) has been conducted to assess the economic, social and environmental impacts of a selection of such green policies. Guyana's GEMS makes use of System Dynamics modelling to test how a transfer of investments from Business-as-Usual (BAU) to Green Economy (GE) policies affects a range of economic, social and environmental indicators. For the purpose of this study, four priority sectors have been identified, where the impact of selected green policies has been evaluated up to the year 2040.

By investing 2.7% of GDP in greening the economy, between 2018 and 2040, Guyana can improve economic, social and environmental performance. GDP is forecasted to be 28% higher than BAU by 2040, with cumulative benefits amounting to GYD 5.63 trillion (the equivalent of approximately 10 years of current GDP, or GYD 7.19 million per person when considering today's population); 15% more jobs created; and water consumption, timber extraction and carbon intensity of the economy all significantly reduced.

- **Agriculture sector.** Investments in more sustainable agricultural practices require additional investments of GYD 417.6 billion. These investments have been shown to lead to cumulative savings of GYD 74.3 billion in water expenditure, as well as to higher yields, with an additional accumulative value of GYD 3.92 trillion between 2018 and 2040, an amount almost 10 times larger than the investment required. The share of land under sustainable management practices is assumed to increase linearly from 0% in 2018 to 10% or 36% by 2030, depending on the scenario. Total cumulative water consumption in the sector will be between 8.9% and 5.2% lower compared to the baseline.

- **Forestry sector.** The implementation of Reduced Impact Logging (RIL) on 1.88 million hectares of logging concessions requires an investment of GYD 104.9 billion. This will lead to a cumulative reduction of forest sector GDP of GYD 41.5 billion between 2018 and 2040, but increased carbon sequestration by an economic value of GYD 20.46 trillion. Timber extraction in the Green Economy scenario can be 23% lower in 2040, compared to the BAU scenario.

- **Energy sector.** Additional investments in energy efficiency for electricity use totalling GYD 235 to 469.1 billion between 2018 and 2040 lead to avoided costs for power capacity of GYD 157 billion, and an additional GYD 123 billion in avoided energy expenditure, as well as to additional economic growth and job creation. However, these positive economic impacts, created by these and other GE investments, cause energy consumption and expenditure in the GE scenario to be close to GYD 2.4 trillion above the BAU case. This means that the modelled energy efficiency investments, as they only take electricity use into account, are not sufficient to reduce total CO^2 emissions. However, carbon intensity (emissions per unit GDP) does go down.

- **Transport Road Infrastructure sector.** The construction and maintenance of a sustainable road network, using Recycled Asphalt Pavement, would require an additional GYD 34.1 billion, but yield cumulative savings of GYD 89.3 billion in material cost over the lifetime of the infrastructure. This is a saving for the government that is three times higher than the investment required. The construction of green roads with permeable pavements could yield significant additional savings. The use of recycled materials reduces the need for virgin materials by approximately 13.5 million tons, or 16.2% compared to the baseline.

- **Education and health.** Even if these two sectors are not explicitly featured in the model, some forecasts about the potential impacts of Green Economy interventions in these sectors can be made. For example, the increased budgetary expenditure for education infrastructure under a Green Economy scenario could increase the number of schools and teachers, improve access to education, and increasing labour productivity. This would stimulate the industrial and services sector, while improved literacy could lead to increased technology uptake. Similarly, Green Economy interventions could also increase budgetary expenditure in the health sector; but in this sector a bottleneck has been identified, as Guyana is facing a shortage of qualified health personnel. Strategic investments in the health sector would be required to tackle this bottleneck, to increase labour productivity in the sector, and to reduce per capita health expenditure.

INTRODUCTION

Guyana is a middle-income country in South America, with a total surface of 214,970 km^2, a population of 777,859 (2017) and a per capita income of US$4,693 (2017, Atlas method). Well-endowed with natural resources, such as fertile agricultural lands, bauxite and gold, the country has an extensive tropical forest cover of more than 80 percent of the country's territory. Agriculture and natural resources are important sources of economic activity in Guyana. In 2016, agriculture, forestry, fishing and mining accounted for about one third of GDP. Gold mining was growing rapidly and accounted for 48 percent of exports. Bauxite, sugar, rice, shrimp and timber are also important export sectors (World Bank, n.d.).

Guyana's growth in Gross Domestic Product (GDP) has been highly volatile over the past decades, settling around 3% over the last few years. Reasons for this volatility have been geopolitical events, natural disasters and global commodity price swings. Given the reliance of its economy on primary commodities, the economy has had little opportunity for diversification. Guyana has an unemployment rate of 12% (World Bank, n.d.), with few opportunities for young people to find jobs. As a result, emigration is very significant. In 2013, it was reported that 463,000 Guyanese resided out of the country, against only 11,000 foreign nationals in Guyana. Since 1992, the average emigration per year has been 10,000 individuals, turning Guyana in one of the Caribbean nations most affected by emigration. Its emigration patterns have led to a 'brain drain', as many highly-skilled professionals are among those who decide to leave the country.

The recent discovery, in 2015 and 2018, of very significant oil reserves (an estimated recoverable resource of more than 4 billion oil-equivalent barrels discovered to date; ExxonMobil, 2018) has put Guyana at a critical point in its history, providing it with the opportunity to shift its development path, modernize its economy and transform the lives of its citizens. In order to capture the full benefit of this discovery, it is imperative for Guyana to chart its course of development in a way that is inclusive, sustainable and respectful of the country's national endowments.

The *Green State Development Strategy – Vision 2040* is the outcome of a long consultative process involving a variety of different stakeholders in Guyana, which included 7 thematic expert working groups involving 92 different agencies, as well as 33 national consultation cluster meetings held across the 10 regions of Guyana, involving 208 communities and local democratic organs, with 1,629 total participants. Moreover, the Partnership for Action on Green Economy (PAGE) conducted a number of technical workshops, including on systems dynamics modelling.

The *Green State Development Strategy – Vision 2040* provides a comprehensive set of strategic policy priorities to guide public investment over the next 20 years. This objective is broader than Guyana's past development strategies and captures a more holistic view of social, economic and environmental well-being, in line with the United Nations' Sustainable Development Goals (SDGs). In particular, it not only aims to foster sustained economic growth that is low-carbon and climate-resilient but also to promote social cohesion, good governance and careful management of finite natural resources.

Green Economy investments have many facets, being capable of supporting simultaneously goals of economic development, social empowerment and the improvement of the quality of ecosystems. Green economy interventions allow the realization of such results in synergy. For instance, investments in resource efficiency can lead to reduced consumption and therefore lower the extraction of natural resources and the pressure on the environment, while at the same time freeing up resources for consumption and investment, triggering technology adoption and leading to employment creation.

However, the socio-economic and environmental dynamics triggered by Green Economy investments are complex. This is because investment outcomes include direct, indirect and induced impacts across sectors, affecting social, economic and environmental indicators, as well as different economic actors, and these outcomes change over time. This complexity leads to synergies, as mentioned above, but could also lead to the emergence of undesirable impacts, such as in the case of a rebound effect.

For this reason, a modelling exercise was conducted to assess the outcomes of selected Green Economy investments in Guyana, using a system dynamics approach. The analysis should be considered exploratory, as it focused only on four main sectors (agriculture, forestry, energy and road transport infrastructure), and aggregate economic and environmental performance. The outcomes of Green Economy investments in education, health, and many other economic sectors were not considered in this initial exercise. As a result, we are currently undervaluing both the investment required and the socio-economic and environmental outcomes of the implementation of these Green Economy Investments.

It should be understood that the methodology used for this exercise – the System Dynamics approach – is applied to analyse multisectoral effects for strategic national planning (i.e. assessing multisectoral outcomes of Green Economy investments). This approach needs to be complemented with other analytical approaches that are better suited towards a more detailed quantification of outcomes of policies in the short term (e.g. impacts on employment, water, energy, land use, etc.). Indeed, System Dynamics is used to create simplified sectoral models that are based on well-established sectoral modelling methods, with the advantage of showing systemic impacts (across sectors and economic actors) of policy interventions. The use of other approaches is recommended in order to gain a more complete understanding and a more accurate quantification of the impact of green economy policies and investments at both the multisectoral and thematic levels.

The results of this initial effort are presented in this Synthesis Report and have helped to guide the elaboration of the *Green State Development Strategy: Vision 2040*, shedding light on, and making more tangible, the possible outcomes of Green Economy investments in Guyana.

1.

BRIEF SECTOR ANALYSIS

This modelling exercise focuses on four priority sectors and priority areas, which have been defined through a consultation with multiple Ministries and other representatives of the Government of Guyana. The modelling was also developed in the context, and as part of the elaboration of the *Green State Development Strategy: Vision 2040*, in close collaboration with the relevant stakeholders in Guyana, including the Inter-Ministerial and Multi-Stakeholder Advisory Committee.

1.1 Agriculture

Agriculture is one of the most important sectors of the economy of Guyana. In 2012, agriculture accounted for approximately 21% of GDP, employed about 33% of the country's workforce and contributed almost 40% of the national export earnings. Agriculture and agro-processing in Guyana consist mainly of sugar, rice, and fruits and vegetables, and to a lesser extent, fish farming. Agricultural activities occupy about 8.5% of the national land area – the majority conducted on the narrow low-lying coastal strip where the most fertile non-forested lands exist. The coastal region is equipped with Drainage and Irrigation (D&I) systems that include about 500 km of main irrigation canals, 1,100 km of secondary irrigation canals, 500 km of main drainage channels, and 1,500 km of secondary drainage channels supported by kokers and sluices. Due to the risk of floods on the Coast, agriculture development will require further investments in drainage and irrigation, which will increase production costs.

At present, there isn't any incentive for commercial production and export of organic foods from Guyana. Except for heart of palm, organic farming in Guyana is done at subsistence or at very small semi-commercial levels. Furthermore, the technical capacity for commercialized organic farming does not exist within the country. In recognition of these weaknesses and the export potentials of organic food production, the Ministry of Agriculture has included organic farming as a component of the National Strategy for Agriculture 2013–2020 (Ministry of Agriculture, n.d.). The activities for organic agriculture as outlined in the strategy include: i) to implement training programmes for integrated soil management using organic matter inputs; ii) to increase by 50% the amount of natural organic products coming from the hinterland; iii) to develop a national organic certification system; and iv) to identify and promote the production of natural stands of organic cocoa and honey in the hinterland areas.[1] Other than floods and limited technical capacities, another barrier to agricultural development in Guyana is limited access to finance, high interest rates on loans and short pay-back periods.

