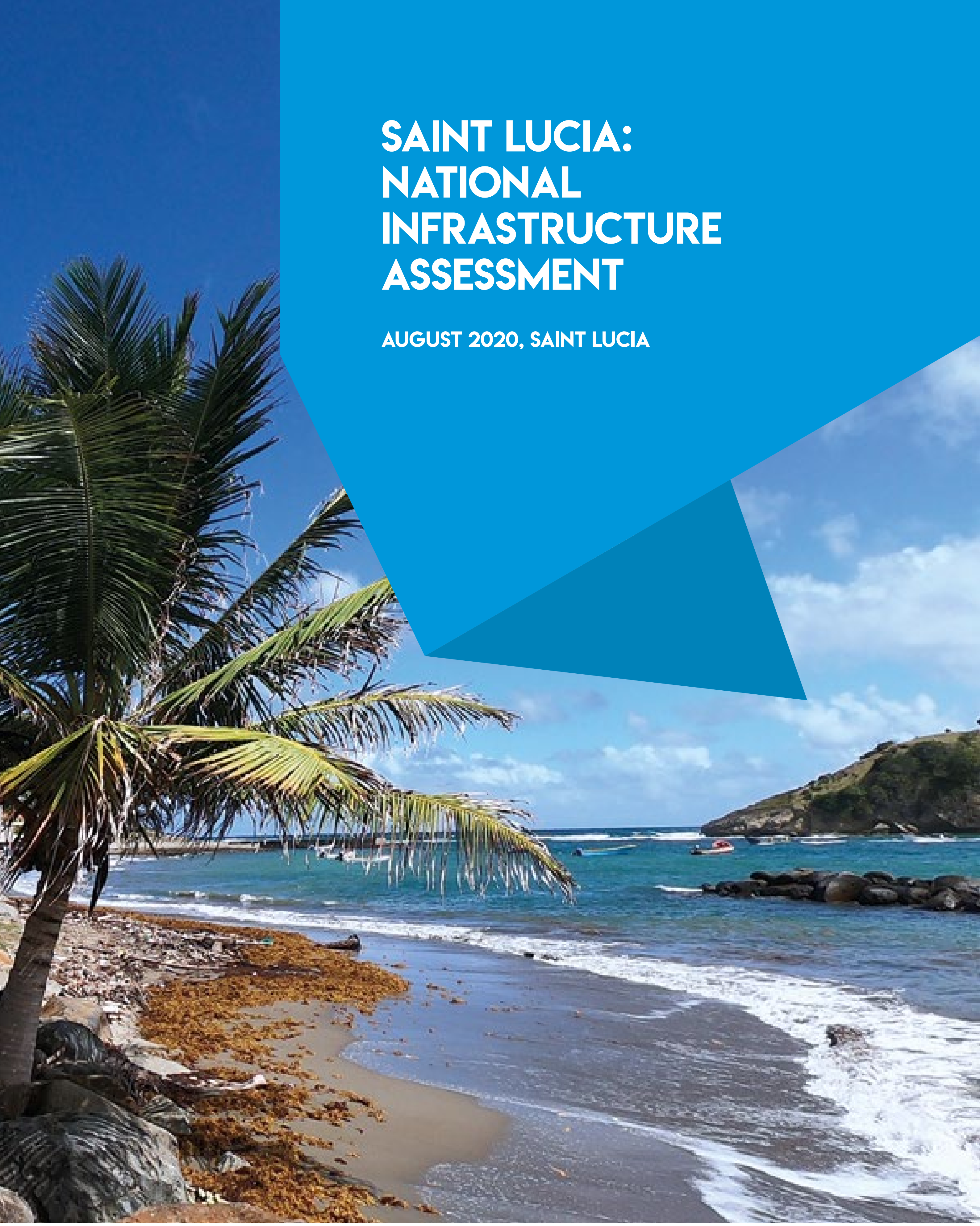
SAINT LUCIA: NATIONAL INFRASTRUCTURE ASSESSMENT

AUGUST 2020, SAINT LUCIA



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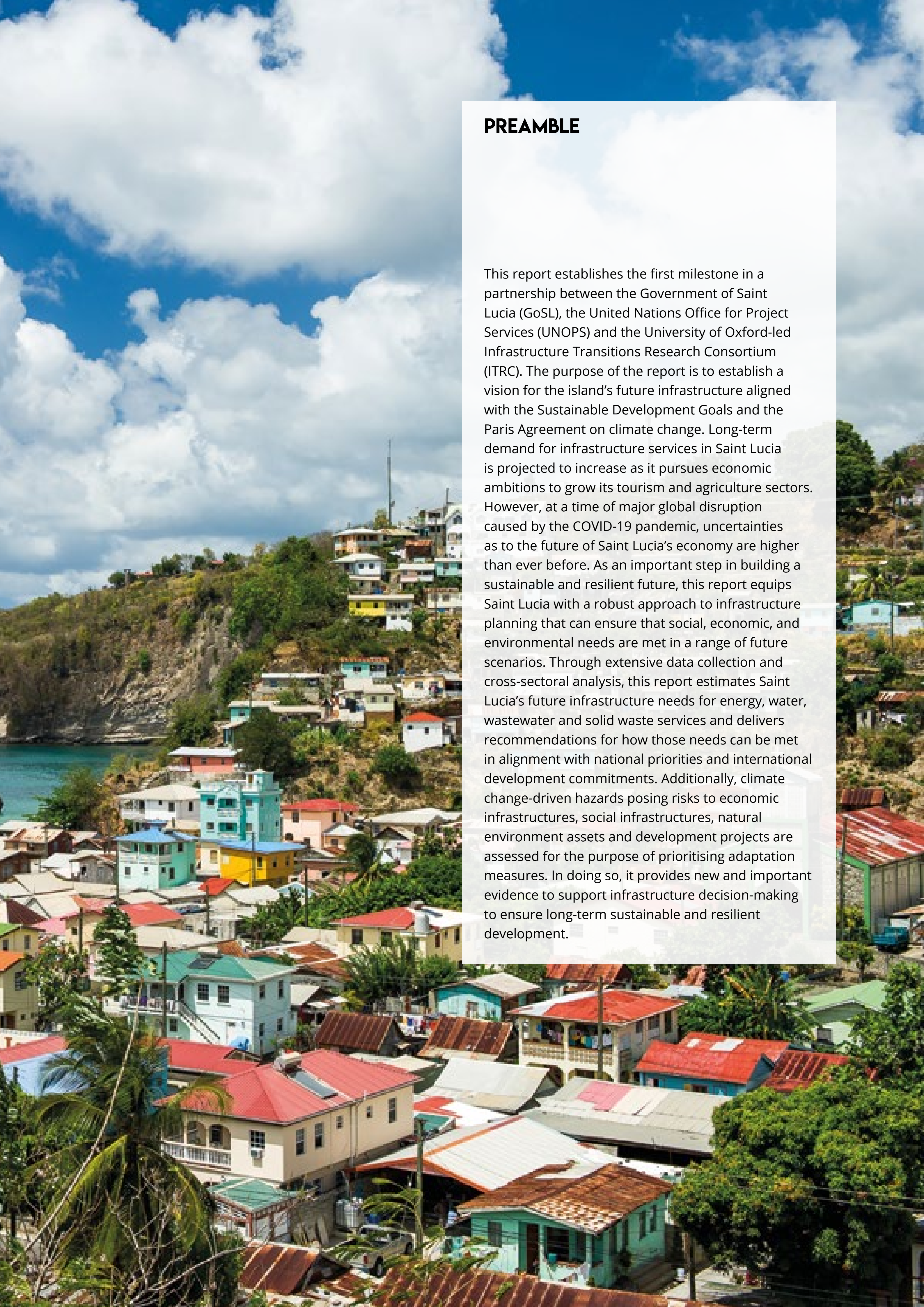


PREAMBLE

This report establishes the first milestone in a partnership between the Government of Saint Lucia (GoSL), the United Nations Office for Project Services (UNOPS) and the University of Oxford-led Infrastructure Transitions Research Consortium (ITRC). The purpose of the report is to establish a vision for the island's future infrastructure aligned with the Sustainable Development Goals and the Paris Agreement on climate change. Long-term demand for infrastructure services in Saint Lucia is projected to increase as it pursues economic ambitions to grow its tourism and agriculture sectors. However, at a time of major global disruption caused by the COVID-19 pandemic, uncertainties as to the future of Saint Lucia's economy are higher than ever before. As an important step in building a sustainable and resilient future, this report equips Saint Lucia with a robust approach to infrastructure planning that can ensure that social, economic, and environmental needs are met in a range of future scenarios. Through extensive data collection and cross-sectoral analysis, this report estimates Saint Lucia's future infrastructure needs for energy, water, wastewater and solid waste services and delivers recommendations for how those needs can be met in alignment with national priorities and international development commitments. Additionally, climate change-driven hazards posing risks to economic infrastructures, social infrastructures, natural environment assets and development projects are assessed for the purpose of prioritising adaptation measures. In doing so, it provides new and important evidence to support infrastructure decision-making to ensure long-term sustainable and resilient development.

FOREWORD

Hon. Allen Chastanet

Prime Minister of Saint Lucia and Minister of Finance

"Saint Lucia is highly vulnerable to the extraordinary changes that are being recorded to our global climate as well as to unexpected human crises, such as the ongoing COVID-19 pandemic, that threaten our people and economy. As a nation, we must act swiftly to ensure preparedness for the worst case scenarios, and to ensure resilience for our people and communities. Our infrastructure systems act as the backbone of our economy, and must be better planned, implemented and managed if we are to fulfil our duties to safeguard future generations. We must work to deliver the right infrastructure by adopting best practices, incorporating state of the art scientific tools and techniques and being proactive in our planning processes in an integrated manner. I am pleased to endorse this report, prepared through the government's partnership with UNOPS and the University of Oxford, which provides a first-ever iteration of the assessment of our national infrastructure systems. Saint Lucia is now poised as a regional trailblazer for resilient infrastructure planning at a time of immense social, economic and environmental challenges.

Ms. Cointha Thomas

Permanent Secretary in the Department of Finance

"The need to reevaluate how we plan our national infrastructure could not have come at a more convenient time than now. The financial consequences of government agencies operating in silos are grave, simply due to lack of or improper planning and collaboration. A strategic move to take a step back and assess our current infrastructure including socio-economic systems is a critical step towards a thriving economy for a developing nation like ours. Physical and socio-economic infrastructure systems are critical assets that shape our people, our lifestyles and our country. With assistance from agencies such as the United Nations, Saint Lucia is making small yet bold steps to improve on infrastructure delivery and management. My department acknowledges the future financial benefits for the Government of Saint Lucia from this initiative by UNOPS and the University of Oxford.

"Across the world, nations face unprecedented development challenges, including climate change and rapid population growth. With nearly one-third of their population living less than five metres above sea level, Small Island Developing States are particularly vulnerable to the climate crisis, and they face greater risks to their economies, livelihoods and food security. In recent months, the COVID-19 pandemic has also highlighted the disastrous impact of health crises on peoples' lives and livelihoods, in small islands as well as in countries across the world. In the face of this global challenge, we all need to redouble our efforts.

UNOPS works hard to help people build better lives and countries achieve peace and sustainable development. As part of that, we support countries in making decisions that ensure sustainable development.

UNOPS' work with the government of Saint Lucia, in partnership with the University of Oxford, ensures the island's national priorities are addressed hand in hand with international development concerns. The result allows a more comprehensive understanding of Saint Lucia's infrastructure needs to facilitate evidence-based decision making, while also aligning recommendations with the Paris Agreement and the SDGs. In this way, we aim to inspire progress that can be taken from a national to a global level as we work towards resilient and sustainable development that will last far into the future.

St Lucia is to be commended in adopting this approach, which will help ensure that limited resources are applied to maximise socio-economic development, while protecting the country's unique natural resources and ensuring its resilience amid global challenges. This is an approach that is equally relevant and increasingly vital for other Small Island Developing States during the next decade.

Ms. Grete Faremo

Under-Secretary-General and UNOPS Executive Director

Prof. Jim Hall

Professor of Climate and Environmental Risks, University of Oxford

"I'm delighted that researchers from the University of Oxford have been able to contribute to the evidence-based national infrastructure assessment for the Government of Saint Lucia. I believe that the decisions made about infrastructure are amongst the most important commitments to sustainable development. These are difficult choices which need to be based upon rigorous evidence and analysis. Our team has been developing state-of-the-art infrastructure systems models and assessment methodologies for the last ten years. Over that time, we have developed unique capability to understand the sustainability and resilience of infrastructure systems in an uncertain future. We are using these advanced data analysis and modelling techniques to inform decision making around the world. Our collaboration in Saint Lucia has been the latest step in that journey.

The COVID-19 pandemic has shown how shocks to the systems upon which society depends can take many, and unexpected, forms. Unlike climatic extremes like the hurricanes that sometimes sweep across Saint Lucia, COVID-19 has not done any physical damage to infrastructure, but it has thrown crucial lifelines like shipping and aviation into disarray. The pandemic has illustrated the importance of social infrastructure like hospitals and care homes. It has also reinforced lessons about the need to have spare capacity to cope with unexpected demands.

Though we are based in a world-leading university, we are not only motivated by excellent research – we want to see the fruits of our research making a difference around the world. That is why we have committed to a partnership with UNOPS and have used our tools and technologies to inform infrastructure decision making in Saint Lucia, which is the latest in what I hope will be a growing number of applications that are helping to shape sustainable infrastructure worldwide.

1

SAINT LUCIA: TOWARDS SUSTAINABILITY AND RESILIENCE

Like other small island developing states (SIDS), Saint Lucia faces key challenges to ensure its infrastructure promotes social, economic, and environmental well-being for its residents and visitors

Infrastructure forms the backbone of Saint Lucia's society, delivering services that provide for the daily needs of its citizens while supporting a strong tourism-based economy that brings hundreds of thousands of visitors to the island each year. However, the island faces economic vulnerabilities due to its small size and reliance on imports, while its geography leaves it exposed to natural hazards such as flooding and landslides that threaten lives and livelihoods. As a result of climate change, the intensity of tropical storms and hurricanes affecting the island is likely to increase. Human-caused disasters, as exemplified by the current COVID-19 pandemic, can have also have devastating impacts on development and economic outcomes.

At the same time, Saint Lucia possesses a wealth of resources that can be harnessed to support sustainable growth and increase the country's resilience to extreme weather events. The island's natural beauty, favourable renewable energy conditions, and agricultural potential provide it with opportunities to develop a sustainable and self-sufficient economy. Recognising this, decision-makers in government and the private sector have a responsibility to deepen the understanding of these challenges and opportunities, and to best position infrastructure as a driver of sustainable development. For example, by modelling future energy and water needs, policy-makers can take appropriate long-term actions to counter fossil fuel dependency and minimise water shortages. Utilising a range of available spatial data on natural hazards can help prioritise risk-reduction initiatives across physical and natural assets and inform the building of new development projects. An understanding of the interactions and impacts between infrastructure sectors can help identify efficient and cost-effective actions to achieve strategic national targets and objectives.

The Government of Saint Lucia has partnered with the United Nations Office for Project Services (UNOPS) and the Infrastructure Transitions Research Consortium at the University of Oxford to integrate informed, cross-sectoral decision-making into its national infrastructure strategy

This engagement began in 2018 with the formation of the National Integrated Planning and Programme unit (NIPP), based in the Department of Finance and responsible for defining the overarching vision, strategy and roadmap for the development of Saint Lucia's national infrastructure agenda (Figure 1). This report presents findings and recommendations that have emerged from this journey of collaborative infrastructure assessment between these entities.

The report is accompanied by (1) a detailed spatial infrastructure asset database for Saint Lucia and (2) a cross-sectoral long-term infrastructure planning model. The transfer of these open-source modelling capabilities to stakeholders in-country will provide a foundation for future evidence-based infrastructure planning, based on the latest available data and evolving national priorities and sustainability targets.

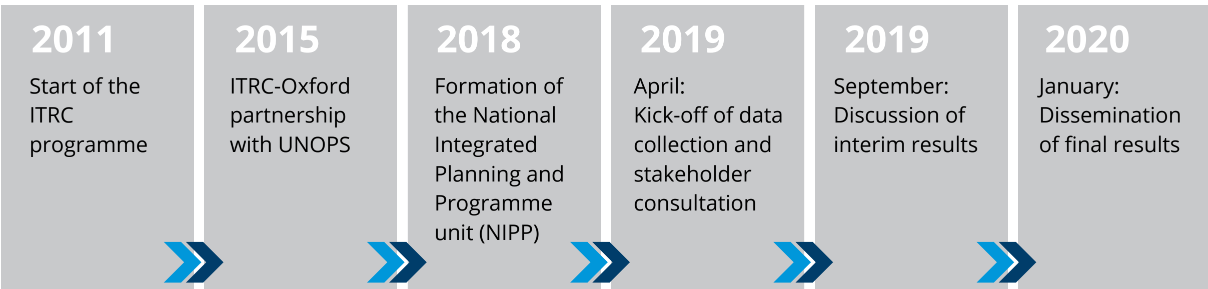


Figure 1:
Timeline of the UNOPS-ITRC Evidence-Based Infrastructure (EBI) process in Saint Lucia

EVIDENCE BASED INFRASTRUCTURE

Developed by UNOPS, Evidence-Based Infrastructure (EBI) is an integrated approach to the planning, implementation and management of national infrastructure. It encompasses the processes and tools for successful implementation, considering a diverse range of social, environmental, and economic contexts. EBI addresses the need to move away from a traditional silo-based planning approach, to one that recognises the interdependence of infrastructure systems – across cities, countries, and regions. Evidence-based planning supports governments and decision-makers in achieving national development plans with better knowledge of demographic, economic, and climate change risks.

NATIONAL INFRASTRUCTURE SYSTEMS MODELLING

Central to EBI and to the analysis contained in this report is the National Infrastructure Systems Model (NISMOD), developed by the Infrastructure Transitions Research Consortium led by the University of Oxford. NISMOD includes a process, composed of a series of analysis steps, which has been designed to assess a country's current and future infrastructure needs and to provide recommendations on how those needs can best be met. An in-depth description of each step of the NISMOD process is included in Appendix A at the end of this report.

Integral to the NISMOD is the incorporation of a wide range of datasets with country-specific engineering insights and on-the-ground assessments. These datasets represent:

- The size, usage, location, and interconnectivity of current and planned infrastructures for energy, transport, water, wastewater, and solid waste;
- Social infrastructure, such as schools, hospitals, community centres, tourist facilities, and government buildings;
- Forecasts for the main drivers of infrastructure demand, notably future population and tourism projections;
- Geospatial data characterising asset locations, natural environment, and land-use, as well as exposure to natural hazards in order to inform the prioritisation of adaptation options.