1.2 Forestry

Forests cover more than 87% of Guyana's national land area and create around 8% of its national GDP. Since 2010, Guyana's Low-Carbon Development Strategy has attracted foreign funding under the Guyana REDD+ Investment Fund (GRIF) to protect Guyana's forests. Even though this scheme has had a positive impact on the protection of Guyana's tropical rainforest, producers in the forestry sector have had little incentive to switch to sustainable practices. In addition, regulatory change is needed to increase the productivity (and added value) of current concessions and the recovery rate of extracted logs.

This modelling exercise looks at the possibility for Guyana to increase its share of Reduced-Impact Logging (RIL), which has been defined by the International Tropical Timber Organization as 'the intensively planned and carefully controlled implementation of timber harvesting operations to minimize the environmental impact on forest stands and soils'.[2] Conventional timber harvesting in Guyana is selective, and as a result logging intensities remain low. On average, 2–3 trees are felled per hectare, with an average yield of about 7 m^3. This extraction rate is less than half the maximum allowable cut of up to 20 m^3 per hectare in a 60-year cycle, as listed in the national forest plan guidelines. However, harvesting methods results in soil compaction and damage to nearby trees, whilst inhibiting the regeneration of seedlings that survived during felling. In the 1990s, RIL techniques were introduced into Guyana to address the environmental damage associated with timber harvesting. The core activities of RIL may be summarized as follows: careful planning of roads and all other interventions, including plans for the use of every machine; directional felling of trees to avoid damage to nearby trees; control over every aspect of the logging operation to manage costs and conserve the environment; occupational safety and health/worker welfare, cutting of vines and lianas that would pull down nearby trees along with those felled; and reduction in wastage.

In practice, RIL has shown to reduce skidder damage by as much as 50%, and the average size of logging gaps by 40% (Van der Hout, 2000). Though more expensive to implement than conventional logging, the RIL techniques yield greater economic and environmental benefits in the long term. In Guyana, RIL is the approved practice for sustainable forest management. The GFC through the Forest Training Centre Incorporated provides training to concessionaires, including Community Forest Organisations, on the implementation of the technique.

1. Guyana's National Agriculture Development Strategy 2013-2020

2. ITTO website, www.itto.int/feature15/.

1.3 Energy

In 2016, 85% of Guyana's total installed power generation capacity consisted of fossil fuels, whilst renewable sources, including biomass (bagasse and rice husk) and small installations of solar PV and wind turbine systems account for 15% of installed capacity. It is estimated that the transportation and power (electricity) sectors consume three quarters of total imported petroleum products; with the latter being the country's largest energy user (36%); followed by the transportation sector (35%); agriculture, fishing and mining (21%); the residential sector (4%); and industry/manufacturing (3%).

Guyana is highly dependent on imports of fossil fuel for its energy needs in the power and transport sectors. For its energy security, the transition to renewable and clean energy should rely more on the country's natural wealth than on imports. This includes the use of natural gas, hydro- and solar power, biomass and wind. By 2035, the government has set the target to reach 63% of the country's power supply from renewable energy sources. The shortfall from the original goal of 'near 100%' does not completely remove the ambition but rather takes into consideration the local realities of making the renewable transition (e.g. remoteness and lack of infrastructure) in hinterland areas. In 2035, the Government must review and re-evaluate the progress of the transition and recommit to the 'near 100%' objective.

Per capita electricity consumption in 2016 was on average 1,069 kWh, putting Guyana well below the average for other upper middle-income countries (3,404 kWh/capita). Power supply capacity is in excess of demand by less than 15%. 82% of the population is connected to the national grid, with the highest concentration in urban areas. 30% of the non-grid-connected rural population has access to electricity through Government of Guyana initiatives that promote photovoltaic installations. Guyana's electrical grid has insufficient or low redundancy in power generation, which makes it unreliable, unstable and costly to maintain. As a result, the country faces high energy costs, as well as technical and commercial power losses.

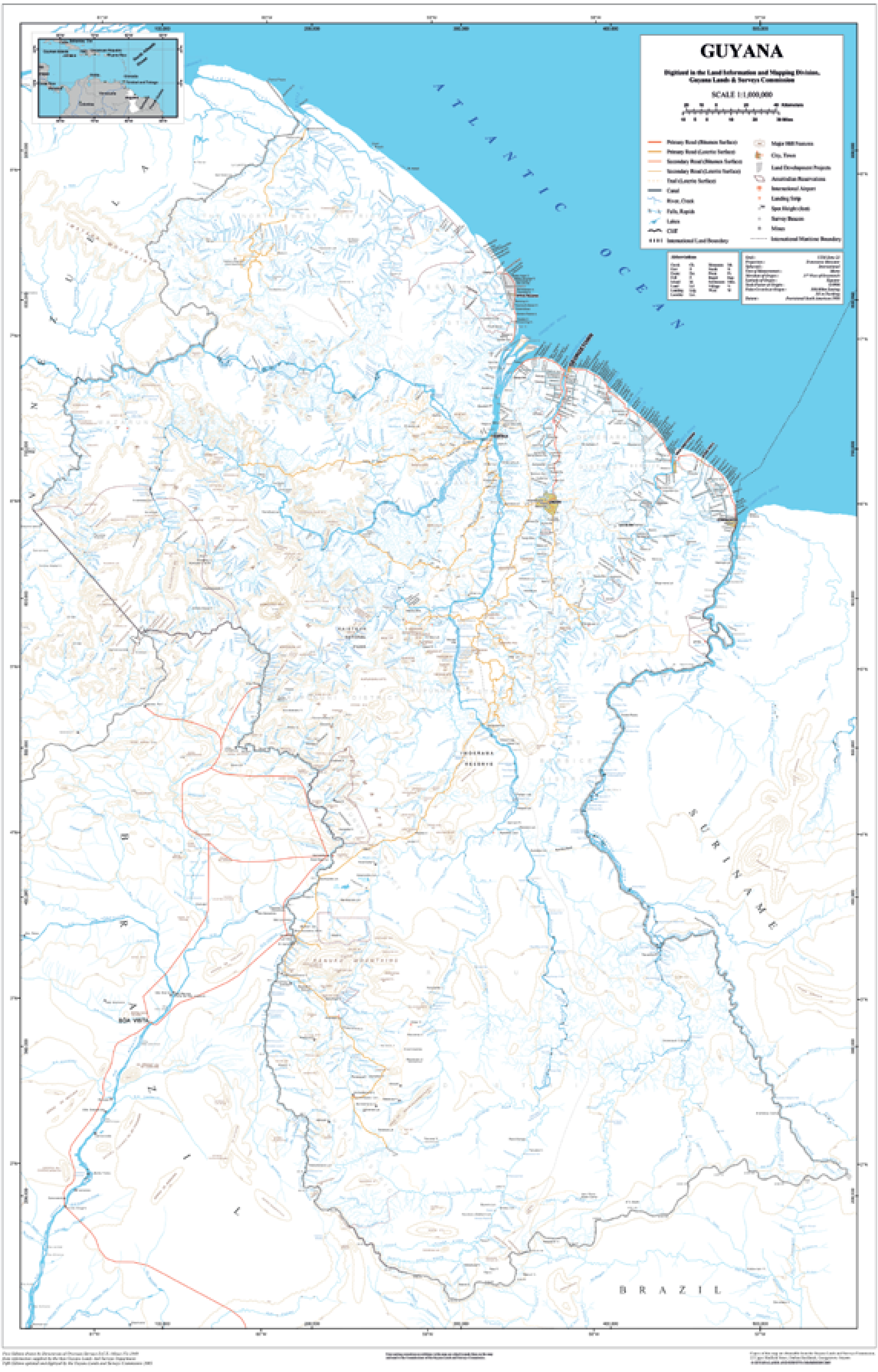
1.4 Road Infrastructure

Land transport is still limited in Guyana and pavement is mostly restricted to the coast, with a few roads penetrating into the hinterland along rivers. The main roads along the coast and those along the river banks are paved and account for one third of the network, whereas hinterland roads are unpaved and account for two thirds of all roads in the network. The general condition of these unpaved roads varies, but in general they all display varying levels of distress such as poor drainage, improper cross sections, rutting, potholes and excessive dust. During prolonged rainy seasons, the unsurfaced roads usually experience significant deterioration, which is partly due to inadequate drainage.

A number of key constraints and opportunities for improvement have been identified:

- River crossings are key constraints on the road network. Bridges on the coast are currently congested and require upgrading.
- There is a need to customize interventions in land transport according to the needs of each regional network.
- It is necessary to increase the investment in the development of the coastal network, and in the reduction of congestion within this network.
- There is a need to improve transport links inland, to the mining networks around Bartica (West Network) and Linden (East Network), and establish a robust Southern Network linking Lethem at the Brazilian border with the rest of the country.

| FIGURE 1: MAP OF GUYANA **|**



Source: Guyana Lands and Surveys Commission

2.

OVERVIEW OF THE GREEN ECONOMY MODELLING FOR GUYANA

The methodology used for the creation of the quantitative sectoral and macroeconomics modelling presented in this report is called System Dynamics (SD) (Forrester, 1961; Sterman, 2000). SD is a methodology that uses causal relations, feedback loops, delays and non-linearity to represent real-life complexity. SD models run differential equations through the explicit representation of stocks and flows. In the context of this Green Economy assessment, the use of SD facilitates the accounting of the various benefits that can be accrued over time by implementing Green Economy policy interventions (or reaching GE targets) across broadly defined sectors and economic actors (Probst & Bassi, 2014; UNEP, 2014). Since SD can provide approximate long-term trends in aggregate economic and environmental dimensions, more accurate predictions of the outcomes of policies (for instance on employment, water, energy, land use, etc.) should be obtained with more disaggregated modelling approaches. Using SD for multisectoral analysis in conjunction with more detailed modelling tools would allow policy-makers to benefit from the complementarity of the approaches, obtaining an understanding both of the long-term patterns of Green Economy investments and a more accurate quantification of economic, social and environmental variables.