NISMOD integrates this complex range of data to provide state-of-the-art analysis to underpin infrastructure investment decisions and policies. In doing so, NISMOD enables evidence to be incorporated at the heart of long-term infrastructure planning – reducing future risks and providing confidence to investors.

Figure 2 illustrates how each step of the NISMOD process underpins one of three main components of evidence-based infrastructure development:

1. Accumulation of comprehensive datasets on existing infrastructure and demand drivers, including spatial data, from in-country sources.
2. Modelling and analysis to assess the performance of the infrastructure system in relation to pre-defined performance targets set in alignment with global agendas such as the Sustainable Development Goals and national contributions under the Paris Agreement (both the Nationally-Determined Contributions and National Adaptation Plan).
3. Results and outputs of the modelling process to provide the basis for investment and policy recommendations that can align system performance with these targets. This process incorporates explicit interdependencies between sectors, discussed in Section 9, that provide an integrated approach to decision-making beyond the usual sectoral approach.

NISMOD has been applied successfully in the United Kingdom and is used by the UK National Infrastructure Commission to undertake integrated national infrastructure planning of public and private investment totalling over 800 billion US dollars.[1] The model has also been applied in the Caribbean context in 2018 through an Evidence-Based Infrastructure assessment in Curacao,[2] with key findings used to underpin infrastructure decisions in the country.

NISMOD has further been used to assess infrastructure strategy development in Palestine,[3] and additional elements of the NISMOD methodology have been applied to infrastructure resilience planning in other countries, including Argentina, China, New Zealand, Tanzania, and Vietnam.

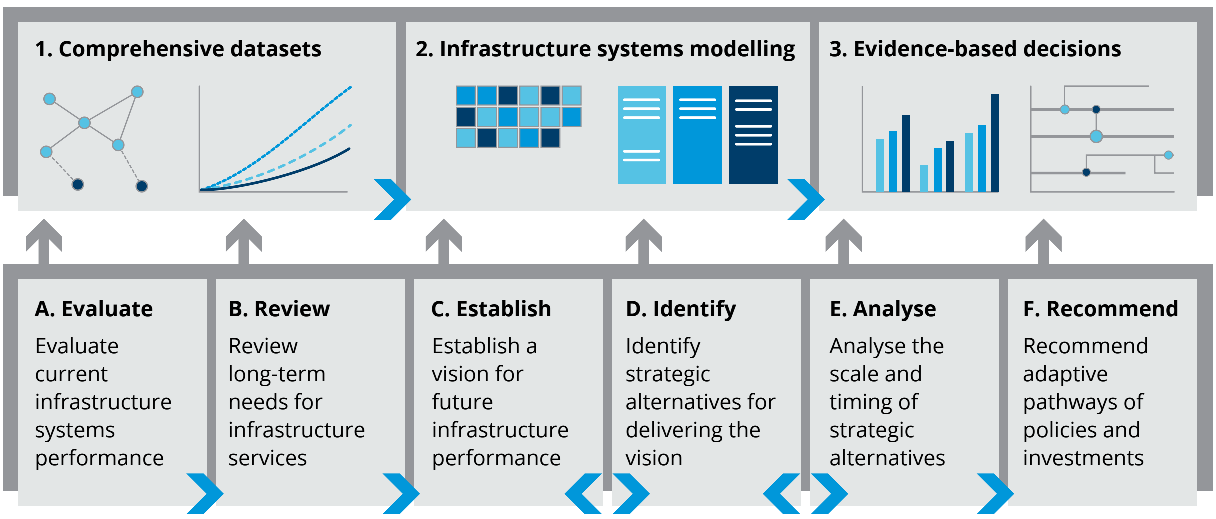


Figure 2:
The National Infrastructure Systems Model underpinning the Evidence-Based Infrastructure framework

3

THE SAINT LUCIA INFRASTRUCTURE ASSESSMENT

This assessment is driven by consultations and contributions from a cross-section of local stakeholders in Saint Lucia

Initial consultations and data collection for the first stage of analysis were initiated in April 2019, facilitated by the NIPP and carried out with the assistance of various government ministries and agencies, including the Departments of Finance, Economic Development, Infrastructure, and Sustainable Development; the Water and Sewerage Company (WASCO); the Solid Waste Management Authority (SLUSWMA); and the National Emergency Management Organisation (NEMO). Consultations were also held with various academic and private sector organisations in-country. In September 2019, interim results from the two components of the assessment, outlined below, were presented in a series of meetings to approximately 134 local stakeholders in government, research, or the private sector. Feedback from this series of consultations was used to align the results of the study with the GoSL's strategic objectives and existing sectoral strategies based on the latest available data.

The infrastructure modelling undertaken for this report comes together in two distinct components: long-term strategic planning, and adaptation planning

Each of these components is analysed according to the assessment framework set out in Figure 3. First, comprehensive data is collected on a set of defined infrastructure assets in Saint Lucia. Key drivers influencing the provision or demand for infrastructure are determined. Modelled outcomes provide the basis for decisions and recommendations with regard to the type, capacity, location, and sequencing of proposed infrastructure interventions.

The long-term strategic planning component focuses on four interdependent infrastructure sectors: energy, water supply, wastewater, and solid waste, and characterises future changes in demand for these infrastructure types caused by trends in resident population and tourist arrivals. Though not modelled in the same way, the importance of transport is also emphasised due to its role in providing access to infrastructure services and in increasing demand for other infrastructure types through expansions to international transport hubs.

Using targets set in alignment with national objectives and international development agendas such as the Sustainable Development Goals (SDGs) and the Paris Agreement, long-term, cross-sectoral portfolios of investments and policies are identified. These targets are adaptable to rapidly-changing national priorities – for example, a focus on health or economic indicators to combat the devastating impacts of the COVID-19 pandemic.

The adaptation planning component focuses on four relevant climate hazards: sea-level rise, storm surges, flash floods and landslides. This study assesses the direct risk from these four hazards on economic infrastructures (roads, freight, airports, ports, electricity, water, wastewater, solid waste), social infrastructures (healthcare, education, civic, emergency, food, tourism, finance, manufacturing, retail, and wholesale), and natural environment assets (forests, agriculture, wetlands, barren, rangeland, and water-based ecosystems). The direct impact of reduced service delivery from these sectors on the Sustainable Development Goals is analysed, focusing on those SDGs influenced by the assessed sectors.[4] Adaptation options aligned with those in the National Adaptation Plan, which fall under Saint Lucia's commitment to action under the Paris Agreement, are prioritised.

The Saint Lucia infrastructure assessment: key figures

18 Contributions from ministries, agencies or other organisations from government, academia, and the private sector

134 Individual stakeholders and experts involved in the consultation and data collection process

13 National policy documents consulted, including the National Adaptation Plan and the Third National Communication on Climate Change

28 Datasets that describe the location and performance of Saint Lucia's infrastructure across 24 sectors.

30 Studies by consultancies, academic or research institutions, including the World Bank and the United Nations

	1. Comprehensive datasets	2. Infrastructure systems modelling	3. Evidence-based decisions

Part 1: Strategic long-term planning	**Interdependent infrastructures**
	• Energy
	• Water
	• Wastewater
	• Solid waste
		Responding to demands
		• Population growth
		• Tourism growth
		  • Air transport
		  • Cruise ship transport
			Recommended policies and investments
			• Long-term sectoral plans
			• Cross-sectoral initiatives
			• Achieving long-term targets

Part 2: Adaptation planning	**Spatial assets** • Economic infrastructure • Social infrastructure • Natural environment	**Risk characterisation** • Sea-level rise • Storm surge • Flash flood • Landslide	**Recommended resilience building activities** • Multi-hazard exposure • Regional prioritisation • Adaptation measures

Figure 3:
Analysis components of the Saint Lucia infrastructure assessment

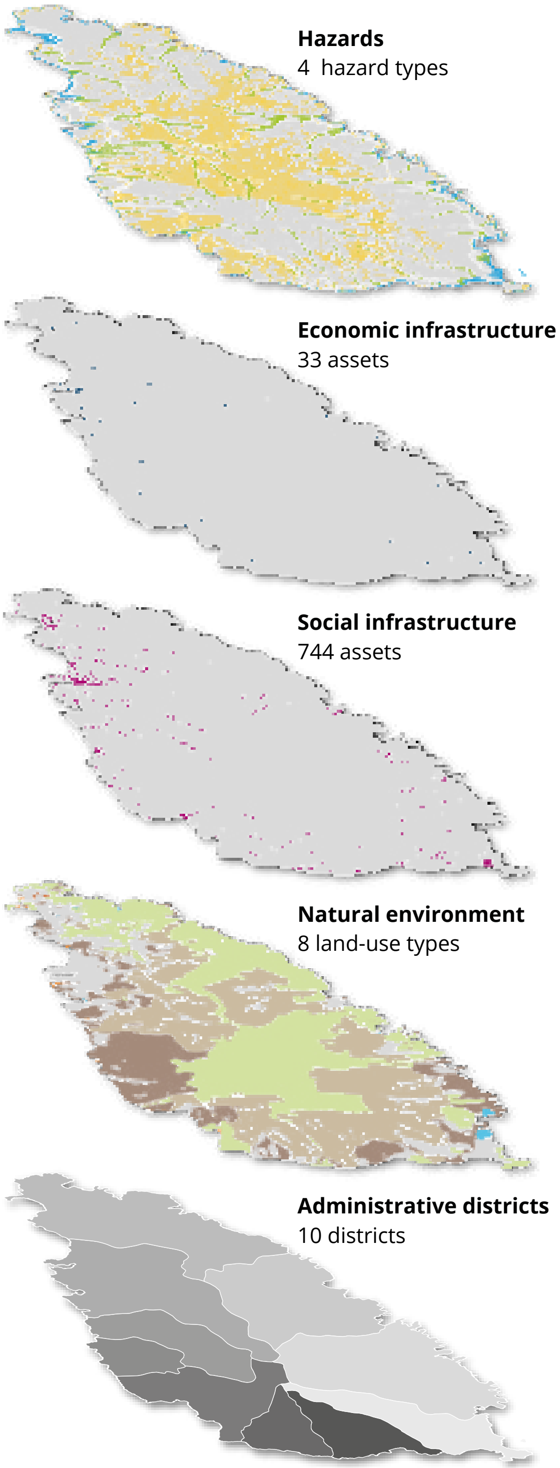


Figure 4:
Spatial representation of the infrastructure and hazard data used in the risk assessment

This analysis focuses on adaptation to natural hazards. However, human crises such as global health disasters can impact the island in similar ways, such as through disruption of transport networks and the normal functioning of social, economic, educational, and community facilities.

Key data for this assessment was obtained from a wide range of national, regional, and global datasets, projections, and studies

Information on existing infrastructure assets was obtained from data published by sector-focused infrastructure agencies such as WASCO, SLUSWMA, St. Lucia Electricity Services Limited (LUCELEC), the Saint Lucia Air and Sea Ports Authority (SLASPA), and the Ministry of Infrastructure, Ports and Energy. Plans or proposals for future infrastructure projects in these sectors, including relevant data, were sourced from entities including Invest Saint Lucia. Additional data on social and economic assets and trends were extracted from the Population and Housing Census,[5] annual reports such as the Economic and Social Review,[6] and open-source resources such as Open Street Map. Where country-level data was not available, regional studies from leading organisations such as the World Bank and the United Nations were used to inform estimates and assumptions. A full list of sources for the infrastructure projects analysed in this report can be found in Appendix B.

Data obtained and used in the adaptation planning component is visualised in Figure 4. A detailed description of the datasets and assumptions used in the analysis is contained in the technical description in Appendix A.

4

DRIVING THE DEMAND FOR INFRASTRUCTURE

Growth in national demand for infrastructure services is driven in large part by changes in a country's resident population

Saint Lucia's population has seen steady growth over the past decades, doubling in size between 1960 to 2015, which has required an increase in the provision of infrastructure to meet the country's needs. To account for the uncertainties around population growth over the coming decades, several population variants for Saint Lucia are compared from UN DESA population projections,[7] reflecting different assumptions with regard to fertility, mortality, and migration rates. Under the medium variant, Saint Lucia is expected to maintain a similar population by 2050, while the Caribbean region as a whole is projected to grow by a rate of 8.8 percent. Under alternative variants, changes in Saint Lucia's population range between nine percent decline and 15 percent growth by 2050.

In this analysis, national demand for infrastructure is calculated on a per-capita basis using the medium variant to project the expected number of infrastructure users on the island.

Per-capita use of infrastructure will shift according to national economic and income scenarios, which may correlate with population trends. For example, higher per capita use of electricity and water may indicate a prosperous economy and be correlated with more workers moving into the country. An economic decline or austerity, in which residents are unable to afford luxuries, may result from a smaller productive workforce and lead to emigration from the country.

Tourism is a key contributor to Saint Lucia's economy and creates thousands of jobs for the local population

The expansion of Saint Lucia's major tourist transport hubs will serve as a main driver of demand for infrastructure services on the island in years to come, although the long-term impact of the COVID-19 pandemic on tourism growth is yet to be determined. Tourists have historically demonstrated a disproportionately larger demand for infrastructure services compared to residents, requiring greater amounts of energy and water per capita for luxury and leisure activities, and generating more waste per person than the average resident.

Tourists can be divided into two types: stay-over tourists, who arrive by air at Hewanorra International or George F. L. Charles Airports; and cruise ship tourists, who spend less than a day on the island, generally at beaches, restaurants, and tourist-oriented zones. Since cruises provide electricity, water, and waste disposal services for their guests, these types of tourists generally rely less on services provided on-island. However, the influx of cruise ships at certain times of the day and year places high stress on the island's infrastructure. A significant number of stay-over visitors also arrive by ferry or yacht at the island's marinas – Rodney Bay, Marigot Bay, and Soufriere.

Key statistics on Saint Lucia's tourist arrivals[8]

452,121	Airport arrivals (2018)
1.5 million	Post-expansion arrivals capacity of Hewanorra International Airport (2021)
9	Average number of nights spent on the island (airport arrivals) (2019)
760,306	Cruise ship arrivals (2018)
1.3–2.7 million	Range of projected annual cruise ship tourists (2042)
63,331	Arrivals by private boat or yacht (2018)
2.4	Average number of nights spent on the island (marina arrivals) (2019)

Three scenarios have been developed – high, moderate, and low – indicating the potential numbers of tourists who may visit the island from now until 2050. These are combined with a set of population variants in Figure 5. These scenarios can be adapted to reflect changes to tourism trends caused by the coronavirus outbreak and other events. For the purpose of this analysis, tourism growth is driven in large part by major transport hub projects that should increase visitor numbers to the island: the planned expansion of Hewanorra International Airport and the recent agreement to construct and operate a new cruise port in Vieux Fort. The current two-phase expansion of the airport will provide for up to 750,000 additional annual arrivals,[9] more than tripling its current capacity. For the cruise terminal, three growth scenarios have been constructed based on SLASPA projections for increased passenger throughput: a Base, Medium and Optimistic case based on berth enhancement and tourist infrastructure around the Vieux Fort cruise port until 2042. However, the cruise ship trend is highly variable and there is a need to continually update these projections to provide an accurate assessment of the port's impact on Saint Lucia's future tourism numbers. This is particularly relevant in light of the recent pandemic which has all but halted the cruise industry and which may affect it for years to come.

The potential for recovery and growth of Saint Lucia's agriculture sector requires targeted investment in the island's infrastructure – including road and port networks, irrigation systems, waste management capacity, and flood protection

Saint Lucia's agriculture sector contributes only around three percent of the country's GDP.[10] The recent decline of the banana industry, linked to the loss of preferential access to the EU market, has been a key factor in the sector's overall decline. As of 2010, only 9.4 percent of the workforce is engaged in the agricultural sector, down from 34.6 percent in 1980.[10] Recently, the sector has shown signs of recovery, with a 5.8 percent expansion in 2018, reflecting increased production and export of the island's major crops, specifically bananas.[6]

Nevertheless, agricultural output is highly vulnerable to the adverse impacts of weather events such as hurricanes and tropical storms.

The GoSL has developed a strategic policy framework identifying future objectives for the agricultural sector and specific policy tools required to achieve them. These strategic options include agricultural diversification, export market development, and the implementation of disaster risk reduction and adaptation measures. Each of these has implications for the island's infrastructure systems. In the transport sector, these objectives will define the quality and capacity of road networks required to transport crops, as well as the port capacity required to export them. Crop varieties determine irrigation needs, which may put varying levels of stress on Saint Lucia's rivers, particularly in the dry season. Large amounts of additional farm waste will need to be managed sustainably. Increasing resilience of the agricultural sector will require careful analysis to assess the specific risks posed by sea-level rise, storm surges, inland flooding, and landslides, as well as adaptation measures that should be taken to minimise them.

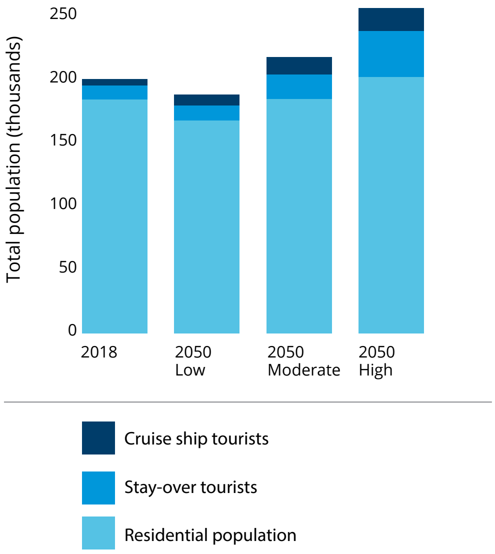


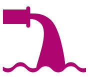
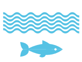
Figure 5:
Combined residential and peak tourism scenarios, 2050

Climate change will amplify existing hazards to infrastructure assets on the island

Extreme weather events pose a high risk to infrastructure in Saint Lucia, particularly assets located in exposed areas. Climate change may intensify the impacts caused by these events, resulting in a greater intensity of negative consequences to residents' lives and livelihoods. In addition to catastrophic events, climate change may also cause gradual changes that can affect the island's provision of certain types of infrastructure. Disruptions to basic infrastructure services, such as water, electricity, or waste management, may have cascading socio-economic consequences, particularly for low-income or vulnerable communities, to hygiene, disease transmission, education, or community services. The potential impacts of climate change across key infrastructure sectors are shown in Table 1.[11,12,13]

Despite recent advances in climate impact research, there remains uncertainty regarding the frequency and magnitude associated with future climate change and its potential consequences.