The creation of a SD model follows an iterative five-step process: (1) problem identification, (2) dynamic hypotheses (system mapping), (3) formal model development, (4) validation and (5) simulation of alternative scenarios (Sterman, 2000). These five steps are closely related to the five steps of the integrated policymaking cycle developed by UNEP (2009), and show how SD can be used to inform various stages of the decision-making process. Specifically, SD highlights the role of feedback loops in shaping trends and allows for the anticipation of potential synergies and side effects. Coupled with scenario analysis, SD can be used to test exploratory scenarios as well as to test existing policy proposals. As such, SD models do not optimize performance; instead, these models simulate "what if" scenarios. The result is an assessment of the likely outcomes of policy implementation (desired and undesired), which can inform the formulation of complementary policy options for long-term sustainability – as they have been used, in this case, to inform the elaboration of the Green State Development Strategy.

For more information on Green Economy Modelling, please click here: www.un-page.org/files/public/20170728_report-layout-online.pdf.

2.1 Green Economy scenarios

A System Dynamics model was created to assess the potential outcomes of reaching GE targets in Guyana. This model includes several interconnected sectors, starting with the macroeconomic module (including GDP, households and government accounts), which is directly affected by agriculture and forestry, and indirectly (through productivity) by the energy sector and infrastructure. These core sectors of the model are described next. Additional sectors are included in the model to operationalize the integration of the ones mentioned above. Examples are population, land use, and emissions from energy and land.

The Guyana Green Economy System Dynamics model is used to simulate several Green Economy

(GE) scenarios and compare them against the Business-as-Usual scenario (BAU). The BAU scenario is defined as a "no action scenario", in which historical trends continue into the future. The GE scenarios are simulated to assess the impact of the individual interventions and targets, as well as their combined implementation.

Table 1 below presents the assumptions used for the sectoral GE scenarios. Apart from comparing the BAU scenario with a GE scenario, both scenarios are also considered in a "High Ambition" (HA) and a "Low Ambition" (LA) case. The high ambition scenario includes (i) higher expansion of crop land (100% in the HA case and 25% in LA case), (ii) higher efforts to adopt sustainable agriculture practices (36% instead of 10%), (iii) lower post-harvest losses (with a reduction of 20% instead of 10%), (iv) higher energy efficiency improvements for electricity consumption (5% per year instead of 2% per year). The assumptions for each of these four scenarios are outlined in Table 1 below.

| TABLE 1: SCENARIO ASSUMPTIONS FOR GUYANA'S GREEN ECONOMY MODELLING STUDY **|**

Ambition	Scenario	Land expansion	Share sustainable farming practices	Post-harvest treatment	Road construction	RIL	Additional value added RIL	Deforestation	Expansion of power generation capacity	Annual EE improvement	Oil production
Low (LA)	BAU	25%	0%	0%	1000km	0%	0%	Yes	Case 1	1%	Steady (120,000bbl/day)
	GE	25%	10%	10%	1000km	40%	30%	No	Case 1	2%	Steady (120,000bbl/day)
High (HA)	BAU	100%	0%	0%	1000km	0%	0%	Yes	Case 1	1%	Steady (120,000bbl/day)
	GE	100%	36%	20%	1000km	40%	30%	No	Case 1	5%	Steady (120,000bbl/day)

Table 1 shows developments projected on the year 2040 and compares a BAU scenario with a GE scenario both in a setting of low and high ambition. For example, both the BAU and the low-ambition GE scenario assume a land expansion of 25% between now and 2040, but the GE scenario, on top of that, assumes that 10% of the agricultural sector will practice sustainable farming and reduce post-harvest losses by 10%, while 40% of the forestry sector will practice Reduced Impact Logging (RIL), etc. The numbers in the table serve as assumptions for Guyana's Green Economy Modelling Study (Guyana's GEMS) and are then used as the basis to calculate their impact on other segments of the economy. The full technical report of Guyana's GEMS includes a variety of models and scenarios for the different sectors, but in this summary report, the results are presented for the four scenarios represented in Table 1. It has been assumed that land expansion could reach 25% or 100%. As a result, two simulations were created for both the BAU and Green Economy scenarios, to ensure that these scenarios are compared coherently (i.e. using the same underlying scenario assumptions, with the only difference being policy ambition and related investments). For this reason, Table 1 distinguishes two different BAU scenarios, but the land expansion is the only difference between them.

The policy of having 40% of the forestry sector practicing RIL has been modelled under two different assumptions: one in which the price of timber remains unchanged by the production method, and one where a price premium of 30% is obtained as a result of the sustainable production method. Oil production and road construction are assumed to be stable across the four scenarios. The factor land expansion, which refers to increasing cropland available for agricultural production, is assumed not to be different in a BAU or a GE scenario, but to depend solely on the level of ambition for the growth of the agricultural sector. The column "expansion" refers to the two scenarios for power expansion that were modelled, among which Case 1 was deemed to be more realistic (Case 2 is discussed in the full technical report, but not in this Summary report).

Below, the different feedback loops are presented that have been used to estimate the effect of policy changes from a BAU to a GE scenario on other segments of the economy, including economic, but also social and environmental indicators. The magnitude of the relation between different indicators is based on historical data. Relations have either received a + or a - sign, which indicates whether there is a positive or a negative correlation between the two factors.

Below, the causal loop diagrams are presented for the macroeconomy, as well as for the four sectors included in Guyana's GEMS: Agriculture, Forestry, Energy and Road Infrastructure.

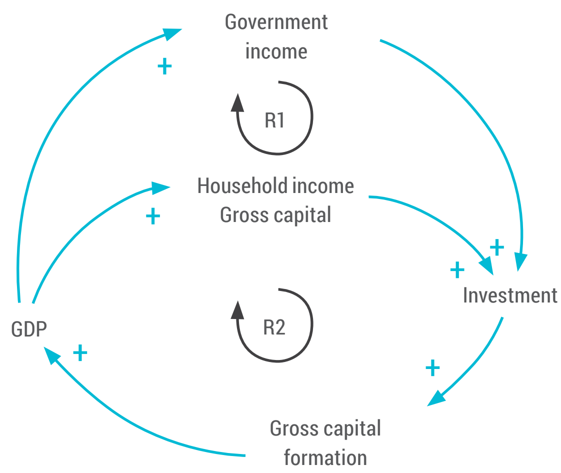
Box 1 : How to read Causal Loop Diagrams

- A causal link from variable A to variable B is positive (+) if a change in A produces a change in B in the same direction; a causal link from variable A to variable B is negative (-) if a change in A produces a change in B in the opposite direction. Example: a plus sign means that: the more demand, the more production, but also: the less demand, the less production. A minus sign stands for: the more production costs, the less profits.
- Feedback loops, represented in the diagram with R or B sign surrounded by a circular arrow, can be classified as positive or negative. Positive (or reinforcing) feedback loops amplify change and are typically identified by a 'R' notation, while negative (or balancing) counter and reduce change are identified by a 'B' notation.
- Black variables are relevant indicators of sectoral performance; orange variables represent policy interventions and related policy assumptions; and grey variables are a copy of others already in the diagram, to simplify the view and avoid the crossing of arrows.

2.1.1 Macroeconomy

At the macroeconomic level, we can identify two reinforcing feedback loops (R1 & R2) (Figure 1). The first loop (R1) represents the government revenues (or government income) and investment loop. Improving economic conditions lead to a higher GDP, which increases government revenues. The more budget the government has at its disposal, the more investment (gross capital formation) will flow through the economy and accumulate in capital (e.g. infrastructure). The second reinforcing loop (R2) represents the household income and investment loop. It follows the same logic of public investment, but it represents investment from the private sector. Similar loops can be found for employment creation, and its contribution to production and consumption. A third reinforcing loop involves productivity, which increases with improvements in education, health (impacted by public expenditure), as well as with changes in energy intensity and technological improvement.

| FIGURE 2: CAUSAL LOOP DIAGRAM – MACROECONOMIC LEVEL **|**

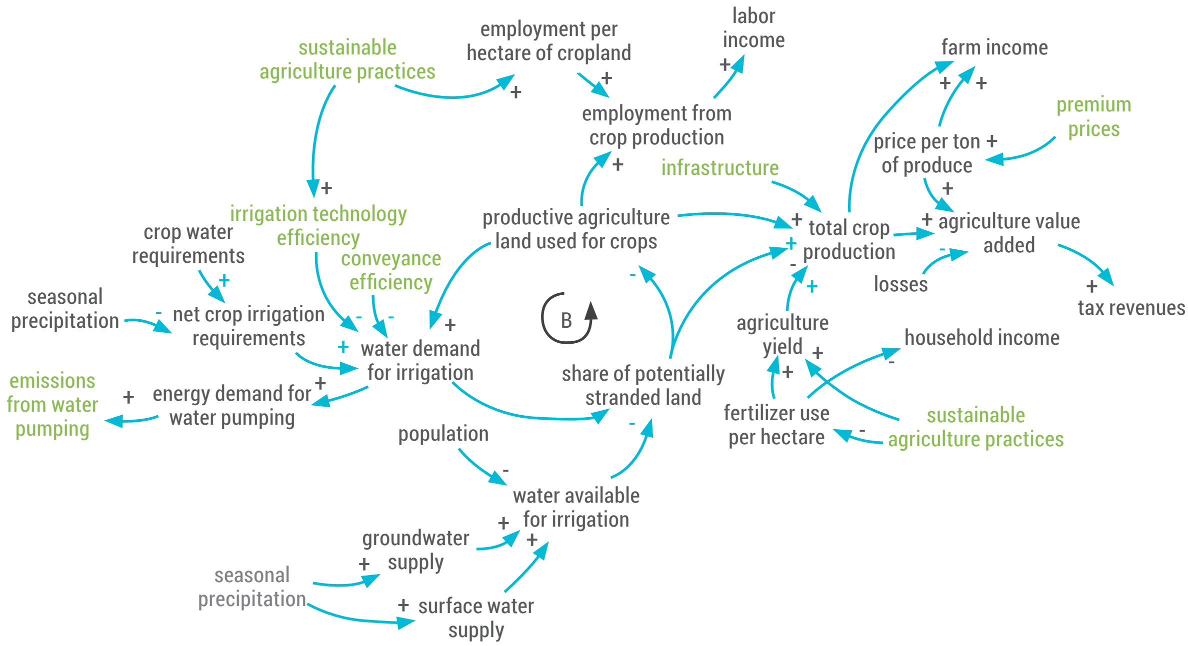


Source: Author's Own representation.