Table 1: Overview of potential climate change impacts on Saint Lucia's key sectors

	Climate change impacts					
	CYCLONE / EXTREME PRECIPITATION	PRECIPITATION	EXTREME TEMPERATURE	CO_2 FERTILISATION	DRYING TREND	WARMING TREND
Change	↑ Up to 66% projected increase in rainfall episodes of 30–40mm/day for 2040–2050 and up to 20% for 2070–2080 (compared to 1990–2000)	↓ 10–20% annual projected decrease of average precipitation by 2050 (wet season: –25mm Castries to –60mm/ season along east coast); dry season: –75mm/ season along the eastern coast and –125mm/season in interior)	↑	↑	↑ Driest month likely to move forward (wet season: driest month from September to December; dry season: climate models not concurrent)	↑ Up to 2.5 degrees potential increase for 2040–2070 (compared to 1981–2015)
	Potential damages resulting in service outages		Potential service outages			
	Potential damages resulting in service outages; Reduced water quality due to potential saline intrusions into waterways and agricultural soils	Potential reduced water supply	Potential service outages	Potential reduced water quality – increased saline intrusion when combined with extreme precipitation	Potential reduced water supply	
	Potential damages resulting in reduced capacity, including through siltation and dam failures			Potential increase in demand for wastewater services		
	Potential damages resulting in reduced capacity		Potential difficulty in waste collection due to road impacts			
	Potential damages resulting in reduced use		Potential road damages reducing accessibility to critical services			
	Potential crop losses	Potential negative effect on agricultural productivity for current crops	Change in agricultural productivity	Potential crop losses	Change in agricultural productivity due to less water availability, Taro yield decreasing by 12–25%, Tomato yield decreasing by 25–30%, banana yield increasing by up to 10%	
	Potential reduced quality and quantity of freshwater resources, potentially reducing fish yield	Potential reduced availability and quality of freshwater resources		Coral bleaching potentially reducing fish yields; reduced area of coral reefs		

LONG-TERM STRATEGIC PLANNING

Photograph by LUCELEC

5 ELECTRICITY

Like many of its Caribbean neighbours, Saint Lucia is highly dependent on the import of fossil fuels, which supply approximately 99 percent of the island's installed electricity capacity

These imports have a cost to the government of around 10 percent of GDP annually.[14] As a result, residential electricity tariffs are approximately $0.34 (USD/kWh), in line with the Caribbean average of $0.33/kWh but more than triple the US average. In contrast, Trinidad and Tobago, which has access to cheap and abundant oil and natural gas resources, has electricity rates as low as $0.04/kWh.[15] The majority of Saint Lucia's electricity is provided by the diesel-fuelled Cul De Sac Power Station, which feeds seven substations across the island (Figure 6). Solar PV installations account for the remainder of Saint Lucia's energy portfolio.[13] Since 2018, 3 MW of utility-scale solar generation has been operational at Vieux Fort, while 190 kW of small-scale grid connected projects have been installed on residential or commercial properties.

Nearly a third of electricity demand is domestic, with a further third coming from commercial establishments. Hotels account for over a fifth of electricity demand, highlighting the importance of tourism to the sector. Saint Lucia has a National Energy Transition Strategy aiming for a sustainable and cost-effective transition to a renewable energy portfolio over the next 20 years, which will allow the country to contribute toward meeting international targets on climate change that disproportionately affects small island states.

While installed diesel capacity is currently sufficient to meet Saint Lucia's electricity demand needs, margins are likely to shrink over the next few decades in line with changing population and tourism trends

Saint Lucia's long-term electricity needs are likely to increase by 30 percent between 2020 and 2050 under an assumption of moderate population and tourism growth (Figure 7). Future needs are based on estimated current electricity use of 1.42 MWh per resident per year, which is lower than the average of the Caribbean region as well as the wider Latin American region. Peak demand for electricity is projected to grow in line with annual needs, particularly during the tourist season.

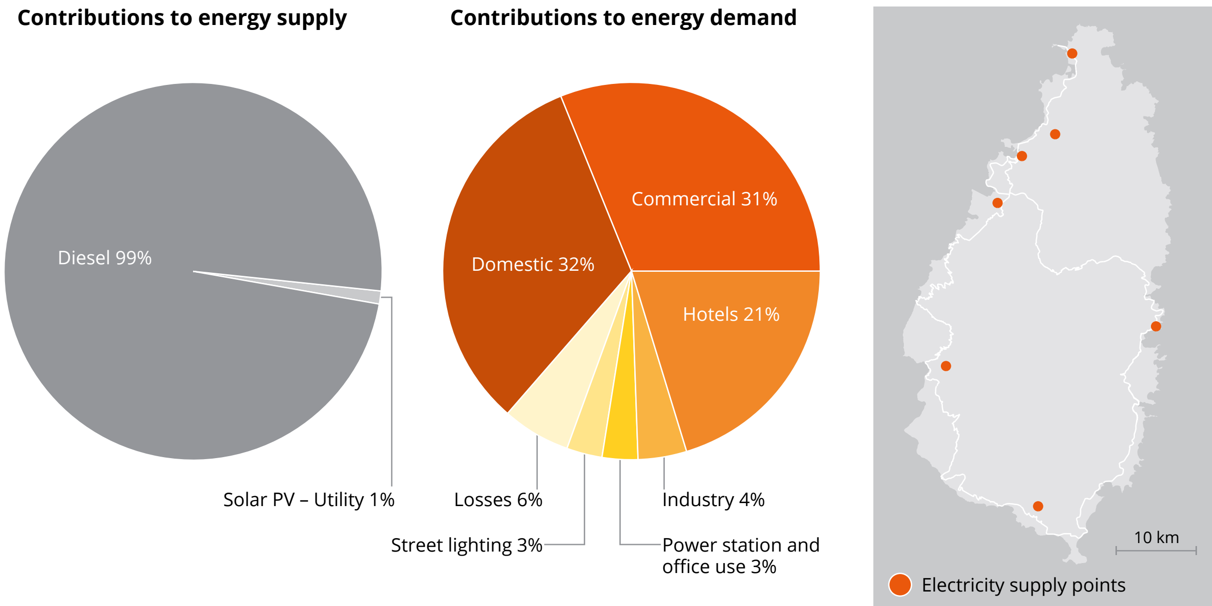


Figure 6:
Current breakdown of electricity supply and demand

However, planned tourism infrastructure and facility expansions means that the current capacity margin may be insufficient to deal with a high-growth tourism scenario. Such a scenario would likely incorporate economic development in the tourism sector and growth in the number of food and commercial establishments. The Saint Lucia Electricity Supply Act[16] requires sufficient generating capacity to be maintained at all power stations, assuming that the two largest generating units are unavailable. While current installed diesel capacity is within a safe margin, peak demand is projected to increase by up to 87 percent in a high-growth scenario.

A national infrastructure strategy for energy should capitalise on the island's favourable conditions for solar, wind, and geothermal energy, and integrate targeted interventions in energy use and demand

Saint Lucia has begun to tap its renewable energy potential, confirming several medium-scale projects for implementation over the next five years (Figure 8). A solar farm in the south of the island will supply 10 megawatts of power annually to the grid, expanding the island's minimal solar generation capacity. A wind farm at Dennery will provide an additional 12 megawatts per year from 2022, taking advantage of favourable conditions on the east side of the island. Additional solar generation in the short term is considered feasible: up to 28 MW of solar capacity could potentially be installed before large investment in battery storage and upgrades are required.[17] An expansion of distributed solar generation, while a small-scale supply source, would provide energy self-sufficiency to buildings across the island. However, it faces barriers linked to regulation and the lack of feed-in tariffs.

Saint Lucia's geothermal resources provide another untapped, and potentially low-cost, renewable energy source, with a recent exploration survey identifying the potential for an estimated 30 megawatts of generation capacity in the Soufriere area.[17]

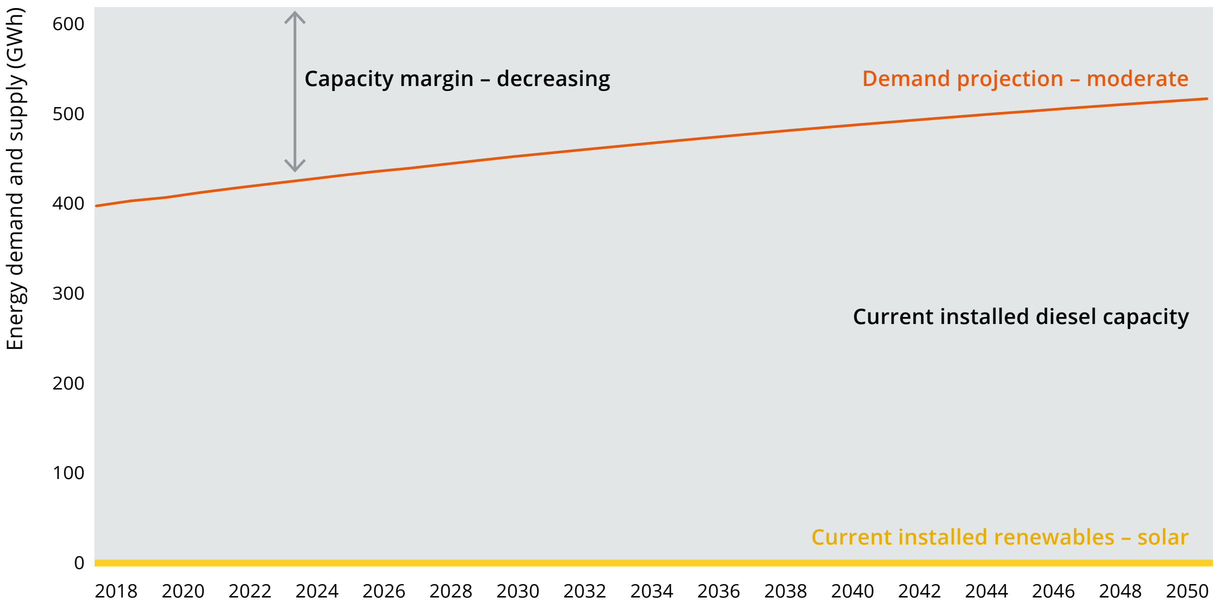


Figure 7:
Future needs under a moderate demand growth scenario, electricity sector

Due to the significant technological capacities required to exploit this resource economically, geothermal energy generation could be designed in two phases: an initial pilot phase commencing in the mid-2020s, and a larger-scale take-up of the technology within the following decade.

Demand reductions and system efficiencies make up the third major component of a national infrastructure strategy for energy (Figure 9). Saint Lucia's climate change strategy outlines several actions that could be feasibly implemented to reduce national energy demand by over five percent, including through LED street lighting, lighting and cooling efficiencies in new buildings, and a focus on energy use reductions in the tourism sector. The cumulative CO_2 emissions avoided by these actions by 2030 are roughly equivalent to the effect of planting 7.5 million trees.

KEY NATIONAL AND INTERNATIONAL TARGETS

7.2 The Government of Saint Lucia has set renewable energy goals in line with its commitment to combating climate change. The government's most recent objective aims for a target of **35%** renewables by 2030. In order to continue this clean energy transition, an increase to **50%** is considered feasible by 2040.

7.1 Saint Lucia's Electricity Supply Act sets out reserve margin guidelines to ensure that installed generating capacity can reliably meet peak demand. In line with this law and an International Energy Agency (IEA) recommendation, this assessment uses a **35%** capacity margin for installed electricity capacity.

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Emissions reductions in Saint Lucia's electricity sector are set in line with the country's Nationally Determined Contributions (NDCs) of **16%** 2025 and **23%** by 2030.

Figure 8:
Long-term electricity capacity and demand planning to meet national targets

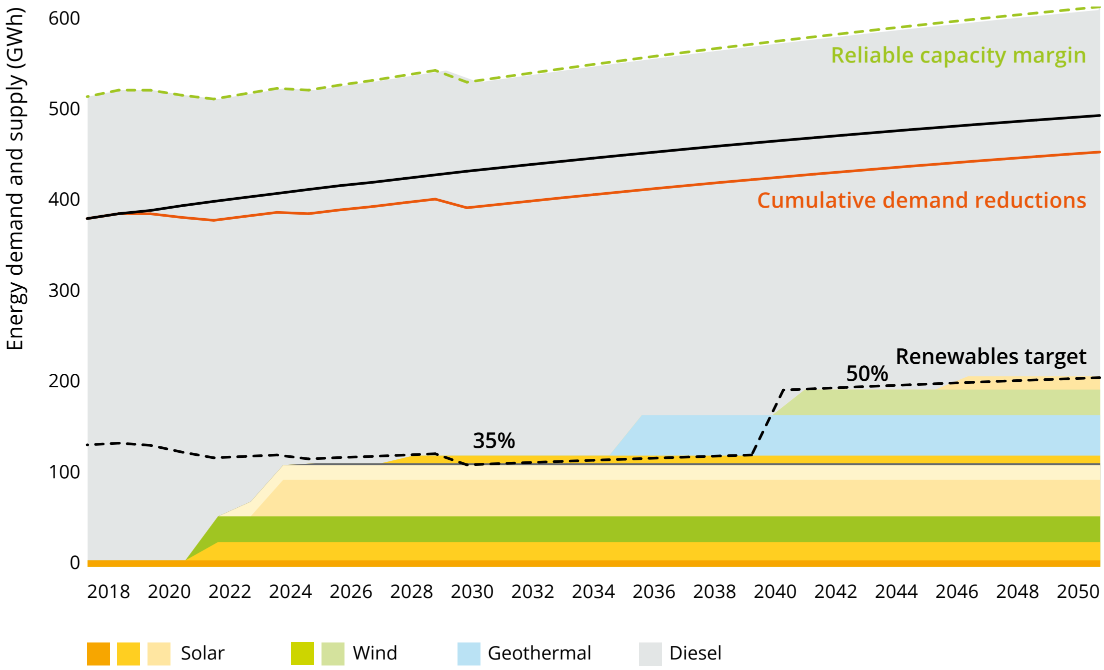
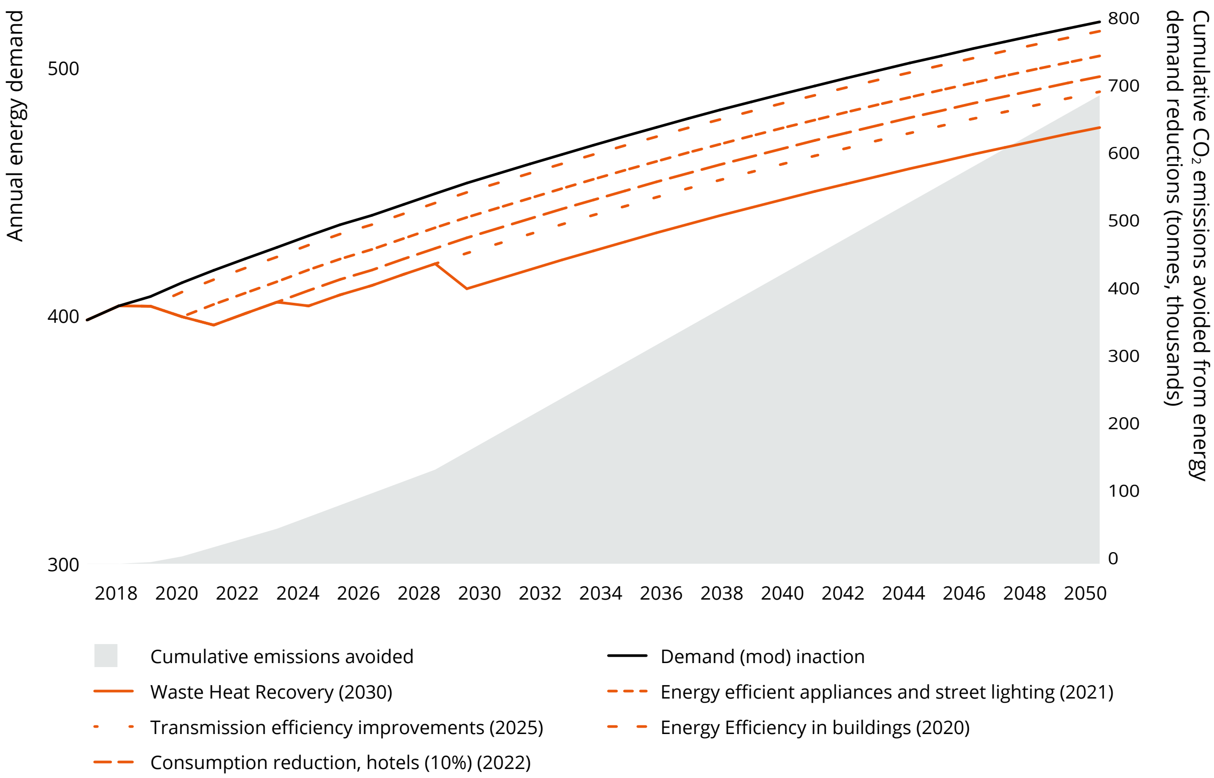


Figure 9:
Electricity demand reductions and efficiencies, and avoided CO_2 emissions



PRIORITY AREAS AND QUICK WINS: ELECTRICITY SECTOR

1. Energy demand reductions

Several energy demand initiatives can contribute to reducing Saint Lucia's national demand for electricity by over 5 percent, as proposed in the island's Third National Communication on Climate Change. Actions currently proposed for short-term implementation are the finalising of building codes for increased energy efficiency in commercial and residential buildings, the implementation of a comprehensive appliance labelling programme, and the retrofit of approximately 21 thousand street lightbulbs to LED.

2. Solar capacity

Additional utility-scale solar sites should be identified across the island. Given favourable conditions for the resource, a large portion of Saint Lucia's electricity generation portfolio – up to 28 MW of installed capacity – has been determined to be feasible through solar PV before significant upgrades or storage investments are required. In the short term, feasibility assessments for small-scale solar installations at facilities such as the Owen King EU Hospital, the Bordelais Correctional Facility, and the Saint Lucia Bureau of Standards have already been carried out.[18]

3. Geothermal energy

The addition of geothermal energy to Saint Lucia's generation portfolio will provide a major contribution to meeting its renewable and mitigation targets. Pre-feasibility, environmental and social impact studies for the initiative at Soufriere have already been conducted. Initial generation through a pilot project is feasible by 2025, requiring technical design and specification of a geothermal plant. Large-scale production can come into effect within the next decade.