2.1.2 Agriculture

The dynamics of the agriculture sector are driven primarily by one balancing feedback loop (B1), which affects the change in agriculture land used for crop production (Figure 2). The desired amount of cropland depends on population and yield. If the desired amount of cropland is higher than the current amount of cropland, the loop (B1) causes cropland to adjust to the desired levels. Total production, employment and fertilizer use for crop production are determined on the basis of total cropland. Crop production depends on the amount of land used for each crop type and the respective yield per crop, as well as crop losses. The use of fertilizer is assumed to have a beneficial impact on agriculture productivity, while raising costs for production and negatively impacting water quality. Agriculture value added is influenced by production and by its value, which is assumed to be higher for sustainable production due to premium prices for certified production.

| FIGURE 3: CAUSAL LOOP DIAGRAM – AGRICULTURAL SECTOR **|**

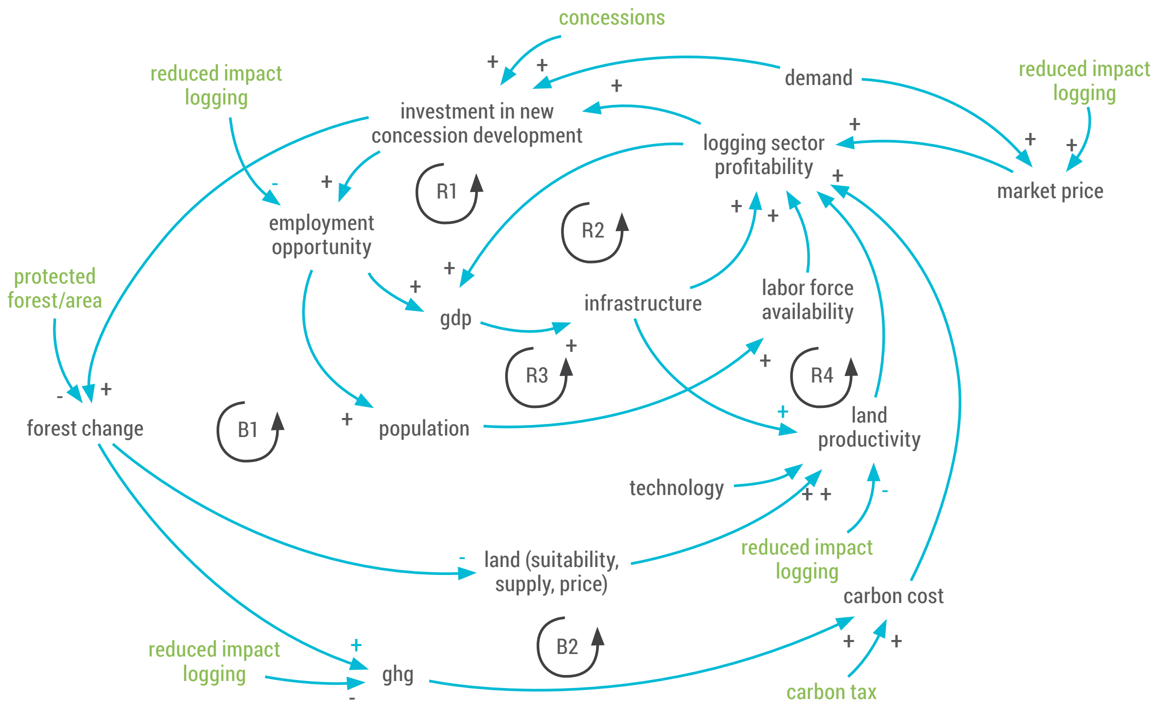


Source: Own representation.

2.1.3 Forestry

Figure 3 illustrates the causal relations in the forestry sector. Total timber production depends on the area dedicated to logging concessions, and the respective productivity level. The forestry sector is affected by four reinforcing loops (R1-4) and two balancing feedback loops (B1 and B2). The four reinforcing loops capture the impacts of economic development on the forestry sector. R1 through R4 represent how logging affects GDP and employment, and triggers investments in infrastructure. Infrastructure in turn has a positive impact on the profitability of concession areas (R4) and the value-added of the sector (R2). Increasing employment triggers migration and causes the population to increase. B1 and B2 represent the adjustment to the desired area in use for logging, and the impact of an eventual carbon tax on the profitability of the sector. In general, this sector is heavily influenced by the approval of concessions (an exogenous input into the model) and the expansion of infrastructure. Reduced Impact Logging (RIL) improves the carbon storage per hectare and contributes to the reduction of logging-related GHG emissions. At the same time, RIL concessions are less productive and less labour-intensive, reducing total production.

| FIGURE 4: CAUSAL LOOP DIAGRAM – FORESTRY SECTOR |



Source: Author's Own representation.

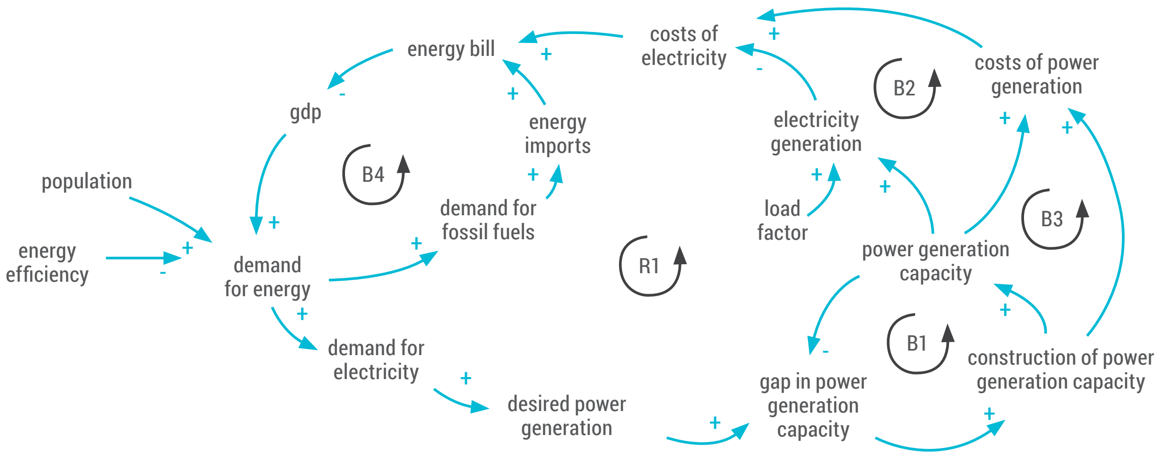
2.1.4 Energy

The energy sector covers energy demand and supply. The latter includes electricity generation as well as oil extraction, which will see commercial production as of 2020–2021.

The dynamics of the power generation sector are affected by five main feedback loops, four balancing (B1-B4) and one reinforcing loop. The Causal Loop Diagram of the energy sector is displayed in Figure 4. Energy demand is affected by population, GDP, electricity price and energy efficiency. The first balancing loop (B1) captures the adjustment of capacity to ensure sufficient generation to satisfy the demand for electricity. The loops (B2) and (B3), together with R1, capture the potential impact of new capacity additions on the cost of power generation. Balancing loops (B2) and (B3) capture how investments in power generation (B3) and Operations & Maintenance (O&M) costs (B2) affect economic growth by affecting energy prices. GDP growth increases the demand for electricity, leads to higher generation requirements and triggers investment in capacity. Investments in capacity increase the cost of power generation and consequently the sales price of electricity and the national energy bill. High energy prices curb economic growth and the growth of energy demand and hence reduce the need to invest in capacity.

These two simultaneous factors (costs and generation) are used to estimate the levelized cost of electricity generation (LCOE) in the model. In the case in which electricity costs increase, the energy bill will also increase, and GDP growth would be lower than expected, reducing in turn the growth of energy and electricity demand. On the other hand, if electricity prices decline, the energy bill will also decline, stimulating GDP growth and energy demand. Lastly, the loop (B4) represents the impact of fuel imports on the energy bill. Higher fuel imports increase the energy bill and thereby reduce GDP growth and energy demand.

| **FIGURE 5:** CAUSAL LOOP DIAGRAM – ENERGY SECTOR |



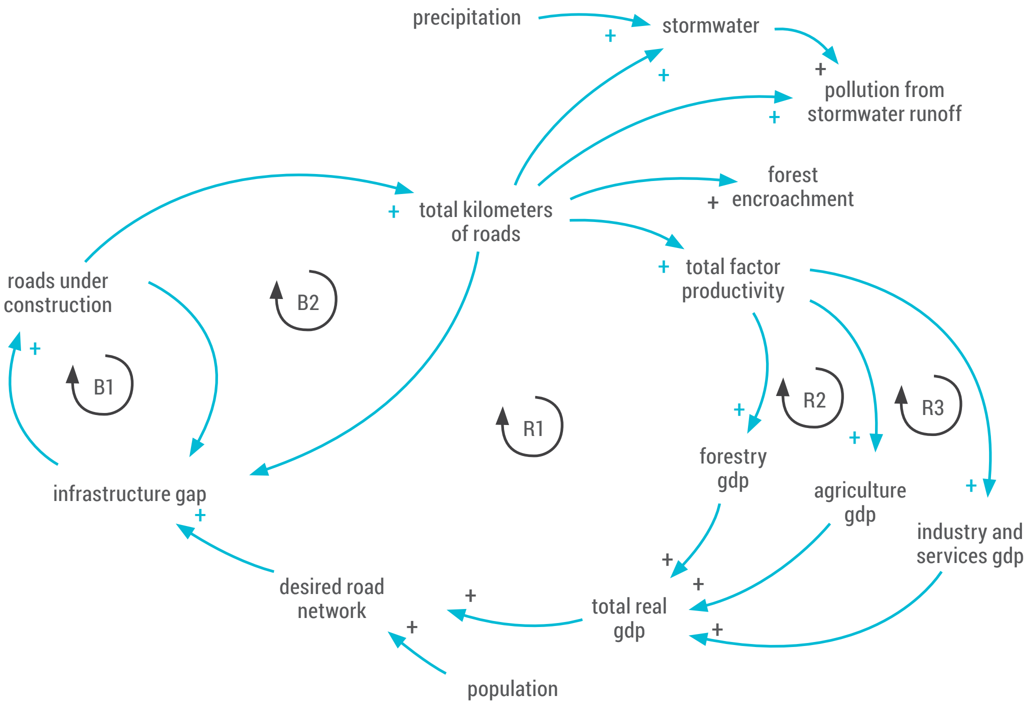
Source: Own representation.