Photograph by Saint Lucia News Online

6 WATER

Fresh water in Saint Lucia is largely supplied by surface water withdrawals from rivers and watersheds

During the rainy season (June to November), these provide reliable flows due to the island's mountainous topography and low-permeability rock basement. Unlike many other SIDS in the Caribbean region, Saint Lucia does not currently rely on desalination for municipal water production. Thirteen water treatment plants, with various levels of filtration, are located around the island and operated by the Water and Sewerage Company (WASCO). Over half of municipal water is provided by the Theobalds Water Treatment Plant, which serves most of the northern population. The plant is supplied with raw water from the John Compton Dam and its reservoir which has experienced heavy siltation as a result of upstream erosion from heavy rainfall and landslides, leading to significant reductions is storage capacity.

The southern part of the island faces water security challenges in the dry season (December to May), when river water flows reduce by 40 percent on average, with some ceasing completely.[19] Low volumes of available water storage contribute to the risks of water shortage during this season. Water demand related to the tourist sector accounts for approximately 16 percent of total annual demand. This is a particular challenge during the dry season, which coincides with the arrival of cruise ships.[20] To address this, desalination plants have been commissioned at a number of tourist resorts – however, the water produced is for private use and does not contribute to the municipal water supply.

A major challenge for the water sector is the high levels of non-revenue water. Approximately 30 percent of total water supply is lost through physical leaks in the transmission system (real). When combined with water unaccounted for due to theft or metering inaccuracies (apparent), this figure reaches 56 percent (Figure 10).

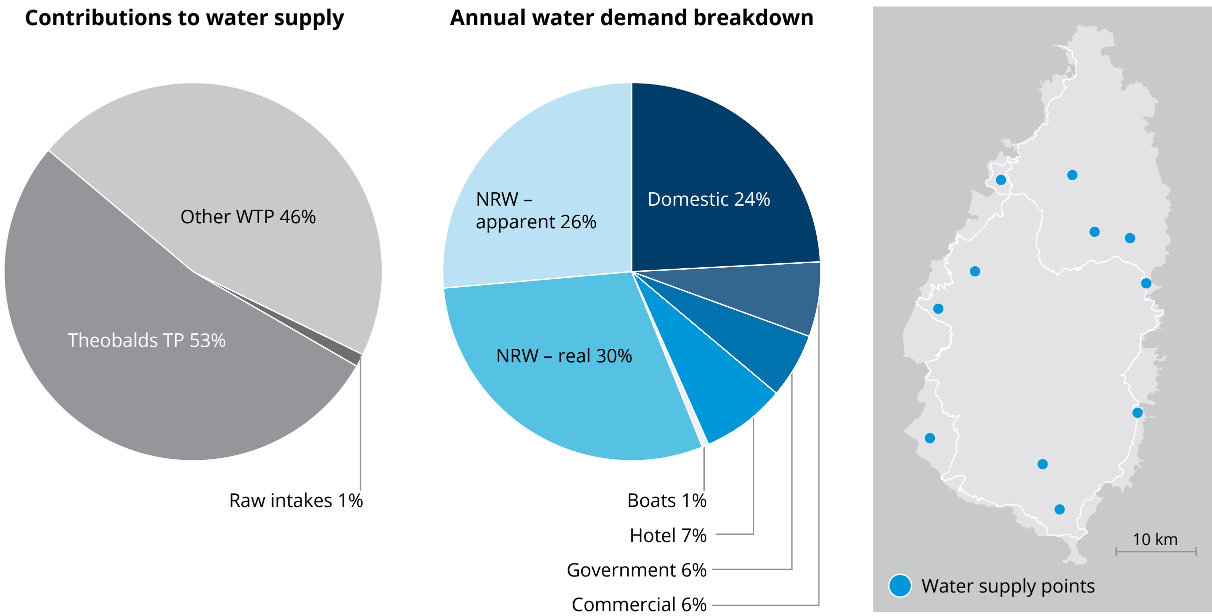


Figure 10:
Current breakdown of water supply and demand

Without urgent efforts to address water security in Saint Lucia through demand- and supply-side measures, water shortages will continue to increase in magnitude, particularly during the dry season

The current challenge is illustrated in Figure 11, where low river flows in dry periods may reduce total water supply to lower than 40 thousand cubic metres per day, far lower than the average daily demand at nearly 60 thousand per day. Decreased river flows of up to 50 percent in the dry season have been measured, reducing capacity of treatment plants using the river as an intake, although these rates vary according to location. In high-demand periods, approximately 100 thousand cubic metres per day is required to ensure a reliable supply for all residential and tourist needs. This assumes a peaking factor of 1.8, used in the water industry, to account for the additional strain on water resources posed during these periods.

According to current trends and an assumption of moderate population and tourism growth scenarios, peak daily water needs will increase by nine percent by 2030 and 13 percent by 2050. However, numerous uncertainties may affect these projections. For example, climate change may amplify dry season shortages by further reducing the amounts of water that can be abstracted. A lack of adequate and regular maintenance may lead to the deterioration of current infrastructure including the siltation of storage reservoirs, further reducing their supply capacities.

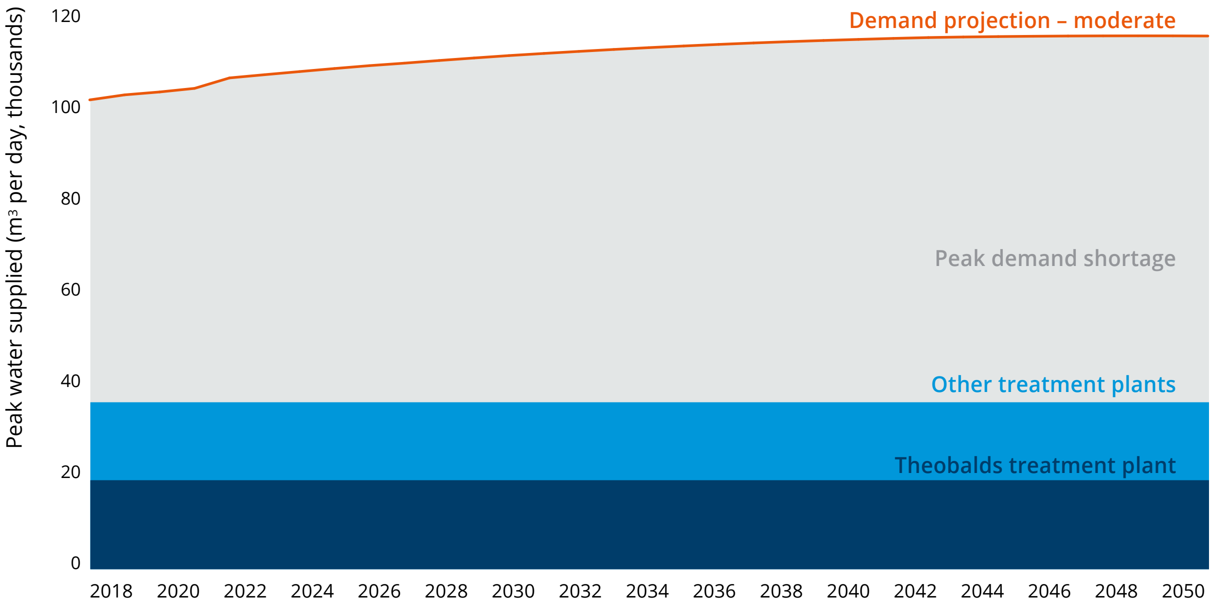


Figure 11:
Future needs under a moderate demand growth scenario, water supply sector

A combination of water storage, desalination, and demand and loss reductions can eliminate the gap between reliable water supply and peak demand in the long-term

Several water redevelopment projects are confirmed or underway, specifically in the districts of Dennery and Vieux Fort. These projects contain both water treatment and storage components and target communities where water shortages have been particularly acute, both in the rainy season, due to high turbidity, and the dry season, due to decreases in water flow. The use of desalination plants is being considered in the northern district of Gros Islet, where WASCO has identified the need to implement short-term solutions to the water security challenge. These plants would be solar-powered and could provide over 20 thousand cubic metres per day, regardless of the season (Figure 12).

KEY NATIONAL AND INTERNATIONAL TARGETS

6.1 Efforts to reliably meet peak water demand in the dry season will require that treatment, storage, and demand-side solutions be implemented progressively over the coming years. This assessment aims to provide adequate capacity to meet this peak demand by 2035.

6.4 Achieving water security, particularly during the dry season, will require that water-use efficiency measures are implemented and that loss-reduction targets are met.

1.4 Ensuring that all residents of the island have access to basic services requires focused efforts on water security in low-income communities.

Figure 12:

Long-term water supply and demand planning to meet national targets

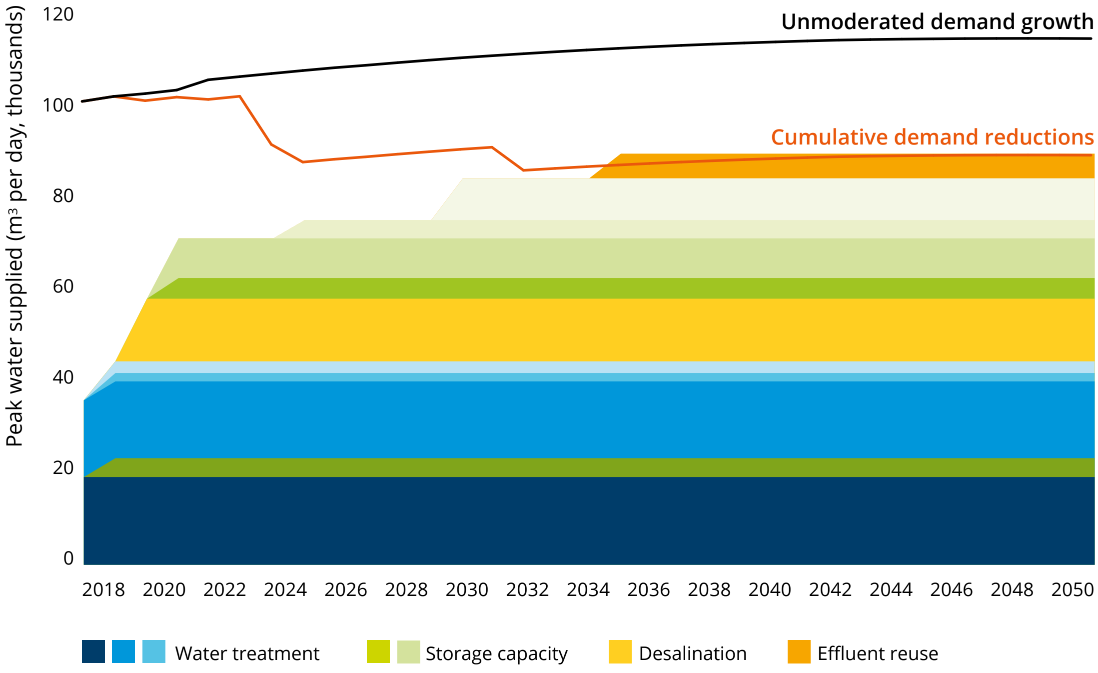
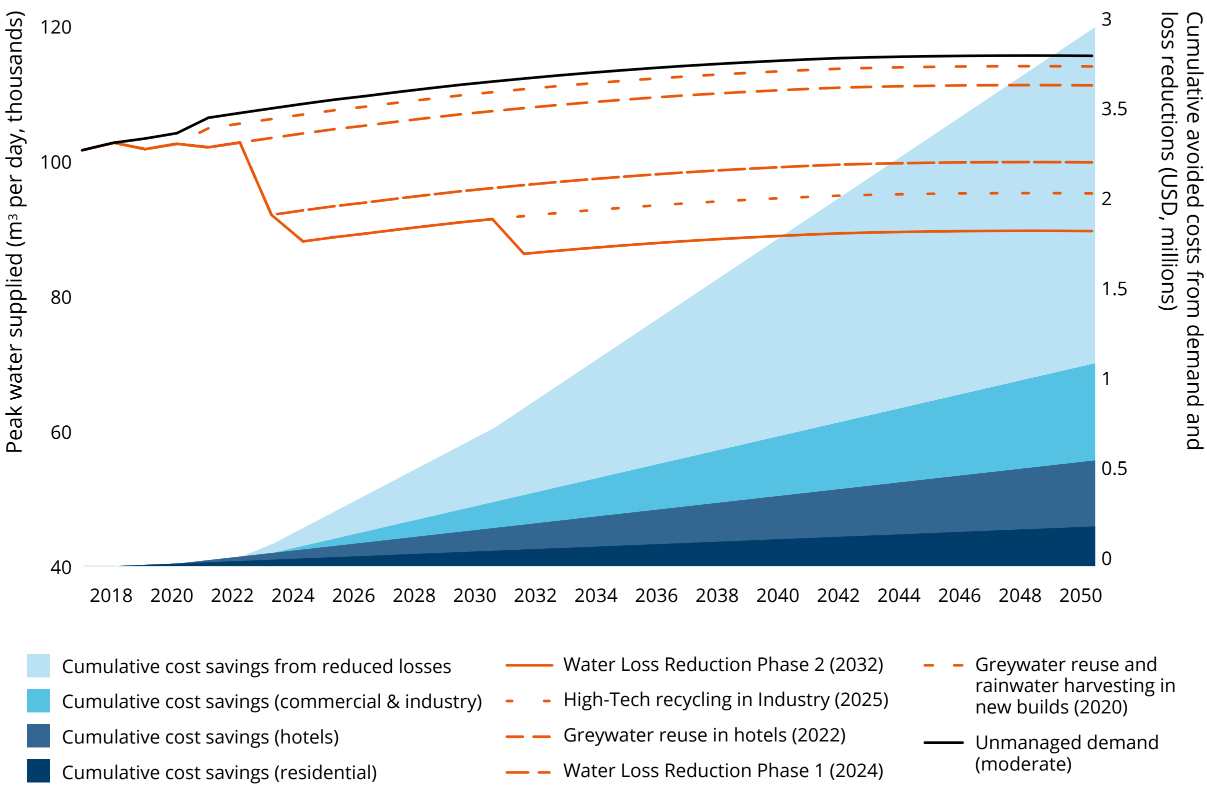


Figure 13:

Water demand reductions and efficiencies, and avoided costs



The first phase of the John Compton desilting and rehabilitation project began in 2018, designed to remove 1.5 million cubic metres of sediment from the reservoir and restore its original active capacity, which has been reduced by half. A future phase of pipe installation and sediment removal will be necessary to ensure the Theobalds treatment plant can operate at its maximum capacity of nearly 50 thousand cubic metres (10 million gallons) per day.

Given its high share of the water demand breakdown (56 percent), non-revenue water represents a strong opportunity to target water supply efficiency by avoiding losses in the water transmission system. Reducing non-revenue water may be undertaken over multiple phases and involve several steps, for example by establishing metering zones for better monitoring of flows and pressure, establishing a comprehensive asset management strategy, and undertaking pipe replacement to increase transmission efficiency to 80–90 percent. Figure 13 highlights the role of demand and loss reductions in a national infrastructure strategy. Using WASCO's water rates for different types of consumer – domestic, commercial/industrial, and hotel – cumulative cost savings associated with the implementation of these measures can be estimated.

PRIORITY AREAS AND QUICK WINS: WATER SECTOR

1. Water loss reductions

Addressing non-revenue water has been identified as a major priority by WASCO. Systematic replacement of existing pipes in the north of the island can improve transmission efficiencies to around 80-90 percent. Establishing metering and pressure zones along faulty networks for better monitoring of flow and pressure will contribute to leak identification and eventually reduce apparent system losses.

2. Increased water storage capacity

Added storage capacity will be key to providing water security in the dry season, particularly in the south of the island where there is no reservoir. Rainwater harvesting capacity – which has been implemented in a pilot study – should be integrated into new building construction to provide additional sources of decentralised water collection and storage.

3. Dam desilting and rehabilitation

The desilting of John Compton dam commenced in 2018 and will greatly increase the dam's capacity to supply the Theobalds Treatment Plant, serving most of the island's north. Future planned phases can ensure that the dam is restored to its original capacity, as climate change factors such as hurricanes have been shown to rapidly obstruct the dam and its main outlet pipe through heavy siltation. Vegetation and protection of the reservoir basin may be considered to prevent or limit future siltation related to these events.

Photograph by FFelix (UNOPS)

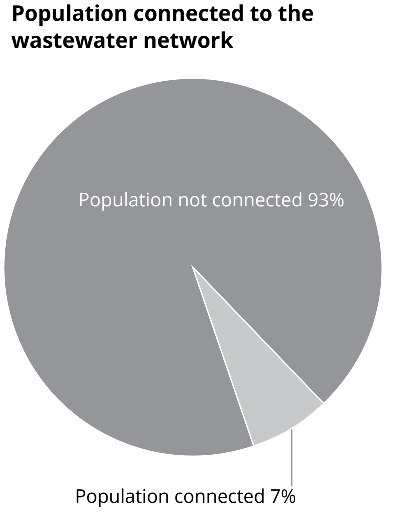
7 WASTEWATER

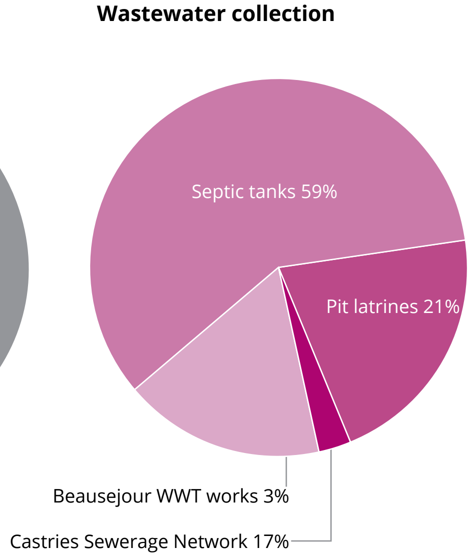
Levels of wastewater treatment are currently inadequate in Saint Lucia

Only two percent of wastewater is treated, while 70 percent is collected through on-site sanitation facilities such as septic tanks and pit latrines (Figure 14). A further 28 percent is directly discharged into the environment as raw sewage.[21]

WASCO operates three public sewer systems on the island, to which only seven percent of the population is connected, compared to a Caribbean average of 17 percent. There is one wastewater treatment plant at Beausejour, which treats wastewater from several communities within the Gros Islet district. Treated wastewater from the plant is released into the environment via a stream, with some effluent used for irrigation at a nearby golf course. The Beausejour plant was designed to treat 2.7 million cubic metres of wastewater annually,[22] or around 20 percent of the total wastewater produced in the country. However, the plant is currently being utilised far below design capacity due to undersized sewer pipes in some areas, which are unsuited to carrying larger volumes to the plant. Financing upgrades to these systems remains a major challenge for WASCO.