Fossil fuel production is partially exogenous and determined by the production schedule announced by ExxonMobil, so oil production is not being modelled endogenously.

2.1.5 Infrastructure / road transport

The infrastructure module currently only includes the road network. Figure 5 illustrates the dynamics of this sector, which is dominated by three reinforcing loops (R1–3) and two balancing feedback loops (B1 & B2). The two balancing loops are controlling the adjustment process responsible for the construction of roads. The current road network is compared to the desired road network to assess whether there is an infrastructure gap, to estimate the required kilometres of road to be constructed. The adjustment process is corrected by the kilometres of roads under construction to ensure that only the required number of roads is ultimately built. The three reinforcing loops capture the desire to expand the road network resulting from population growth and economic development, and how the construction of roads facilitates this process. Better infrastructure access leads to higher productivity across most production and services sectors and increases sectoral GDP. Loop (R1) captures the impacts on forestry production and GDP, (R2) on agricultural GDP and (R3) on residual economic impacts across all sectors. The increase in sectoral GDP leads to an increase in total GDP and triggers investments in more infrastructure to sustain economic growth.

| **FIGURE 6:** CAUSAL LOOP DIAGRAM – ROAD INFRASTRUCTURE SECTOR |



Source: Author's Own representation.

3.

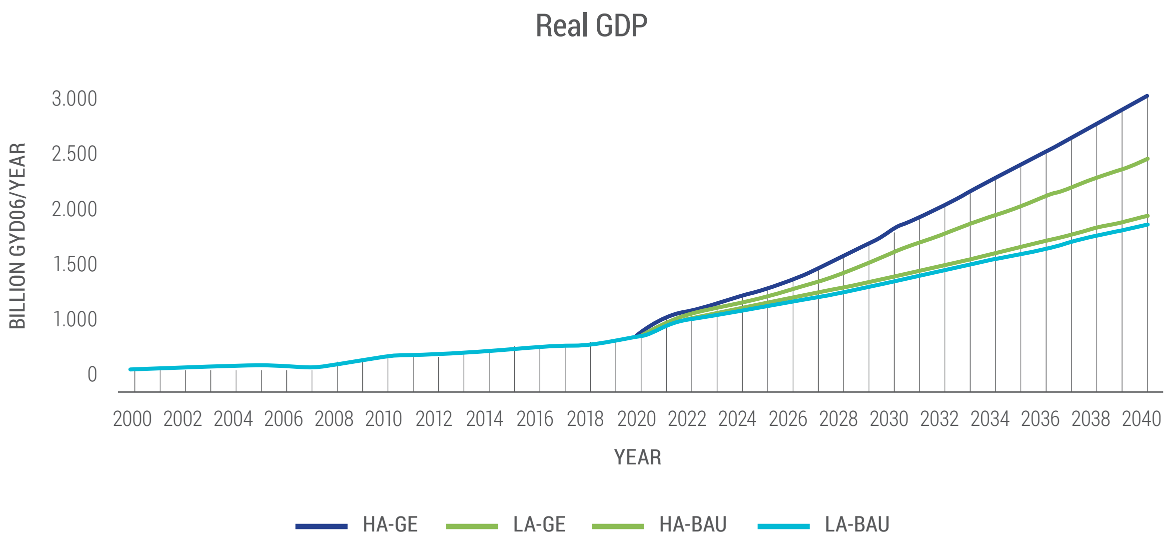
MODELLING RESULTS

3.1 Macroeconomy

Guyana's population is projected to increase by 2040 to 1.07 million people in the low-ambition (LA-BAU) and to 1.3 million people in the high ambition (HA-BAU) scenario. In the GE scenarios, by 2040, the population will have increased by 2.2% in the low-ambition (LA-GE), and by 14.3% in the high-ambition (HA-GE) scenario. The growth of Guyana's population occurs past 2020, partly as a consequence of increasing economic activity from oil production, which is expected to reduce emigration and potentially attract migrants or members of the Guyanese diaspora.

The average GDP growth rate between 2018 and 2040 is projected to be 6% for the LA-BAU and 7.4% for the HA-BAU scenario. GDP in 2040 is 5.8 and 28% higher than in the respective BAU scenarios. In the LA-GE and HA-GE scenarios, the GDP growth rate is on average 0.24 and 1.06% higher compared to the respective baseline. A strong increase is projected between 2020 and 2023, caused by oil extraction activities, with GDP growth rates up to 23%. This assumes that oil production remains constant at 120,000 barrels per day throughout the simulation (although scenarios assuming a more significant oil production have also been modelled). Figure 6 compares the development of real GDP and its growth rate in the BAU and GE scenarios, and illustrates their consistency with historical data.

| FIGURE 7: REAL GDP AND REAL GDP GROWTH RATE IN THE DIFFERENT SCENARIOS |



Source: Author's Own modelling.

By 2040, Guyana's economy is projected to provide employment for 696,700 people in the LA-BAU scenario and 853,100 people in the HA-BAU scenario. Employment levels in the LA-GE and HA-GE scenarios are forecasted to be respectively 2.3 and 14.9% higher than in the BAU case. This is an average increase of 2.6% per year in the LA-BAU and 3.5% per year in the HA-BAU scenario between 2020 and 2040. The unemployment rate decreases until 2025, when full employment is projected. Future unemployment depends on multiple factors such as work-related migration, labour force participation and education levels. The careful assumption that migration occurs once full employment is reached might not hold true in reality, for which reason the projections regarding the unemployment rate should be regarded with care.

The growth of population and GDP leads to higher energy consumption and CO^2 emissions relative to the BAU scenario (despite a 3% reduction in emission intensity relative to the BAU, or 28% when compared to 2017). This indicates that the economy will become less carbon-intensive, but the growth brought by infrastructure and the limited effort to improve energy efficiency in the GE scenarios (as we only assume the implementation of energy efficiency investments for electricity use, not other energy sources) cause the impact of economic growth to be strongest. The package of GE measures included in this scenario are not sufficient to reduce total emissions but will lead to a lower carbon intensity per unit GDP.

An overview of the results of the modelling exercise at the macroeconomic level is presented in Table 2.

| TABLE 2: SUMMARY OF THE RESULTS AT THE MACROECONOMIC LEVEL ACROSS THE SCENARIOS |

Year				2018	2020	2025	2030	2035	2040
Population	Pessimistic	BAU	Person	783 360	792 700	816 821	928 489	1 014 548	1 068 463
		GE	Person	783 360	792 700	816 246	930 712	1 026 974	1 091 680
		% GE vs BAU	*%*	*0.0%*	*0.0%*	*-0.1%*	*0.2%*	*1.2%*	*2.2%*
	Optimistic	BAU	Person	783 360	792 700	840 571	1 016 241	1 179 110	1 301 645
		GE	Person	783 360	792 700	848 371	1 058 702	1 288 510	1 488 065
		% GE vs BAU	*%*	*0.0%*	*0.0%*	*0.9%*	*4.2%*	*9.3%*	*14.3%*
Real GDP	Pessimistic	BAU	GYD bn	488.9	562.6	868.2	1 129.7	1 421.4	1 726.4
		GE	GYD bn	488.9	566.8	887.7	1 175.3	1 491.1	1 826.7
		% GE vs BAU	*%*	*0.0%*	*0.7%*	*2.3%*	*4.0%*	*4.9%*	*5.8%*
	Optimistic	BAU	GYD bn	493.4	589.5	981.3	1 438.9	1 907.0	2 397.4
		GE	GYD bn	493.5	601.2	1'052.2	1 679.0	2 334.6	3 069.1
		% GE vs BAU	*%*	*0.0%*	*2.0%*	*7.2%*	*16.7%*	*22.4%*	*28.0%*
Real GDP growth rate	Pessimistic	BAU	%	3.27%	7.81%	4.92%	5.25%	4.39%	3.69%
		GE	%	3.28%	8.15%	5.21%	5.63%	4.57%	3.85%
		Δ GE vs BAU	*%*	*0.00%*	*0.35%*	*0.30%*	*0.39%*	*0.18%*	*0.15%*
	Optimistic	BAU	%	3.65%	9.61%	6.69%	7.64%	5.24%	4.31%
		GE	%	3.66%	10.56%	7.89%	9.53%	6.21%	5.18%
		Δ GE vs BAU	*%*	*0.01%*	*0.94%*	*1.20%*	*1.89%*	*0.97%*	*0.87%*
Revenues and grants	Pessimistic	BAU	GYD bn	198.2	231.4	425.4	554.1	704.5	870.1
		GE	GYD bn	198.2	233.2	433.8	574.2	736.4	917.4
		% GE vs BAU	*%*	*0.0%*	*0.7%*	*2.0%*	*3.6%*	*4.5%*	*5.4%*
	Optimistic	BAU	GYD bn	200.0	242.5	473.7	690.7	926.4	1 186.8
		GE	GYD bn	200.0	247.3	503.9	796.7	1 121.8	1 503.9
		% GE vs BAU	*%*	*0.0%*	*2.0%*	*6.4%*	*15.3%*	*21.1%*	*26.7%*
Total labour income	Pessimistic	BAU	GYD bn	713.2	726.5	894.3	1 045.2	1 165.8	1 254.0
		GE	GYD bn	713.2	725.1	893.1	1 048.6	1 181.6	1 282.7
		% GE vs BAU	*%*	*0.0%*	*-0.2%*	*-0.1%*	*0.3%*	*1.3%*	*2.3%*
	Optimistic	BAU	GYD bn	715.4	733.1	931.7	1 153.7	1 363.9	1 535.6
		GE	GYD bn	715.4	732.7	943.2	1 208.6	1 499.1	1 764.8
		% GE vs BAU	*%*	*0.0%*	*0.0%*	*1.2%*	*4.8%*	*9.9%*	*14.9%*
Per capita disposable income	Pessimistic	BAU	GYD mn / person	0.87	1.01	1.56	1.86	2.21	2.63
		GE	GYD mn / person	0.87	1.02	1.60	1.93	2.29	2.73
		% GE vs BAU	*%*	*0.0%*	*0.7%*	*2.3%*	*3.8%*	*3.6%*	*3.6%*
	Optimistic	BAU	GYD mn / person	0.88	1.06	1.72	2.16	2.55	3.00
		GE	GYD mn / person	0.88	1.08	1.83	2.42	2.86	3.36
		% GE vs BAU	*%*	*0.0%*	*2.0%*	*6.2%*	*12.0%*	*12.0%*	*12.0%*
Total employment	Pessimistic	BAU	Person	396 217	403 596	496 841	580 666	647 687	696 692
		GE	Person	396 212	402 837	496 181	582 529	656 425	712 603
		% GE vs BAU	*%*	*0.0%*	*-0.2%*	*-0.1%*	*0.3%*	*1.3%*	*2.3%*
	Optimistic	BAU	Person	397 467	407 252	517 614	640 920	757 710	853 105
		GE	Person	397 462	407 050	524 011	671 457	832 850	980 456
		% GE vs BAU	*%*	*0.0%*	*0.0%*	*1.2%*	*4.8%*	*9.9%*	*14.9%*

Source: Author's Own modelling.

3.2 Agriculture

The implementation of green agricultural practices (increasing sustainable practices to 10% in the GE-LA and 36% in the GE-HA scenario) increases agricultural production. Agricultural output in the GE-LA scenario is 15% higher than in LA-BAU, and the HA-GE scenario exceeds HA-BAU with 43%. Rice is projected to be the largest contributor in terms of absolute production.

Average land productivity, measured as yield per hectare, in the BAU scenario is 4.28 tons per year in both the LA-BAU scenario and the HA-BAU scenarios. In the LA-GE and HA-GE scenario, however, the average yield per hectare increases to 4.75 and 5.32 tons per year, respectively. This increase is 11% in the low-ambition case and a 24.3% in the high-ambition case when compared to the respective baseline.

The real GDP of the agriculture sector is projected to increase to GYD 375.2 billion (LA-BAU) and GYD 719.2 billion (HA-BAU) by 2040. Between 2018 and 2040, the average growth rate of the agriculture real GDP in the LA-BAU and HA-BAU scenarios is 3.4 and 6.2%, respectively. This is due to the increase in land productivity (driven by sustainable practices and the expansion of irrigation) and higher access to the road network (a synergy created with investments in roads). Both GE scenarios assume the implementation of drip irrigation on 20% of total cropland. Efficient irrigation reduces annual water use by 12% in the LA-GE scenario and 11% in the HA-GE scenario.

Between 2018 and 2040, agriculture is projected to provide employment to 95,000 people in the LA-BAU scenario and 116,000 people in the HA-BAU scenario. In the LA-GE and HA-GE, employment is 4 and 15% higher, respectively.

Table 3 provides an overview of costs and benefits forecasted in the agricultural sector. All values presented are cumulative, between 2018 and 2040. The net difference (GYD 4,050 billion) represents net savings or net costs incurred over 22 years.

| TABLE 3: SUMMARY OF INVESTMENTS, COSTS AND BENEFITS IN THE AGRICULTURAL SECTOR **|**

Summary	Unit	BAU scenario	GE scenario	Net difference
Agriculture GDP	GYD bn	10 405	14 528	4 123
Investments				
Investment irrigation	GYD bn	36.3	334.6	298.2
O&M irrigation	GYD bn	73.4	90.5	17.0
Investment in sustainable farming practices	GYD bn	0.0	102.4	102.4
Costs				
Water expenditure	GYD bn	1 425	1 351	-74
SCC from agriculture	GYD bn	76.8	72.8	-4.0
Added benefits				
Discretionary spending from labour	GYD bn	3 841	4 107	266
Added carbon sequestration	GYD bn	1 568 383	1 629 030	60 647
Net benefits	**GYD bn**	**1 581 017**	**1 645 714**	**64 697**
Net benefits (ex-carbon sequestration)	*GYD bn*	*12 634*	*16 683*	*4 050*

Source: Author's Own modelling.

3.3 Forestry

The two GE scenarios assume the implementation of Reduced Impact Logging (RIL) alone (LA) and the implementation of RIL with additional 30% value added for forestry products (HA). In the BAU scenario, timber production benefits from the expansion of the road network and increases to 456,100 m^3 per year in 2040. In the GE scenarios, timber production declines to 350,300m^3 per year in 2040 due to the lower productivity of RIL-certified plantations. Under the assumption that the labour intensity changes when production decreases, employment in logging remains constant at 23,300 jobs in the BAU and declines to 17,100 people in the GE scenarios. The implementation of RIL on 40% of logging concessions reduces forestry production by 23% and employment in forestry by 9% by 2040.

Sectoral real GDP increases to GYD 18.5 billion in 2040 in the HA-GE scenario, as a result of road construction. In the LA-GE scenario, the implementation of RIL practices without assuming higher value-added causes forestry GDP to be 8% lower in 2040. Assuming 30% higher value-added of RIL-produced timer, forestry real GDP declines by only 4%. In the BAU scenario, the share of forestry GDP in total real GDP decreases from 3.4 to 1.13% between 2018 and 2040. In the LA-GE scenario and HA-GE scenario, the share of forestry in real GDP declines to 0.89 and 1%, respectively.

The forest protection and conservation practices assumed in the GE scenarios require additional investments of GYD 104.9 billion between 2018 and 2040. Specifically, cumulative investments of GYD 13.05 billion are required for the adoption of RIL and the obtainment of RIL certification for 1.88 million hectares (40%) of forestry land. The maintenance costs of RIL concessions between 2018 and 2040 total GYD 91.9 billion by 2040. The implementation of RIL practices reduces forestry GDP below the baseline and leads to cumulative reductions in GDP of GYD 41.5 billion between 2018 and 2040. The possible lower labour intensity of RIL concessions could cause employment in forestry to shrink. Table 4 provides an overview of costs and benefits for the forestry sector analysis. All values presented are cumulative between 2018 and 2040. The net difference represents net savings obtained or net costs incurred over 22 years.

| TABLE 4: SUMMARY OF INVESTMENTS, COSTS AND BENEFITS IN THE FORESTRY SECTOR, BY 2040 **|**

Summary	Unit	BAU scenario	GE scenario	Net difference
Additional GDP	mn GYD	407 785	366 302	-41 484
Investments				
Investment RIL	mn GYD	0.0	13 051	13 051
O&M RIL	mn GYD	0.0	91 858	91 858
Costs				
-	mn GYD	-	-	-
Benefits				
Discretionary spending from labour	mn GYD	230 577	185 941	-44 636
Added carbon sequestration	mn GYD	1 598 499 854	1 618 961 347	20 461 493
Net benefits	**mn GYD**	**1 599 138 217**	**1 619 408 681**	**20 270 464**
Net benefits (ex-carbon sequestration)	*mn GYD*	*638 362*	*447 334*	*-191 029*

Source: Author's Own modelling.

3.4 Energy

Guyana's energy demand is driven by population growth and economic development, as well as the price of energy and the technology used (energy efficiency).

Total energy demand is projected to increase slightly during the period 2016–2020. After 2020, the beginning of oil extraction is projected to stimulate GDP growth, which will lead to a higher energy demand. Total energy demand in the BAU scenario increases to 118,400 TJ per year in 2040. Energy demand in 2040 under the LA-GE and HA-GE scenario is 1 and 4% lower, respectively.

The total demand for electricity is projected to reach 2.9 million MWh by 2040. For the current projections, a transmission loss of 28.5% is assumed. The projections for electricity demand are comparable to the high-demand scenario indicated in the updated expansion study by Brugman SAS (2018).

Investments in energy efficiency in the GE scenarios reduce electricity demand in 2040 by 18 and 54% in the LA-GE and HA-GE scenario, respectively. Additional investments in renewable technologies cause the generation cost per MWh to decline by GYD 632 per MWh between 2018 and 2040, which is equivalent to a decline of USD 3.1 per MWh.[3] In the LA-GE and HA-GE scenarios, the cost-reflective price in 2040 is 9.5 and 7.4% lower compared to the respective baseline. Cumulatively, the improvement in energy efficiency requires total additional investments of GYD 469.1 billion by 2040. This

3. Assuming an exchange rate of 204 GYD / USD.

estimate uses a high-cost assumption. This more conservative assumption leads to total costs of GYD 235 billion by 2040.

On the other hand, the reduction in capacity requirements yields cumulative savings of GYD 156.7 billion from investments in power generation capacity between 2018 and 2040, which is equivalent to annual savings of approximately GDY 7.12 billion over 22 years. Because of lower capacity, cumulative O&M costs of power generation are GYD 12 billion lower compared to the BAU scenario. In summary, the implementation of energy efficiency measures yields net savings of GYD 168.6 billion from avoided investments in capacity and avoided O&M expenditure.