A second public sewer system in Castries provides collection and primary settling and screening for the capital's wastewater, using communitor pumps to shred the raw waste and solids into smaller particles. However, the system contains no further treatment and pumps 6.8 thousand cubic metres of sewage in the harbour every day. Sludge from on-site facilities is often discharged directly onto open lands, with less than 50 percent collected and properly treated.[21] Pollution of the sea and coastlines is intensified as yachts and boats empty wastewater directly into the water. Demand for emptying services at marinas is low, attributed partially to poor environmental awareness and limited enforcement of international maritime regulations. A third public sewer system provides septic tank-like treatment at Black Bay-Vieux Fort.





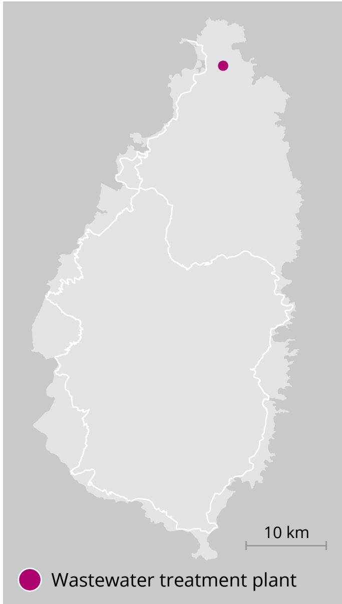


Figure 14:
Current breakdown of wastewater supply and demand

A failure to implement ambitious policies and investments in the wastewater sector will maintain the status quo approach to discharging untreated sewage, threatening the safety of public beaches as well as marine ecosystems

Since Saint Lucia's natural beauty is a primary attraction for thousands of tourists, water pollution could potentially pose a threat to the industry and consequently affect the income it generates for the country. Continued reliance on on-site systems such as septic tanks for residential, hotel, and agricultural properties will not suitably address this national infrastructure challenge. In communities where even these basic sanitation services are lacking or inadequate, an absence of action in the wastewater sector may exacerbate potential health risks such as high levels of bacteria and the transmission of water-borne diseases.[23] From an economic perspective, previous investment in the Beausejour wastewater treatment plant will continue to be squandered as it operates at a fraction of its capacity (Figure 15).

A national wastewater strategy aims to limit terrestrial and marine ecosystem deterioration linked to untreated wastewater discharge, protecting opportunities for long-term employment and economic growth from the tourism sector

Such a strategy will provide reliable collection and treatment of the island's wastewater, using centralised and community-based treatment options and building on synergies with the water supply sector (Figure 16).

Given the current capacity shortage, large-scale treatment plants will necessarily form a part of this strategy. The efficient utilisation of the existing treatment plant at Beausejour can itself increase the national wastewater treatment rate by over five times. This will, however, require investment in new or upgraded sewer pipes to connect the plant to surrounding communities, including Rodney Bay. Alternatively, trucks may be used to pump and haul greater quantities of wastewater to the plant while sewer system expansions are ongoing.

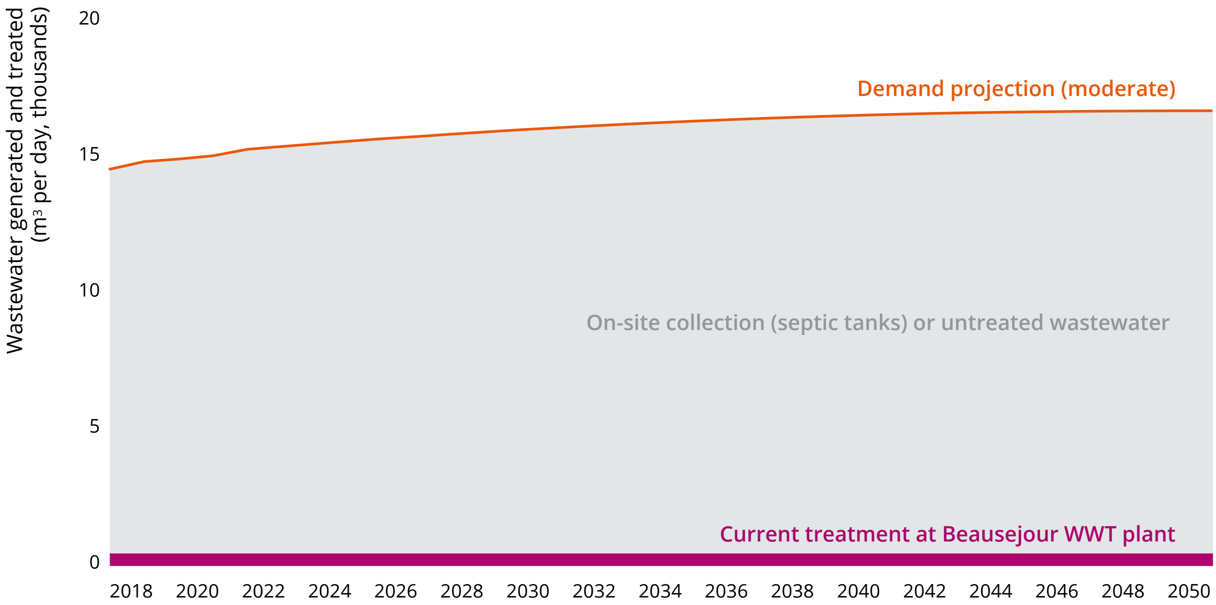


Figure 15:
Future needs under a moderate demand growth scenario, wastewater sector

KEY NATIONAL AND INTERNATIONAL TARGETS

6.3 This assessment aims for an ambitious target of halving untreated wastewater by 2030, amounting to a treatment rate of 61%. Further efforts can aim to halve this once again over the next 15-year period, resulting in a treatment rate of 80% by 2045.

6.2 In addition to treatment capacities, access to toilets should be ensured to achieve access to adequate and equitable sanitation and hygiene as well as to end open defecation. The target for wastewater collection is set at 100% by 2030.

14.1 Protecting natural marine resources and life will require that wastewater discharges are eliminated.

A centralised wastewater treatment plant for Castries city and its suburbs is another current priority for the sector. Catering for 40 percent of the island's population, such a facility will greatly increase the total connected population. In smaller communities, decentralised treatment solutions may be more cost-effective. Wetlands are particularly appropriate for low-income communities due to their simple design, operation and maintenance. However, community-level training and incentives will be required to ensure that projects meet their needs, which will help ensure the viability of the service and its long-term sustainability.[24] A 2010 pilot wetland filtration project in Dennery Valley sought to sensitise communities to the use of communal wetlands to preserve water sources from ground and water pollution. The project demonstrated improved and coordinated water resource management that managed faecal waste and pollution at low cost.[25]

The wastewater sector will equally benefit from actions taken in the water supply sector to reduce water use. Targeted interventions in hotels, new homes, and industrial facilities will lower the amount of grey and black water that needs to be managed. Treated effluent can similarly be reused for non-consumptive uses such as irrigation and industrial use (Figure 17).

Figure 16:
Long-term wastewater capacity and demand planning to meet national targets

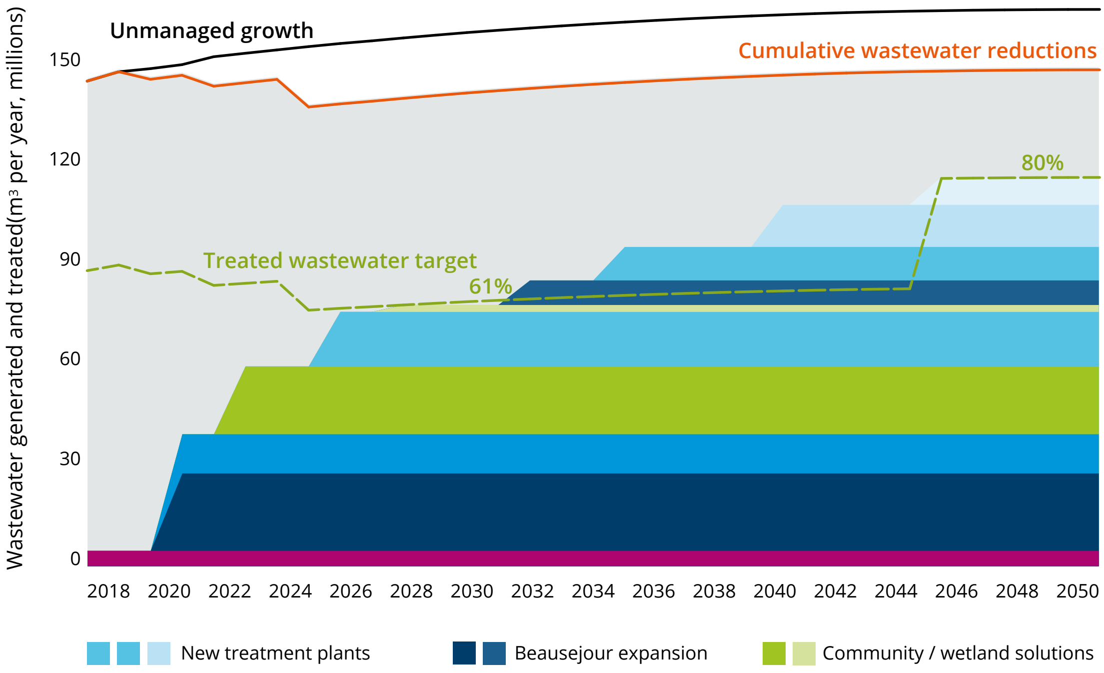
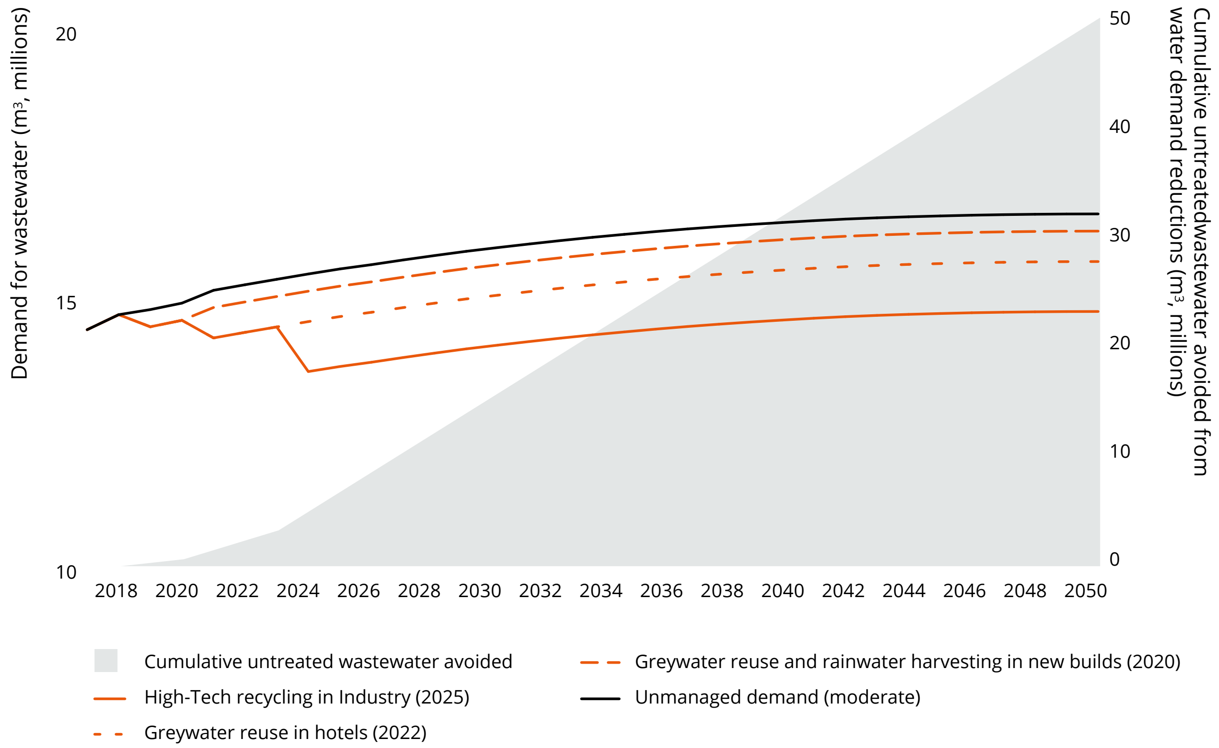


Figure 17:
Wastewater treatment demand reductions, and cumulative avoided discharges



PRIORITY AREAS AND QUICK WINS: WASTEWATER SECTOR

1. Capacity utilisation of the Beausejour treatment plant

Upgrading and replacement of existing sewer lines – or the laying of additional pipes – is required to supply the treatment plant at its full capacity of 7.5 thousand cubic metres per day and to connect new residential developments in the north of the island to the sewage treatment network. In the short term, the collection and transport of sewage from homes and buildings served by septic tanks may increase the utilisation of the plant.

2. Castries wastewater treatment plant

A new wastewater treatment plant has been prioritised to serve the greater Castries region, which will eradicate the institutionalised discharge of raw sewage into Castries Harbour by treating a minimum of 5,678 cubic metres per day.

3. Greywater and effluent reuse in hotels and resorts

Hotels and resorts require large amounts of water for uses such as recreation and irrigation. Initiatives targeting the reuse of greywater and effluent treated on site have the potential to reduce wastewater discharge while lowering stress on the water supply network.

4. Public sensitisation campaigns

These low-cost initiatives can significantly raise awareness of the dangers associated with dumping sewage into local streams, particularly near informal settlements, which include increased concentrations of bacteria such as faecal coliform.

Photograph by FFelix (UNOPS)

8 SOLID WASTE

Saint Lucia's solid waste sector faces challenges common to other SIDS: limited landfill space and underdeveloped and costly sustainable waste management options

In recent years, most of the country's waste has been disposed of in two sites: the Deglos Sanitary Landfill, occupying 9 hectares in the island's north, and the Vieux Fort controlled dumpsite in the south. As of October 2019, the Vieux Fort site is closed due to a strategic change in use of the land, requiring all waste from the south of the island to now be transferred to the north. The Deglos site, opened in 2003, was built with an initial design capacity of 1.1 million tons, with the current remaining capacity as of 2019 at approximately 300 thousand tons. The facility also has a leachate collection and treatment system.[14] With the landfill receiving an average of 60 thousand tons per year, the site will reach the end of its lifespan within the next five years. Substantial amounts of solid waste are also dumped illegally at sites across the island (Figure 18).

There are no recycling facilities in the island, and no waste transfer stations, meaning that there is little opportunity to sort waste before it arrives at landfill sites.[14] A number of informal waste handling operations exist, which collect recyclable items including scrap metal, spent lead acid batteries, PET plastic, and cardboard paper for shipping. However, with countries such as China and India restricting recycling imports, the international market for recycled materials is increasingly shrinking. Small amounts of specific types of waste are treated through specialised processes: for example, biohazardous waste from health care facilities is sterilised through autoclaving. An industrial-grade shredding machine has been commissioned to deal with an accumulation of tires at the Deglos Landfill. Waste associated with tourism – produced by hotels or cruise ships – accounts for 10 percent of the total.

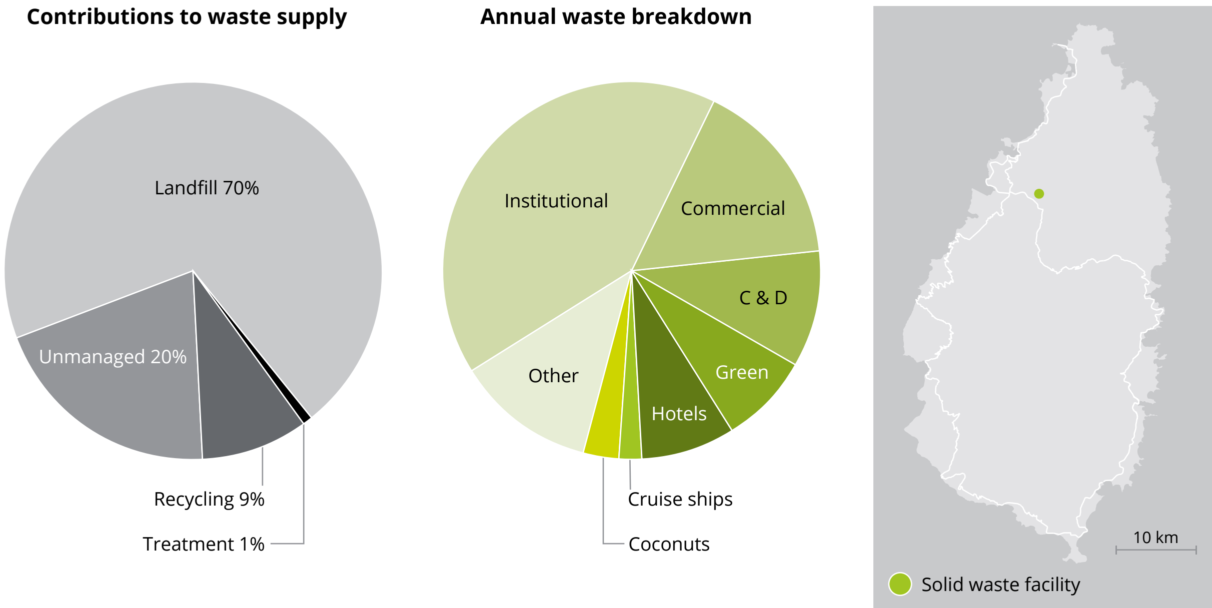


Figure 18:
Current breakdown of solid waste supply and demand

The Saint Lucia Solid Waste Management Authority (SLUSWMA) is responsible for waste collection from residential and government-owned properties, which is conducted at a minimum frequency of twice per week, or three days a week in Castries city. Bulky waste items such as furniture and appliances are collected once a month in all areas of the island. The private sector is responsible for its own waste collection and transport to landfill.

There is no user (or 'tipping') fee for use of the landfill. Two main challenges related to transport in the waste sector are the aging fleet of waste collection vehicles and the poor conditions of many roads (in regard to both surface condition and ease of access), making collection impossible at many properties. Communal collection areas are set aside for this purpose, but often attract additional waste, leading to problems of overflowing.

Solid waste management in Saint Lucia faces a looming capacity shortage due to the closing of the Vieux Fort dumpsite in 2019 and the limited lifespan of the Deglos facility

Current per capita waste generation is over half a tonne annually, roughly in line with other upper middle-income countries. This may rise further if the Saint Lucian economy accelerates due to increased tourist income. It would likely be accompanied by increases in the volumes of certain waste streams, such as commercial and food (e.g. coconuts) waste.

Under a moderate demand scenario, annual waste generation may increase by 12 percent from current levels by 2050 (Figure 19). With the closure of the landfill, Saint Lucia's waste must be treated on-island through alternative waste management options or exported to other countries at cost. Without a strategic plan to address the waste problem, the risk of illegal dumping and informal waste incineration will increase.