Reductions in energy consumption and the expansion of renewable capacity lead to a reduction in energy-related CO_2e emissions. Projections indicate that annual CO_2e emissions are 2 and 5% lower in the LA-GE and HA-GE scenario, respectively. Between 2018 and 2040, implementing energy efficiency measures in the LA-GE and HA-GE scenarios yield cumulative avoided emissions of 1.31 million tons and 3.73 million tons respectively, which is equivalent to average reductions of approximately 59,500 tons and 169,700 tons per year over 22 years. The reduction of CO_2e emissions translates in a reduction of the social cost of carbon (SCC) from energy. Cumulative SCC in the BAU scenario reach GYD 1.07 trillion in 2040. In the LA-GE and HA-GE scenario, the energy-related SCC is 0.7 (GYD 7.62 billion) and 2.1% (GYD 22.07 billion) lower compared to the BAU scenario.

Table 5 provides an overview of the investments, costs and benefits in the energy sector. All values presented are cumulative between 2018 and 2040. The net difference represents net savings or expenditure incurred over 22 years.

| **TABLE 5:** SUMMARY OF INVESTMENTS, COSTS AND BENEFITS IN THE ENERGY SECTOR |

Summary	Unit	BAU scenario	Low-cost scenario (750USD / MWh avoided)		High-cost scenario (1,500 USD / MWh avoided)	
			GE scenario	Net difference	GE scenario	Net difference
GDP	bn GYD	23 927	23 956	29	23 956	29
Investments						
Investment in energy efficiency	bn GYD	0.0	235	235	469.1	469.1
Costs						
Investment Power generation	bn GYD	433.3	276.7	-157	276.7	-156.7
O&M power generation	bn GYD	148.5	136.5	-12	136.5	-12.0
SCC	bn GYD	768.3	746.2	-22	746.2	-22.1
Energy bill	bn GYD	8 550	8 427	-123	8'427	-123.0
Benefits						
Discretionary labour income	bn GYD	15.5	10	-5	10.3	-5.1
Net benefits	**bn GYD**	**14 042**	**14 145**	**103**	**13 910**	**-131.6**
Net benefits (ex-carbon sequestration)	*bn GYD*	*14 042*	*14 145*	*103*	*13 910*	*-131.6*

Source: Author's Own modelling.

Note: low-cost and high-cost assumptions were made for energy efficiency improvements. As a result, the cost benefit analysis for the energy sector includes two estimates, while for other sectors a single scenario is presented.

3.5 Road Transport Infrastructure

In the BAU scenario, the total capacity of established road infrastructure is projected to reach 3,500 km in the LA-GE and up to 4,360 in the HA-GE scenario, by 2040. This represents a net increase of at least 1,200 km compared to 2016 and is the result of new projects, as well as higher demand (driven by population growth and the expansion of urban centres).

The use of Recycled Asphalt Pavement (RAP) reduces the amount of virgin raw material required for road construction processes by approximately 13.5 million tons, or 16.2%. Further reductions in virgin materials stem from maintenance, where material savings of 12.8% or 40,400 tons can be achieved through the use of 15% RAP. In addition, the use of permeable surfaces and stormwater management infrastructure reduces stormwater and pollution runoff from the road by approximately 50%, which reduces maintenance efforts and hence the additional costs for stormwater management.

Net savings of GYD 55.32 billion can be realized through the use of 15% RAP during the construction and O&M phase of the road. The use of more expensive machinery causes capital costs to be GYD 34.2 billion higher compared to the BAU scenario. At the same time, the reduced use of virgin material yields savings in material cost of GYD 89.52 billion over 22 years, or GYD 4.07 million per kilometre per year on average. In addition, green roads reduce by design the amounts of stormwater and related pollutant loadings, which reduces the overall risk of accidents and requires less maintenance in the longer run.

Table 6 provides an overview of costs and benefits for the road transport infrastructure sector. All values are cumulative between 2018 and 2040. The net difference represents net savings obtained or expenditure incurred over 22 years.

| **TABLE 6:** SUMMARY OF INVESTMENTS, COSTS AND BENEFITS IN THE ROAD TRANSPORT INFRASTRUCTURE SECTOR |

Summary	Unit	Conventional road	Green road	Difference
Added GDP	bn GYD	0.0	0.0	0.0
Investments				
Construction				
Capital	bn GYD	360.9	395.0	34.1
Material	bn GYD	441.9	352.6	-89.3
O&M				
Capital	bn GYD	0.3	0.4	0.09
Material	bn GYD	0.9	0.7	-0.2
Costs				
Cost of stormwater management	bn GYD	2 791.2	1 535.3	-1 256.0
Social cost of carbon	bn GYD	30.4	25.1	-5.3
Nitrogen removal cost	bn GYD	0.8	0.3	-0.5
Benefits				
Additional carbon sequestration	bn GYD	1 598 500	1 629 863	31 362.8
Labour income	bn GYD	7.9	7.8	-0.1
Net benefits	**bn GYD**	**1 594 881**	**1 627 561**	**32 680**
Net benefits (ex-carbon sequestration)	*bn GYD*	*-3 618*	*-2 301*	*1 317*

Source: Own modelling.

3.6 Education and Health

Section 3 of this report has presented the results of the analysis, for various scenarios. These results should be interpreted taking into consideration the boundaries of the model – not only the sectors and indicators that are included in the model but also, or even more importantly, the ones that are not taken into consideration. Two sectors that are critical for Guyana but are not explicitly featured in the model are education and health.

Education can impact simulation results in several ways. Firstly, the economic stimulus provided by Green Economy interventions could increase budgetary expenditure for education infrastructure. Subsequently, a higher number of schools and teachers would then increase access to education. Third, the resulting improvement in the level of education would increase labour productivity and stimulate the growth of the industrial and services sector further. Fourth, improved literacy and knowledge would increase technology uptake (e.g. reducing resource and energy intensity). On the other hand, the lack of investments in education and the unavailability of prepared teachers in the short run could limit the forecasted impact of green economy interventions.

Similarly, the lack of qualified personnel in the health sector may lead to higher budgetary expenditure, but no tangible improvement in access to healthcare and treatment. On the other hand, strategic investments in the health sector, connected with education and professional training would lead to higher labour productivity and possibly reduced per capita health expenditure.

Other Green Economy investments, such as the expansion of the road network, could leverage health and education expenditure.

As a result, it is worth considering when reading the results presented in the preceding sections that there are three potential positive feedback loops (contribution of health and education to labour productivity and employment creation; to economic growth; and to increased technology uptake and higher resource productivity) that are not included in the model but have the capacity to improve the forecasts. One bottleneck (the lack of skilled personnel) has also been identified. This bottleneck has not been explicitly addressed but may lead to more conservative results.

4.
ENABLING CONDITIONS

The transformation to a Green Economy requires certain enabling conditions, all of which are linked – either directly or indirectly – to sustainable infrastructure. Indeed, the four sectors analysed in the model reflect the importance of infrastructure to sustainable development. Two of them, transportation and energy, directly involve the development of new infrastructure systems. The other two, agriculture and forestry, are very closely linked to infrastructure: sustainable forestry and agriculture practices must be supported by sustainably designed and operated roads and irrigation, for example. In the case of forestry, investments made into low-impact logging also serve as investments into ecological, or nature-based, infrastructure. Such infrastructure provides important services such as water retention, carbon sequestering, habitats for biodiversity, and land stabilization, among others.

Ensuring that green investment in infrastructure is strategic and effective requires an integrated, systems-level approach to planning, financing, developing, and operating infrastructure. As the modelling analysis demonstrates, there are many interlinkages between different sectors, infrastructure systems and elements of sustainability (interlinkages between different SDGs, for example). An integrated approach to sustainable infrastructure takes these into account from the earliest planning phase all the way through to the operation phase. Rather than assessing only certain aspects of sustainability at the project or even sector level, such an approach assesses the sustainability of the national infrastructure mix as a whole system, and allows policymakers and planners to integrate social, economic and environmental sustainability measures in ways that take advantage of opportunities for synergies and help to maximize positive impacts and minimize negative ones. *Guyana's Green State Development Strategy: Vision 2040* has identified a number of key actions that would contribute its goals. Chief among them is the need to establish the Natural Resource Fund Act (see Box 2) and move to a Medium-Term Expenditure Framework to transparently and effectively manage oil wealth.

Box 2: The Natural Resource Fund Act

The newly discovered oil wealth will ease pressure on the public budget but also place significant demands on public institutions to manage new economic risks. International experience shows that natural resource wealth does not necessarily lead to broad-based improvements in development and, in some cases, can introduce damaging volatility to fiscal revenue and economic performance. Accelerated fiscal expenditure will raise domestic inflationary pressure, potentially harming the international competitiveness of export industries. To address this, the Government will draft the Natural Resource Fund Act and, once passed through Parliament, rapidly establish the institutional arrangements required for the full operation of the Fund. This Fund should help to ensure that oil revenues are directed to sustainable infrastructure, clean energy, and sustainable practices and more diversification in the agricultural and forestry sector.

The need for natural resource funds arises from the creation of fiscal rules to manage the inflow of high and volatile high resource revenues. Thus, the first step is to develop comprehensive fiscal rules regarding what happens to incoming oil revenues, i.e. how much is spent via the annual budget (as occurs with non-oil revenues) and how much is set aside.

The decision over how much to 'set aside' partly depends on judgements over the inflationary impact of oil revenues being spent immediately and partly over the expected volatility. Such decisions can be politically controversial although it is important to have stability in fiscal rules, possibly by requiring an extra-majority in parliament to adjust these rules or by including fiscal rules in the constitution.

The decision to set some revenues aside automatically leads to a decision being required on what happens to such revenues, which determines the objectives of the natural resource fund. Objectives can include the need to smooth budgetary expenditure during periods of low oil prices, the development of savings for future generations (post-oil extraction) or to invest in national priorities. Fund objectives should be clearly set out in legislation.

Once clear objectives are established, it is very important to develop a strong institutional framework around the management of the fund, due to the significance of the revenues and the opportunity provided for corruption and misuse of funds. On a day-to-day management level, the fund should ideally be operationally independent from government, although working towards objectives set out by Parliament. The Central Bank and the Ministry of Finance should have supervisory roles such as membership of the Board overseeing the fund, and additionally, there must be clear parliamentary oversight of the fund.