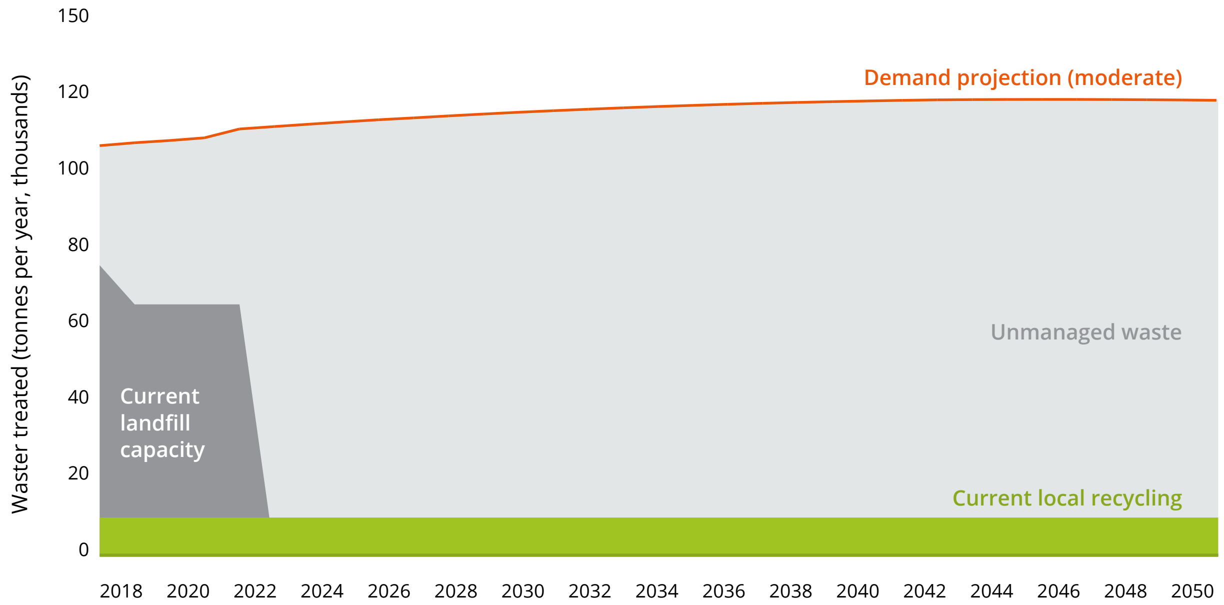


Figure 19:
Future needs under a moderate demand growth scenario, solid waste sector

A national infrastructure strategy for waste should aim to preserve Saint Lucia's natural environment for locals and tourists by sustainably managing waste and creating economic opportunities for local residents. This entails the harnessing of waste to grow the country's circular economy by supporting the recycling and compost industries through incentives and new initiatives.

The future of waste management in Saint Lucia should prioritise regional solutions and the extraction of value from waste, rather than the identification of new landfill sites

To address an urgent need to replace capacity provided by the Vieux Fort dump site, portable waste units have been commissioned to incinerate waste from the south of the island. These units provide a modular approach to waste management that could be augmented as required.

Nearly 50 percent of solid waste on the island is organic. This presents an opportunity to divert compostable material from landfill for use in agriculture. Although initiatives for backyard composting exist – such as in schools or hotels – they do not provide a significant contribution to the management of waste at a national scale. The commercial avenue around composting has not yet been explored. However, a recently-opened facility in the neighbouring island of Saint Vincent[26] suggests that a similar initiative could play a large part in Saint Lucia's national waste management strategy (Figure 20).

Another large component of the waste stream can be addressed with a renewed focus on recycling initiatives. While traditional recyclers currently face barriers to expanding their operations, regional cooperation agreements can provide a means to undertake Caribbean recycling initiatives in an economically viable way. A new recycling plant in Martinique, currently operating under capacity, could serve as a destination for Saint Lucia's plastic, which comprises 22 percent of its waste. Paper (10 percent) and glass (7 percent) are other major waste components that could feasibly be separated from the landfill waste stream[27].

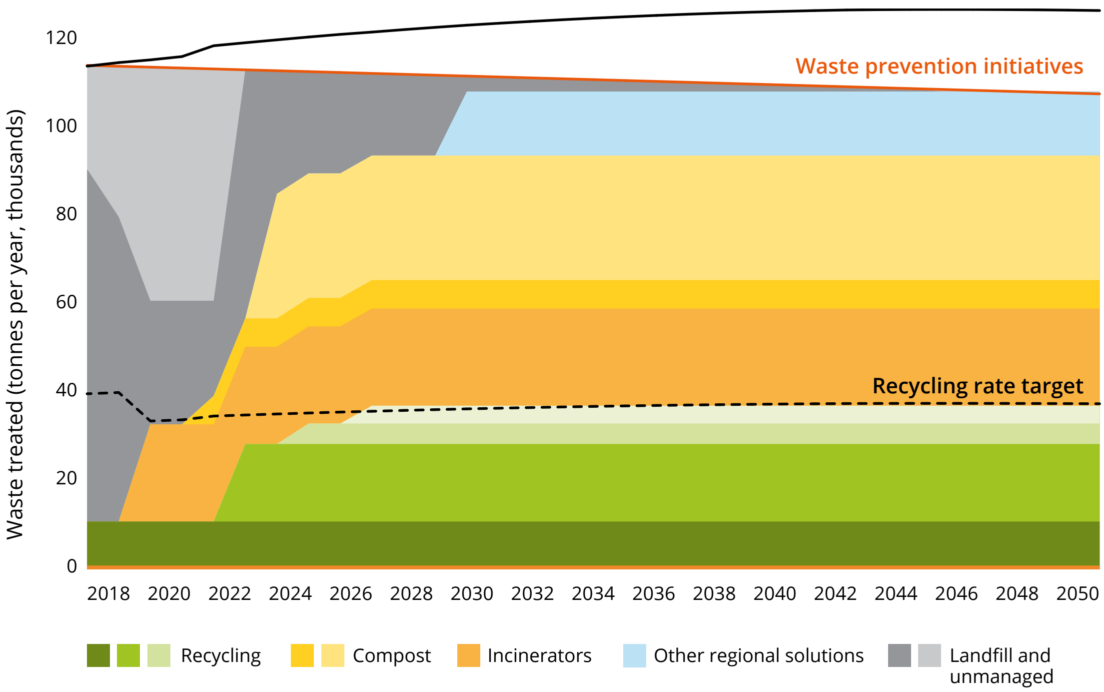


Figure 20:
Long-term solid waste capacity and demand planning to meet national targets

KEY NATIONAL AND INTERNATIONAL TARGETS

12.5 Recycling is a major component of a sustainable waste strategy for Saint Lucia. This assessment sets a recycling target of 35%, similar to rates seen in countries such as the United States.

11.6 With the closure of Saint Lucia's two landfill and dump sites over the next five years, the government aims to avoid the need to identify any large-scale landfill sites in the future, contributing to reducing the environmental impact of waste management.

Reduction targets for emissions in Saint Lucia's solid waste sector (largely methane from landfilled waste) are set in line with the country's Nationally Determined Contributions (NDCs) of 16% by 2025 and 23% by 2030.

PRIORITY AREAS AND QUICK WINS: SOLID WASTE SECTOR

1. Inter-regional recycling and waste initiatives

A cooperation project would allow used plastic bottles to be exported to a recycling facility in the neighbouring island of Martinique – the SIDREP (La Société Industrielle de Recyclage et de Production) plant – which is currently not operating at full capacity. The success of such an initiative could encourage further cooperation on other scalable waste solutions, including waste-to-energy, throughout the Caribbean region.

2. Compost facility

High levels of organic waste (nearly 50 percent) in Saint Lucia's waste stream can be harnessed for agricultural purposes through composting initiatives. Specifically, a large-scale facility designed to treat the majority of the island's green, food, and farm waste can create value in the waste industry and provide nutrient-rich matter for Saint Lucia's agriculture industry. A similar facility was recently constructed in Saint Vincent and the Grenadines, equipped with bio-digesters and a steam-sterilising machine, and opened in 2019.

3. A national waste prevention initiative

A national waste prevention programme, targeted at specific products and industries, can contribute to successfully reducing waste levels. This will require participation of the private sector in waste reduction initiatives. Policies mandating reusable or recyclable packaging, plastic bag charges, or deposit refunds can reduce total waste produced by over 12 percent, as demonstrated in other countries. In the UK, plastic bag use at supermarkets dropped by 86 percent within a year of a 5p (7¢ US) charge being implemented.

Photograph by Daniel Adshead

9

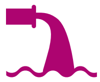
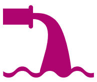
INFRASTRUCTURE INTERDEPENDENCIES AND THE ROLE OF TRANSPORT

Each sector assessed above is part of a wider infrastructure system. Accounting for the ways in which infrastructures are linked can allow for more effective decision-making in the infrastructure planning process

Often, these considerations are overlooked, leading to silo-based planning of individual sectors. Interdependence has relevance both in the long-term planning of infrastructure and in minimising the risks of system failure. Given the interconnectedness of the system, a strategic infrastructure plan for Saint Lucia should assess the risks of service disruption across the wider range of social assets such as hospitals, schools, and government buildings posed by specific climate and weather hazards. Table 2 outlines key linkages between infrastructure sectors in Saint Lucia, including the necessary roles of electricity, transport, water, and waste in the function of social and economic infrastructures and the agricultural sector. Notably, the transport sector is highly linked to outcomes in other infrastructure sectors as it provides residents, businesses, and communities the physical access required to benefit from infrastructure service provision, including critical social infrastructure services such as healthcare and education. In addition to the physical networks themselves, the quality of the transportation system, for example poor road surfaces, is a concern as it hinders the provision of services such as waste removal.

Interdependencies may increase demand for additional infrastructure services, but can also provide solutions in the form of efficiencies or supply-side capacity that meets the needs of multiple sectors at once. The projected expansions in the capacity of two of the island's international transport hubs by 2050 are shown in Figure 21, indicating 101 and 57 percent increases in annual stay-over and cruise tourist arrivals, respectively. This will greatly increase pressure on the island's existing infrastructure. While currently not under consideration, waste-to-energy and anaerobic digestion technologies may provide solutions that could form part of Saint Lucia's future national infrastructure strategy to treat the majority of waste and sewage sludge while generating electricity for the grid. If not feasible on the island, these technologies may also form part of a regional infrastructure strategy. Numerous interdependencies are also evident between the water and wastewater sectors: implementing identified water efficiency measures could reduce wastewater generation by 12 percent while treated effluent may contribute an additional eight percent of water supply for uses such as irrigation.

Table 2: Cross-sectoral infrastructure interdependencies

		Infrastructure inputs				
						
Impacts on infrastructure sectors			Electricity input to transport assets (port and airport)	Water input to transport assets (port and airport)	Septic tank servicing requires road transport	Municipal waste removal requires road transport
		Tourism growth increases demand for electricity			Wastewater sludge input to electricity generation	Waste input to electricity generation
		Tourism growth increases water usage	Energy input to water supply (e.g. desalination)		Wastewater reuse as water supply source	
		Tourism growth increases production of wastewater	Electricity input to wastewater treatment plants	Water is transformed into wastewater		
		Tourism growth increases production of waste	Electricity input to waste facilities		Wastewater sludge disposed of in landfill	
Impacts on other infrastructures		Roads provide access to buildings and facilities	Electricity input to buildings (e.g. hospitals, schools)	Water connections to all buildings	Buildings connected to the sewer network	Waste streams produced by facilities, including biomedical, e-waste, etc.
		Transportation of crops from farms to markets (domestic sales) or ports (exports)	Electricity to enable the use of modern agricultural processes	Irrigation needs for crops	Control surface runoff contamination	Management of large amounts of farm waste

Degree of sectoral interdependency

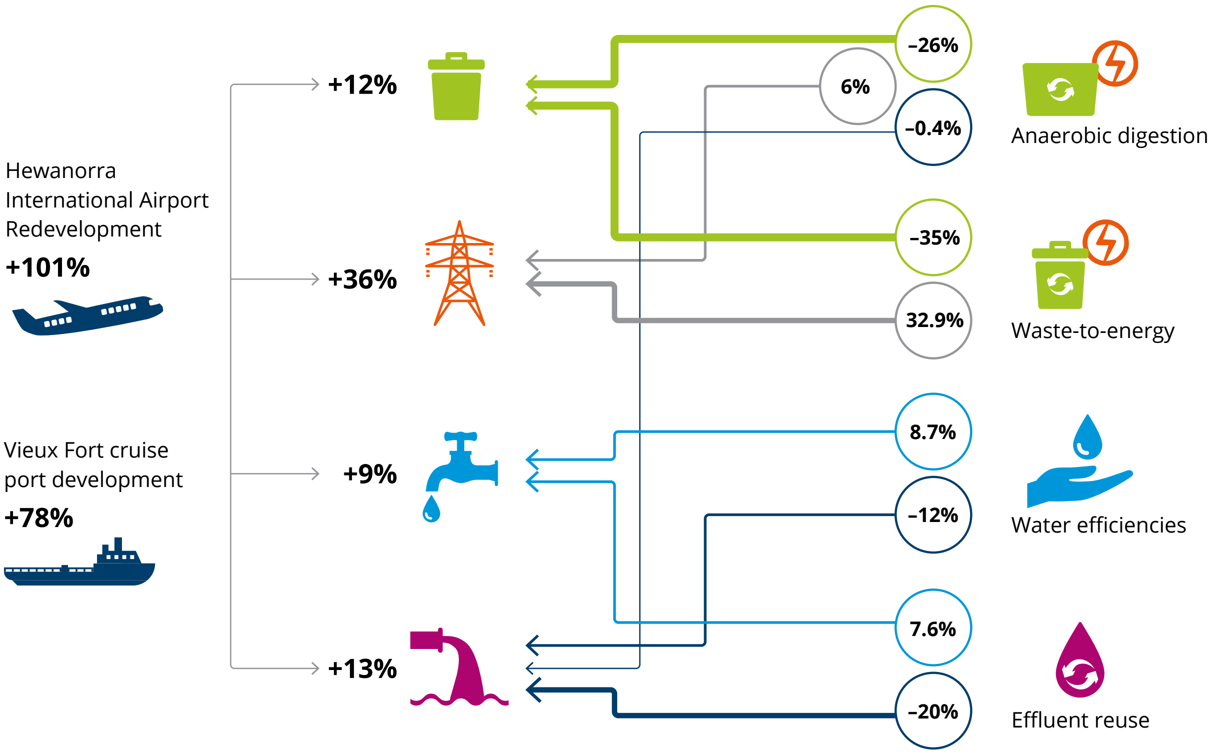


Figure 21:

Impact of Saint Lucia's air and cruise port expansions on visitor numbers and infrastructure needs by 2050, and potential cross-sectoral solutions

Photograph by Daniel Adshead

10

CROSS-SECTORAL PERFORMANCE: LONG-TERM INFRASTRUCTURE PLANNING

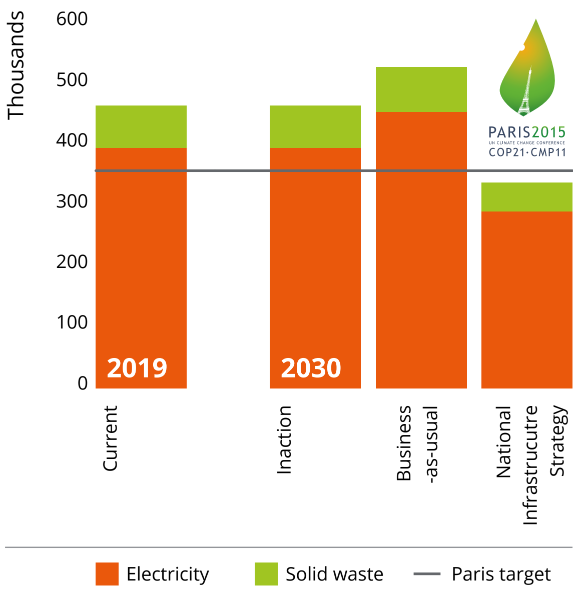
Long-term infrastructure development in Saint Lucia can be fostered in line with its commitments under the Paris Agreement to mitigate the effects of climate change

Given that its contribution to global emissions is low, Saint Lucia – along with other SIDS – has generally prioritised adaptation measures to protect its people and infrastructure from the regular threat of climate change-related hazards, and to build resilience to their impacts. Nevertheless, the country is committed to reducing its greenhouse gas emissions to levels that will restrict global temperature increase to 1.5 degrees above pre-industrial levels.[28] Using cross-sectoral infrastructure modelling, inputting the government's reduction targets of 16 percent by 2025 and 23 percent by 2030 can help define necessary investments and policies as part of a national infrastructure strategy.

Figure 22 shows the full emissions potential, in tonnes of CO_2 equivalent, associated with the current electricity supply and solid waste management portfolios. Over the next decade, meeting a rising demand for these infrastructure services through a business-as-usual portfolio of fossil fuels and landfill capacity will result in a failure to meet its mitigation commitments.

Figure 22:

Emissions potential, electricity and solid waste sectors (tonnes of CO_2 equivalent). Note that current emissions potential is calculated from installed capacity in the electricity sector rather than actual demand



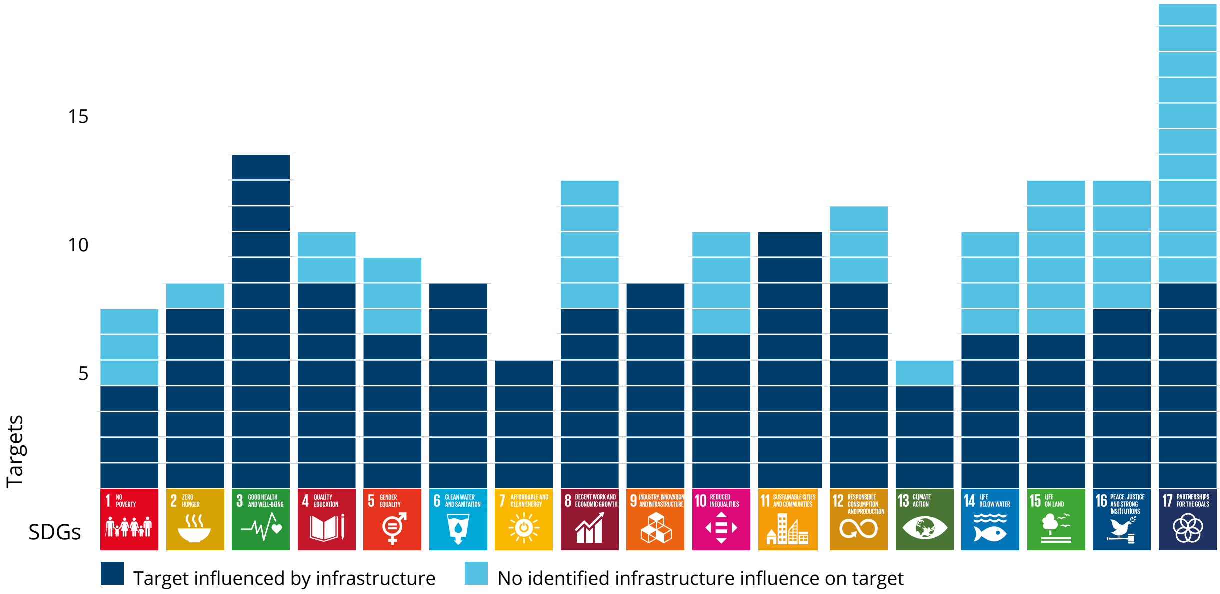


Figure 23:

Scope of potential development benefits from sustainable infrastructure planning[4]

A national infrastructure strategy can reduce emissions levels in line with reductions targets for these two sectors. This will occur largely by shifting the country to a renewables-based energy portfolio, as well as by removing large quantities of methane-producing waste from landfill sites, to be treated instead through recycling and compost initiatives. In addition to these sectors, achieving the targets set by the Paris Agreement will require further emissions reductions in the transport sector.