The second key action is to switch to lower-cost, sustainable and reliable energy sources to support domestic business operations and strengthen energy security. Evidence-based feasibility studies need to be conducted to assess the potential and cost of different renewable and clean sources of energy for electricity generation in different regions of Guyana, in order to support the transition to renewable and clean energy and to achieve an optimized energy mix. Other enabling conditions to harness the green transition in the energy sector involve the development of supporting infrastructure, including: the fortification of the national energy grid, distributed or on-site electricity generation in Guyana's remote hinterland, investments in energy efficiency and demand reduction, and the development of a sustainable low-carbon transport sector.

Effective and well-coordinated management of natural resources is also important, including the expansion of environmental services. Land is Guyana's most abundant asset and improving its governance represents one of the keys to unlocking the structural transformation

envisaged in the *Green State Development Strategy: Vision 2040*. The expansiveness of Guyana's hinterland provides its own set of challenges to effective governance and sustainable development. With the articulation of Guyana's first National Land Policy that will provide the framework for managing the land resources more efficiently and sustainably, improved governance of land will eliminate related resource use conflicts and reduce land degradation. Critical to this effort are new government-wide geographic information systems that form the basis of a state-of-the art integrated land use planning system. Furthermore, the Strategy foresees to: i) establish an integrated Land Use Planning System, ii) assess the feasibility of an overarching land use management authority, iii) prioritize strategic investments to improve land administration, and iv) resolve the land rights of indigenous peoples.

The fourth key action is to diversify Guyana's economic base, to move to higher value-add products and to create decent jobs for all. Guyana's economy relies heavily on primary commodities that provide little opportunity for inclusive growth or economic diversification, while limiting its resilience. Economic resilience can be strengthened both within the current main sectors, further leveraging Guyana's existing skills, resource and network, and in new sectors, developing additional core strengths and drivers of growth. As stipulated in the Strategy, the Government will ensure that resource extraction industries follow evidence-based sustainability guidelines and provide technical and economic support to ease this transition. In agriculture, the Government will help producers overcome the barriers they face while switching to more sustainable techniques and more diverse crops and fruits. Furthermore, the Government will support emerging and high value-adding service industries to compete in international markets and provide sustainable employment opportunities for the local workforce.

Furthermore, measures should be taken to strengthen the capacity and accountability of

key public institutions, underpinned by efficient policy-making procedures. The main thrust of governance and institutional reform under the 'green state' agenda rests on the pillars of good governance, transparency, and the rule of law and strong institutions to manage green growth processes. These pillars embrace the unprecedented opportunity to see Guyana's multi-ethnic, multi-religious population become more socially cohesive, as the country is one of the first in the developing world to embrace the concept and to develop a national action plan to realize the objective to the fullest extent. In order to grasp this opportunity, the *Green State Development Strategy: Vision 2040* realizes the necessity to modernize the transparency and accountability architecture, strengthen the public procurement procedures, improve public access to procurement information, strengthen citizens' participation and inclusion, and strengthen the independent Judiciary with additional resources for greater effectiveness.

Finally, in order to support infrastructure planning that is integrated across project-cycle levels and sub-sectors of infrastructure, the relevant government institutions must also be integrated across different departments and levels of governance. Some form of national planning institution can help to ensure coordinated, planled approaches to infrastructure development. These institutions can constitute commissions, councils, ministries or boards, and would focus on the upstream institutional context, including policies, plans, regulations and legislation. Through strengthening public institutions and policy-making processes in these ways, policymakers can ensure that sustainable forms of infrastructure emerge to lay the foundations for growth of the Green Economy in Guyana.

| TABLE 7: NET BENEFITS OF GREEN ECONOMY INTERVENTIONS |

		Scenario				
		Agriculture GE	Forestry GE	Energy GE **	GE Roads	Total GE
Investments						
Energy efficiency	mn GYD			469 146		497 354
Irrigation	mn GYD	298 209				293 629
O&M Irrigation	mn GYD	17 048				16 112
Sustainable agriculture	mn GYD	102 354				102 354
Sustainable forestry	mn GYD		13 051			13 051
Forest maintenance	mn GYD		91 858			91 858
Infrastructure	mn GYD				34 210	34 210
Infrastructure maintenance	mn GYD				87	87
Total investments	*mn GYD*	*417 611*	*104 910*	*469 146*	*34 297*	*1 048 656*
Costs						
Investment power generation	mn GYD			-156 657		-209 671
O&M Power generation	mn GYD			-11 988		-48 636
Water expenditure	mn GYD	-74 260				-74 260
Electricity expenditure	mn GYD			-122 952		2 391 343
Material expenditure	mn GYD				-89 525	-89 525
Stormwater management	mn GYD				-1 255 966	-1 255 966
Nitrogen removal cost	mn GYD				-498	-498
Social costs of carbon	mn GYD	-4 002		-22 072	-5 279	-4 741
Total costs	*mn GYD*	*-78 263*	*0*	*-313 669*	*-1 351 269*	*708 044*
Benefits						
Agriculture GDP	mn GYD	4 123 018				3 916 858
Forestry GDP	mn GYD		-41 484			-37 427
Energy impact on GDP	mn GYD			28 983		28 983
Additional carbon sequestration	mn GYD	60 647 354	20 461 493		31 362 791	80 630 763
Discretionary labour income	mn GYD	266 039	-44 636	-5 140	-82	459 700
Residual GDP impacts	mn GYD					1 710 837
Total benefits	mn GYD	65 036 411	20 375 373	23 843	637 720	86 709 713
Total net benefits	**mn GYD**	**64 697 063**	**20 270 464**	**-131 634**	**32 679 680**	**84 953 013**
Net benefits (ex-carbon sequestration)	*mn GYD*	*4 049 709*	*-191 029*	*-131 634*	*1 316 889*	*4 322 250*

* Baseline adjusted for land expansion.

** Results presented for the high cost scenario for energy efficiency investments.

N.B.: The investments, avoided costs and additional benefits listed under their respective sector indicate the results obtained if only the GE package in that specific sector is being introduced, whereas the numbers listed under "Total GE" assume that all four sectoral packages are being put in practice, and hence include any potential synergies across sectors.

Source: Results of Author's own modelling.

5.
CONCLUSION

The previous sections have presented the results of sectoral performance, when reaching stated GE targets. This conclusion summarizes the sectoral tables and provides results for the simultaneous implementation of high-ambition GE interventions in all sectors. Results show that the simultaneous implementation of GE interventions requires cumulative additional investments of GYD 1.05 trillion between 2018 and 2040, or 2.7% of GDP over the same period.

As the study shows GE investments can improve economic, social and environmental performance in Guyana. GDP is forecasted to be 28% higher than BAU by 2040, with cumulative benefits amounting to GYD 5.63 trillion (the equivalent of approximately 10 years of current GDP, or GYD 7.19 million per person when considering today's population); 15% more jobs created; and water consumption, timber extraction and carbon intensity of the economy all significantly reduced. However, these positive economic, social and environmental impacts also lead to higher energy consumption and emissions, with 15% higher emissions per capita in 2040 relative to the BAU scenario.

The total avoided costs sum up to GYD 708 billion and added benefits (including stronger economic activity and carbon sequestration) reach GYD 86.7 trillion. These results provide an indication of the potential impact of GE interventions across a variety of indicators, and several more scenarios, where different assumptions are tested, as available in the full modelling report.

Concerning sectoral performance, GE investments show positive economic returns for most sectors, primarily due to cost savings. The sectoral results cited below assume that GE policies are only implemented in the particular sector discussed, while better results can be achieved if GE policies are implemented in all sectors simultaneously.

Additional investments in energy efficiency for electricity use totalling GYD 235 to 469.1 billion between 2018 and 2040 lead to avoided costs for power capacity of GYD 157 billion, and an additional GYD 123 billion in avoided energy expenditure, as well as to additional economic growth and job creation. On the other hand, the growth of GDP generated by other GE investments cause total energy consumption and expenditure in the GE scenario to grow considerably, reaching close to GYD 2.4 trillion higher (cumulatively, by 2040) than in the BAU case. This means that the modelled energy efficiency investments, as they only consider the electricity sector, are not enough to bring down total CO^2 emissions, but total carbon intensity (emissions per unit GDP) does decrease.

Investments in more sustainable agriculture practices and more efficient irrigation systems require additional investments of GYD 102.4 billion and GYD 315.2 billion (as shown in table 7). These investments in agriculture yield have shown to lead to cumulative savings of GYD 74.3 billion in water expenditure, with an additional accumulative value of GYD 3.92 trillion between 2018 and 2040, an amount almost 10 times larger than the investment required, and increases in discretionary income in the agriculture sector by approximately GYD 266 billion.

The implementation of Reduced Impact Logging (RIL) practices on 1.88 million hectares of logging concessions requires an investment of GYD 104.9 billion. This will lead to a cumulative reduction of the forest sector GDP of GYD 41.5 billion between 2018 and 2040 and reduce total discretionary labour income by GYD 44.6 billion. On the other hand, it also increases carbon sequestration by an equivalent economic value of GYD 20.46 trillion. Timber extraction in the Green Economy scenario can be 23% lower in 2040, compared to the BAU scenario. The construction

and maintenance of a sustainable road network would require 34.1 billion in additional capital cost compared to conventional roads, but yield cumulative savings of GYD 89.3 billion in material costs through the use of Recycled Asphalt Pavement (RAP) over the lifetime of this infrastructure. The construction of green roads with permeable pavements could yield additional savings of up to GYD 1.26 trillion and GYD 498 million through reductions in stormwater and nutrient loadings, respectively (especially if these roads are built in urban or suburban areas). The use of recycled materials reduces the need for virgin materials by approximately 13.5 million tons, or 16.2% compared to the baseline.

Guyana's GEMS shows that reinvesting part of the wealth to be obtained from newly discovered oil reserves into the adoption of sustainable policies in the four priority sectors is, on average, cost-effective in the long run, while at the same time leading to better performance in terms of social inclusiveness and environmental sustainability. In order to fully reap the benefits of the economic windfall to be foreseen, the Government of Guyana needs to invest in its legal and regulatory framework, for which the *Green State Development Strategy: Vision 2040* forms an essential first step.

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