The planning of long-term infrastructure strategies for Saint Lucia can equally provide an opportunity for the country to fulfil its commitment to achieving progress toward the Sustainable Development Goals

The SDGs provide a globally-accepted framework by which governments can aspire to meet development targets in line with their national priorities.

Nearly 20 percent of the SDG targets can be directly measured using infrastructure-based progress indicators;[4] for example, the share of renewable energy, the wastewater treatment rate, or the national recycling rate. Incorporating these targets through infrastructure modelling in alignment with Saint Lucia's national development strategy can inform the type, capacity, and sequencing of investments and policies across all sectors so as to achieve these targets by 2030 – the global completion date of the SDG Agenda. Where possible, these quantified targets have been linked into the national infrastructure sector strategies for energy, water, wastewater, and solid waste in the previous sections.

More broadly, implementing climate change mitigation in infrastructure planning has the potential to affect the entire SDG framework through a wider range of potential impacts. Countries such as Saint Lucia are encouraged to capitalise on the development opportunities this offers in terms of potential co-benefits across areas such as health, education, equality, economic growth, and the protection of ecosystems (Figure 23).

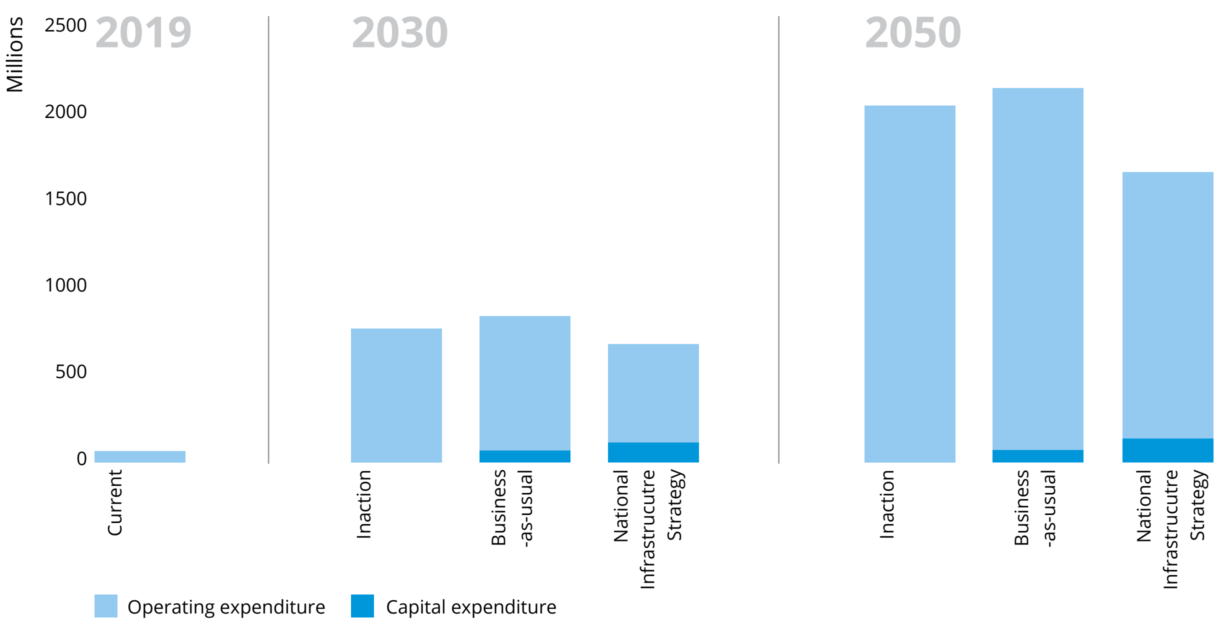


Figure 24:
Long-term cumulative costs of national infrastructure strategies, electricity sector

While the infrastructure planning aspects addressed in this report – assessing future needs and designing informed strategies – are highly important, they only address the upstream planning component of a sustainable infrastructure plan. How infrastructure is then built, used, and decommissioned is an important consideration for practitioners, in order to ensure that the development benefits of infrastructure are distributed to all stakeholders, including the most vulnerable members of the population. The sustainABLE tool,[29] designed by UNOPS, provides a means by which to mainstream SDG considerations across project lifecycles to help ensure influences are realised.

National infrastructure systems designed in line with Saint Lucia's global commitments will require investment in modern, high-tech facilities and networks – but long-term savings make these strategies most cost-effective

Incorporating demand- and efficiency-side measures in all sectors will bring total infrastructure requirements down – as well as the costs required to supply them. Similarly, investing in more sustainable technologies and solutions will cost governments less in the long-term as demand is more efficiently met and operating expenses decrease. In Figure 24, the total cumulative costs associated with different portfolios of investments and policies are shown for Saint Lucia's electricity sector, using data on the average capital and operating costs associated with the use of different energy technologies. Continuing along the current path to meet increased demand requires less short-term investment in capital expenditure, but results in the most costly outcome over time. A sustainable, evidence-based national infrastructure strategy brings down operating costs in future years, leading to lower financial commitments for national governments. Shifting away from a reliance on diesel-based energy generation will increase the country's energy independence by decreasing its vulnerability to fluctuations in international fuel prices.

ADAPTATION PLANNING

11

NATIONAL INFRASTRUCTURE EXPOSURE ASSESSMENT AND ADAPTATION PLANNING

In signing the Paris Agreement, Saint Lucia has committed to undertake ambitious efforts to adapt to climate change, which requires an understanding of the exposure of infrastructure systems to natural hazards

As a small island located in a highly seismic area within the tropical cyclone belt, Saint Lucia's growing economic, social, and natural infrastructure capital is increasingly threatened by extreme climate hazards. The cost of inaction for the island has been calculated to be at 25 percent of GDP by 2050, rising to 50 percent by 2100.[12] Historic impacts from extreme events have shown Saint Lucia's vulnerability and have illustrated a cost estimation of future inaction in preparing for climate change. For example, Hurricane Tomas (2010) resulted in losses of 43 percent of GDP, including more than USD 330 million damages to economic, social and natural assets. Without efforts to adapt against the impacts of such extremes, achievements in ensuring sustainable development for the country may be undermined.

To facilitate the integration of climate change adaptation into development planning, Saint Lucia has proposed a National Adaptation Plan (NAP) with a comprehensive set of 271 climate change adaptation measures aligned with the Global Goals. The plan involves both sectoral and cross-sectoral measures in eight prioritised sectors to be put into practice over the coming 10 years. To date, implementing and prioritising these measures across sectors and districts of Saint Lucia remains relatively poorly informed. To this end, this assessment identifies priority locations of exposure across sectors, hazards, and areas to help inform adaptation prioritisation.

The scope of the adaptation component of this assessment covers four types of hazard threats – sea-level rise, storm surge, flash floods, and landslides – and three sector categories – economic, social, and natural assets. For each of these sector categories, exposure results and policy recommendations are presented at the sector, asset, and district scales. The adaptation assessment explores interventions intended to reduce hazard exposure while contributing to the sustainable development of the country, thereby drawing upon recommendations within the National Adaptation Plan.

The purpose of the exposure and adaptation component of this assessment is to create a high-level indicative screening across sectors and regions. Detailed engineering investigations should be conducted before making site-specific decisions.

Figure 25:

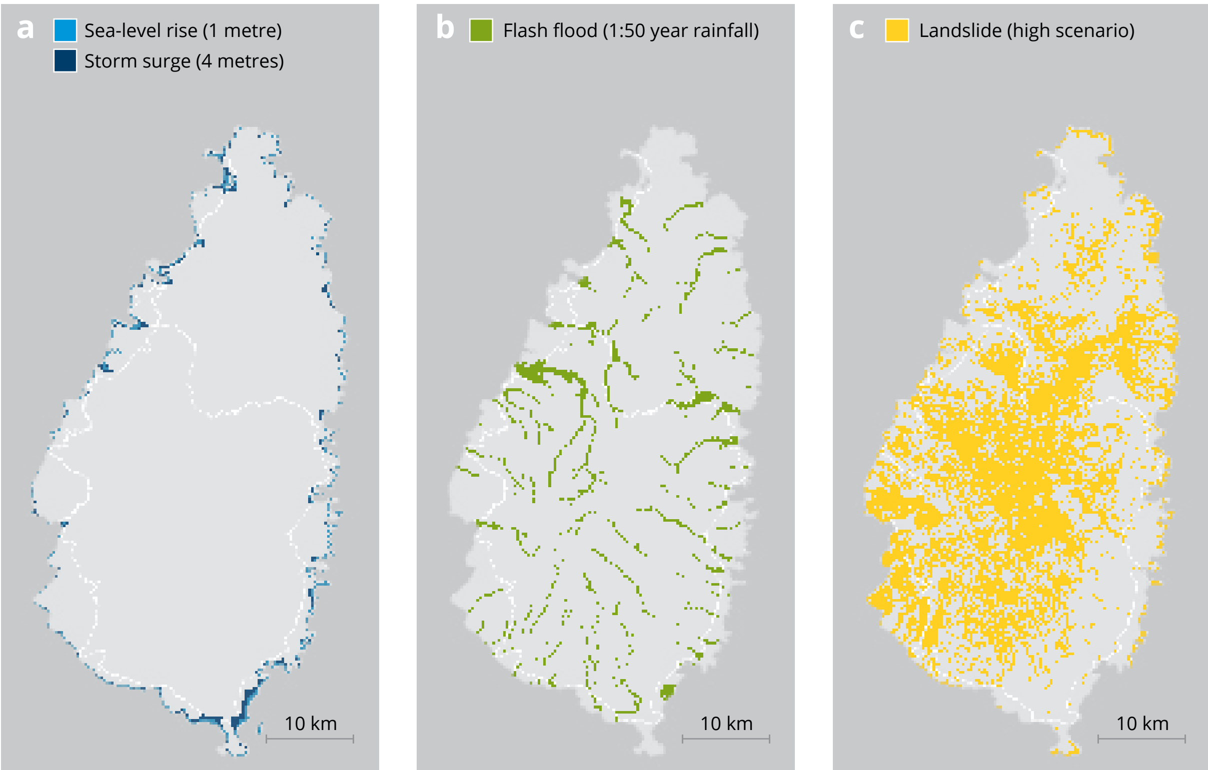
Saint Lucia areas vulnerable to: a) coastal flooding from a 1-metre sea-level rise scenario and a 4-metre storm surge scenario (at a 10-metre resolution); b) flash floods (using national flash flood hazard maps at a 20-metre resolution[33]); and c) landslides (using a landslide susceptibility map at a 20-metre resolution[34])

Link to Saint Lucia's National Adaptation Plan

The results of this analysis and the training of national stakeholders to conduct climate risk assessment of Saint Lucia's national infrastructure using an open-source geodatabase directly responds to and helps implement adaptation measure:

NAP 187-201: Including capacity building of the infrastructure and spatial planning sector and comprehensive assessments of climate change impacts on infrastructures

NAP 268: Sea-level rise model developed



HAZARD THREATS

> **Coastal climate change hazards including sea-level rise and storm surges pose particularly adverse impacts to low-lying islands such as Saint Lucia**

Saint Lucia's coastal zone is characterised by growing high-density infrastructures and tourism attractions. The impacts of increasing coastal climate hazards such as sea-level rise or storm surges can put the development progress associated with these infrastructures at risk. The sea-level rise model developed as part of this assessment assists in characterising areas exposed to a worst-case 1-metre sea-level rise scenario, forecasted for 2100 (Figure 25a). Consistent with previous studies, the storm surge model is represented by a 4-metre inundation scenario, chosen as an average value for Caribbean countries for a 1 in 100-year storm event[30] (Figure 25a).

> **Flash floods, caused by heavy rainfall in a relatively short duration, are expected to become more intense with climate change in the Caribbean region, but total rainfall is likely to decrease**

Flash floods represent the most frequently occurring hazard in Saint Lucia. In the past, flash floods associated with storms have caused rapid erosion, damaging critical infrastructures.[31] In this assessment, flash flood exposure is represented by four return periods, including 1 in 5 year, 1 in 10 year, 1 in 20 year, and 1 in 50 year rainfall scenarios. The exposure assessment in this report focuses on a worst-case 1 in 50 year flash flood scenario (Figure 25b).

> **Landslides – a well-known hazard on the island – are often triggered by extreme rainfall, deforestation, vegetation removal or tropical storms, which are likely to become more intense with climate change**

Characterised by ubiquitous steep slopes, Saint Lucia's natural, social, and economic assets are prone to the impacts of landslides. In the past, landslides from extreme weather events such as Hurricane Thomas (2010) have resulted in fatalities and injuries as well as severe damage to the agricultural and built environment.[32] The landslide model enables the identification of highly susceptible assets, areas or districts (Figure 25c).

Photograph by FFelix (UNOPS)

12 ECONOMIC INFRASTRUCTURE EXPOSURE

Saint Lucia's economic infrastructures – including the country's electricity, solid waste, water, wastewater, and transport (airport, cruise port, freight, and roads) assets – have profoundly developed over the past decades. Today, the island's economic assets include over 35 facilities, of which 80 percent are exposed to one or more of the four hazards of sea-level rise, storm surges, flash floods, or landslides.

National Adaptation Plan

This analysis provides evidence to help prioritise which sectors to focus on for adaptation measures:

NAP 194: Build capacity of the infrastructure sectors for integrating adaptation into their operations

NAP 195: Create plan for retrofitting existing public infrastructure most at risk from climate impacts

NAP 191: Plan phased relocation of vital infrastructures

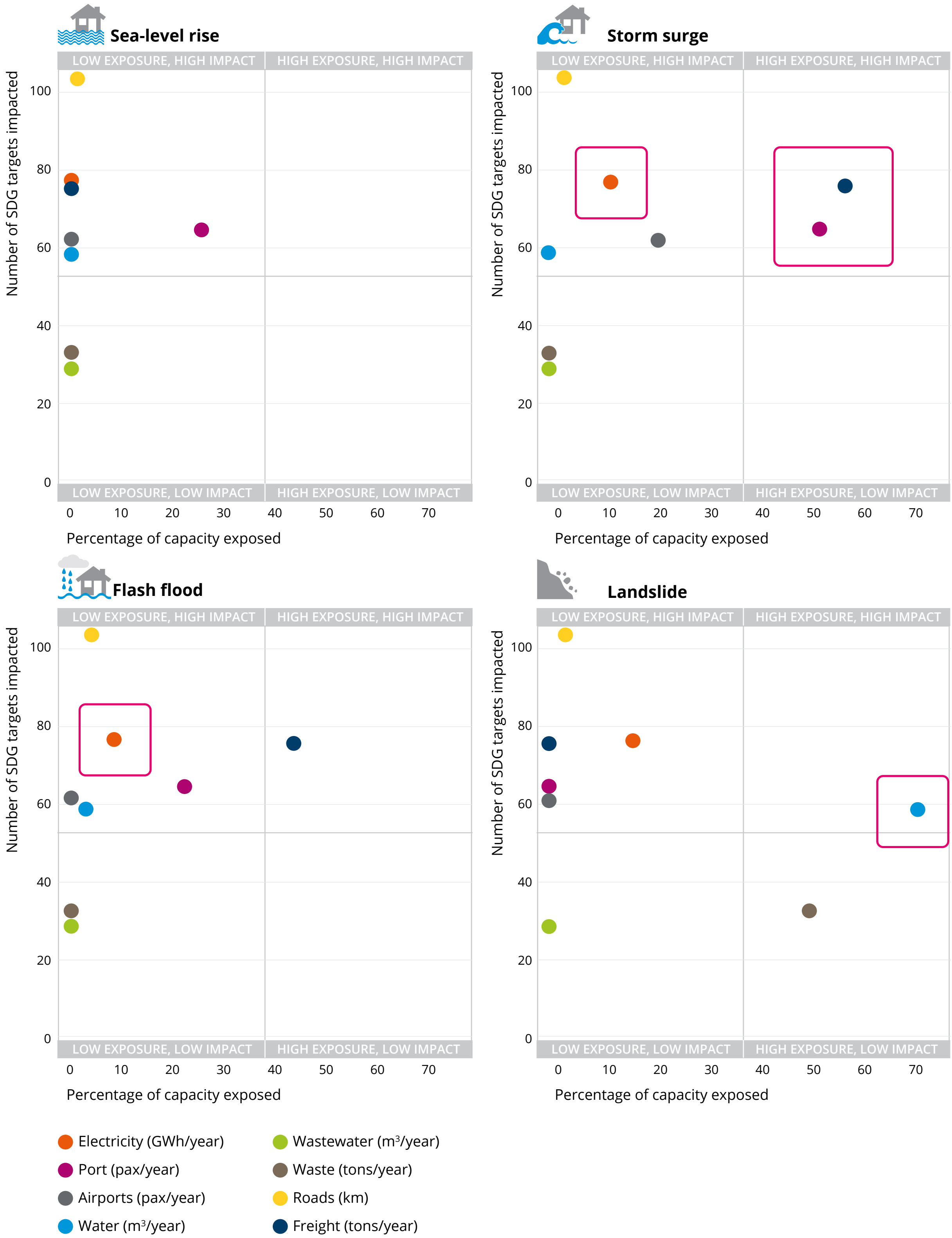
SECTOR PRIORITISATION

At the sector scale, overlaying hazard information with economic infrastructures provides valuable insights on sectoral budget planning and risk reduction prioritisation. Adapting the freight sectors to storm surges and flash floods can provide the largest socio-economic benefits across all economic infrastructures

By visualising hazard exposure and its impact across sectors, decision-makers have evidence to prioritise certain sectors for risk-reduction (Figure 26). Compared to other sectors, preparing the transport sector for storm surges and flash floods is most beneficial for reducing exposed capacity. Storm surges can expose up to 57 percent of national freight capacity (top right quadrant in Figure 26), potentially affecting more than 75 targets established in the Sustainable Development Goals (y-axis). Exposure of 90 km of Saint Lucia's roads (1 percent of total capacity) can hinder the island's ability to meet more than 100 targets established in the SDGs.

Figure 26:

Economic infrastructures exposed to different hazards. The y-axis represents the quantity of targets of the Sustainable Development Goals (SDGs) directly and indirectly affected by different sectors; the x-axis represents the percentage of sector capacity exposed to a hazard



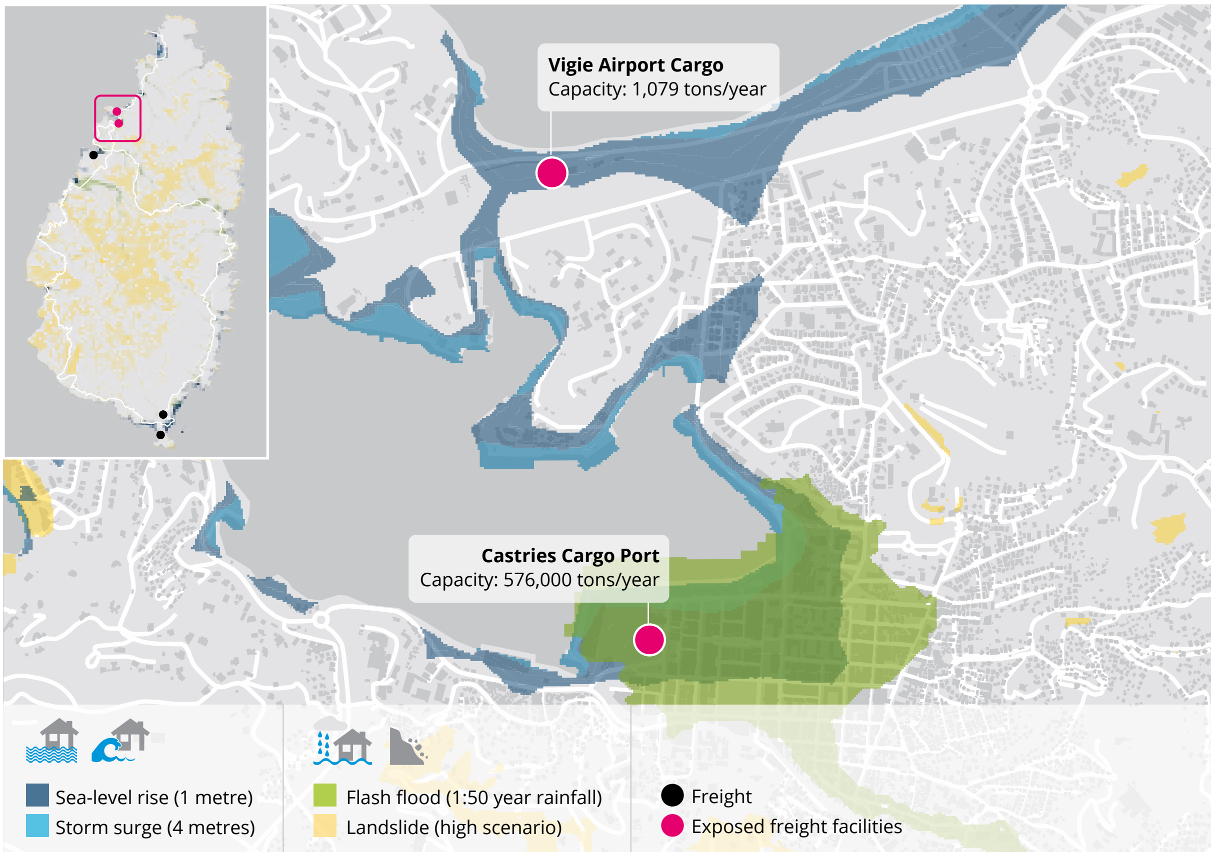


Figure 27:
Freight facilities exposed to different hazards

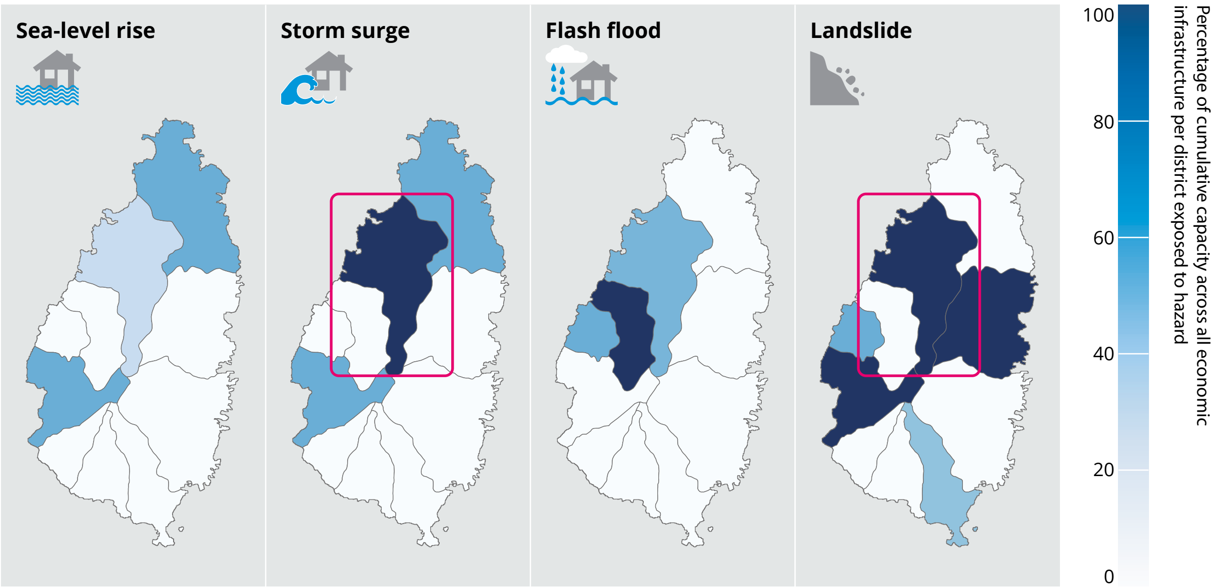
While the transport sector must prepare mainly for impacts from storm surges and flash floods (besides freight and road exposure, up to 50 percent of national port and 20 percent of airport capacity is exposed to storm surges), the electricity sector might focus adaptation also on flash floods and landslides, which expose 12 percent and 16 percent of electricity assets, respectively. Given the large landslide exposure, it is necessary to prepare the water sector for potential sedimentation impacts that could reduce water supply, for example from the John Compton Dam.

ASSET PRIORITISATION

At the asset level, results from the analysis can assist decision-makers in prioritising specific infrastructure within highly exposed sectors

Figure 27 provides evidence to prioritise assets within the highly exposed freight sector against hazard exposure. Compared to other assets, adapting the Castries and Vigie Cargo Port to sea-level rise and storm surges can reduce the largest percentage of potential capacity loss, directly safeguarding the disruption of up to 577 thousand tonnes of freight. Indirectly, freight underpins the import of goods and services to the value of 1.77 billion EC dollars yearly, as well as the export of numerous industries that employ more than 25 percent of the labour force.[35] These imports include vital goods, including wheat, medicaments and food, but also fuel for cooking and electricity, which are essential inputs for most of Saint Lucia's other industries.

Figure 28:
Cumulative economic infrastructure exposure to different hazards



Exposed freight capacity can thus indirectly harm numerous development areas, including food (SDG 2), healthcare (SDG 3), electricity (SDG 7), and economic growth (SDG 8).

Given their importance, risk-reduction investments in the Castries and Vigie Port can help ensure the country's resilience in the face of disasters. Specific adaptation options for these assets can include structural measures like road drainage, storage basins or green infrastructures (SUDs) as well as non-structural measures such as emergency response plans that ensure continued services after a hazard event, including re-routing options to alternative seaports.

DISTRICT PRIORITISATION

At the district level, calculating the cumulative capacity exposure for all economic infrastructures can help prioritise the focus of more detailed studies proposed within Saint Lucia's National Adaptation Plan

By modelling cumulative economic infrastructure exposure across districts, decision-makers can target districts for risk-reduction measures. The Castries district is found to have the largest cumulative economic infrastructure exposure, especially for storm surges and landslides (Figure 28), implying that budget on economic infrastructure adaptation spending might be best focused within the Castries district. For district decision-makers, understanding which specific sectors are simultaneously exposed to a specific hazard can help inform storage prioritisation within district-based emergency shelters. In Dennery, for example, both the provision of water and electricity is potentially disrupted under a landslide event. Despite previous slope stabilisation investments for the Dennery village, continued sectoral collaboration is required to sustainably manage the region's resilience to landslides.

National Adaptation Plan

This analysis provides evidence to enable prioritisation of sectors in the infrastructure-related adaptation options, including:

NAP 191-200: On objectives to strengthen infrastructure to withstand climate impacts and to enhance infrastructure-based climate adaptation

13

SOCIAL INFRASTRUCTURE EXPOSURE

Together, Saint Lucia's social infrastructures underpin the population's welfare, providing essential services such as education, emergency management, wholesale and retail, manufacturing, food, tourism and financial management. This assessment features 744 social assets, of which 48 percent are exposed to one or more of the four hazards.

National Adaptation Plan

This analysis provides evidence to prioritise measures across the education, health, tourism, and infrastructure sections of the NAP, specifically:

NAP 195: Create plan for retrofitting existing public infrastructure most at risk from climate impacts

NAP 191: Plan phased relocation of vital infrastructures

SECTOR PRIORITISATION

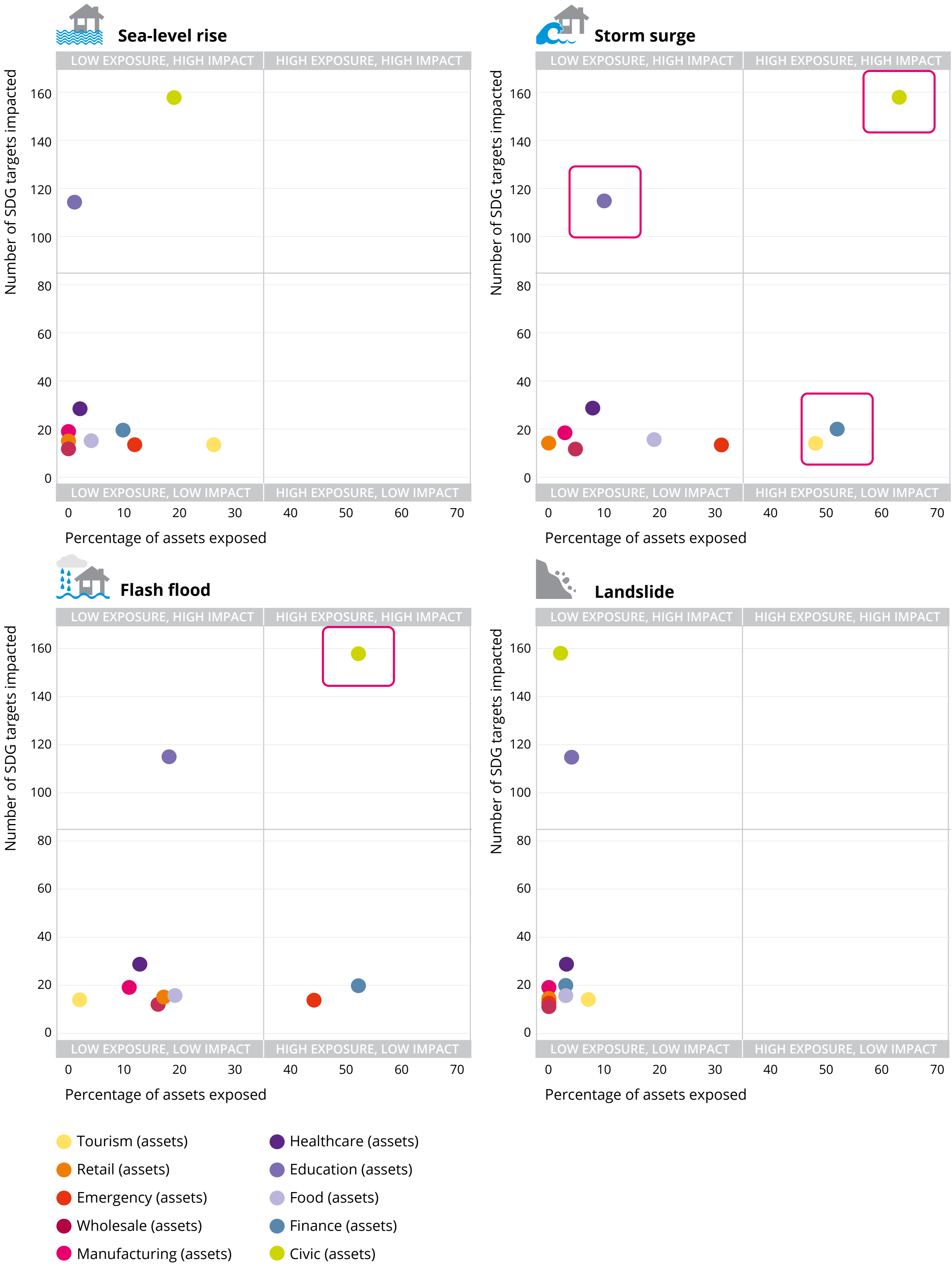
At the national scale, storm surges and flash floods can induce the largest exposure for the civic, financial, and emergency sectors

Compared to other sectors, the civic, finance, and tourism sectors can benefit most from adapting to storm surges, with more than 50 percent of assets within these sectors exposed (Figure 29, top right quadrant). Besides storm surge exposure, safeguarding the services delivered by the civic and finance sectors further requires consideration of potential combined hazard events including storm surges and flash floods, which could magnify impacts (Figure 29, bottom left quadrant).

The largest socio-economic co-benefits can be reaped by protecting civic facilities, which influence more than 150 targets established in the SDGs (see y-axis in Figure 29). This can be attributed to the range of different services provided by civic facilities, including, but not limited to, implementation of government policy or training police and emergency responders to manage disasters. Saint Lucia's civic institutions also underpin the country's sectoral and cross-sectoral governance.

Figure 29:

Social infrastructures exposed to different hazards. The y-axis represents the quantity of Sustainable Development targets directly and indirectly affected by different sectors; the x-axis represents the percentage of all assets within one sector exposed to the hazard



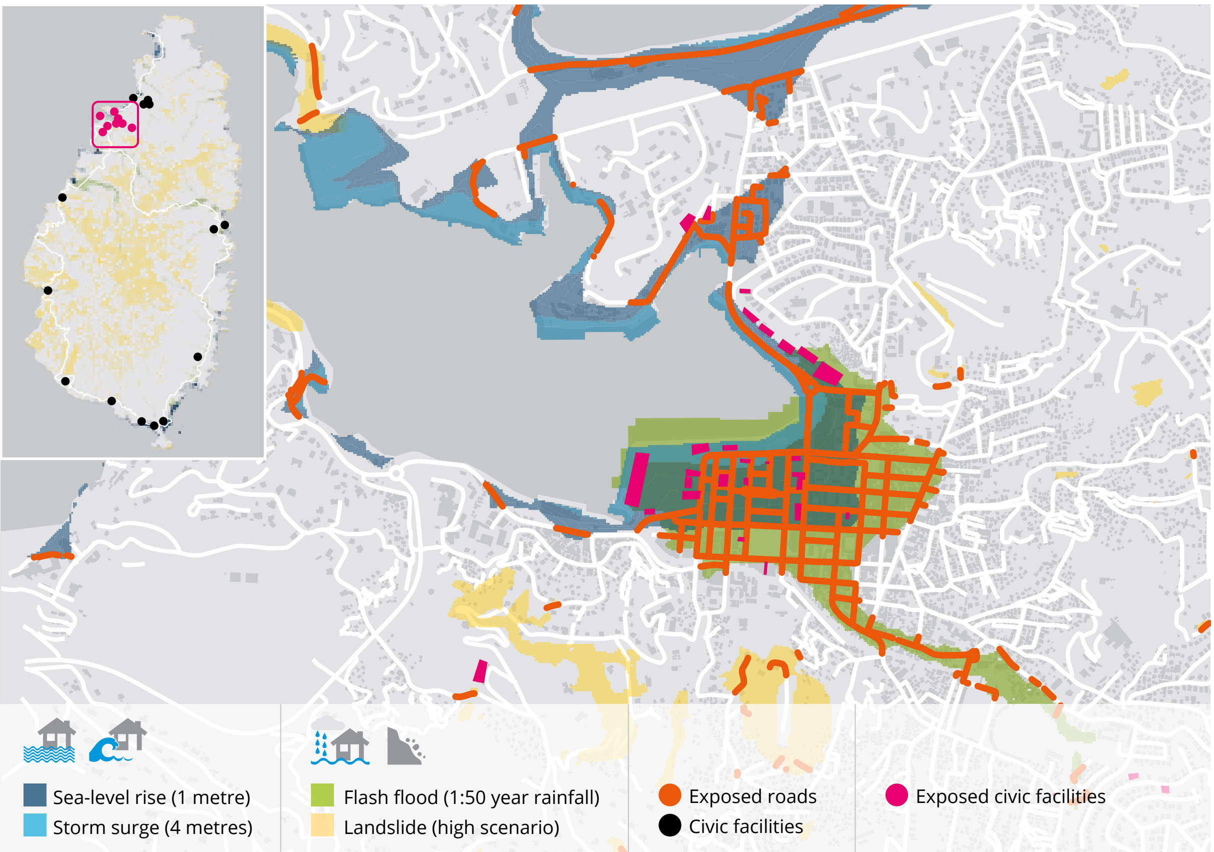


Figure 30:
Civic facilities exposed to different hazards

At the same time, inaction on developing a strategic plan to reduce exposure of civic facilities can result in significant governance issues into the future. Ensuring the provision of education on the island in the face of storm surges is recommended in order to safeguard the achievement of 115 SDG targets influenced by educational facilities. Detailed vulnerabilities pilot studies[36] in the education sector are already underway, and should continue to be funded, not least given the importance of educating future generations to sustainably manage their resources.

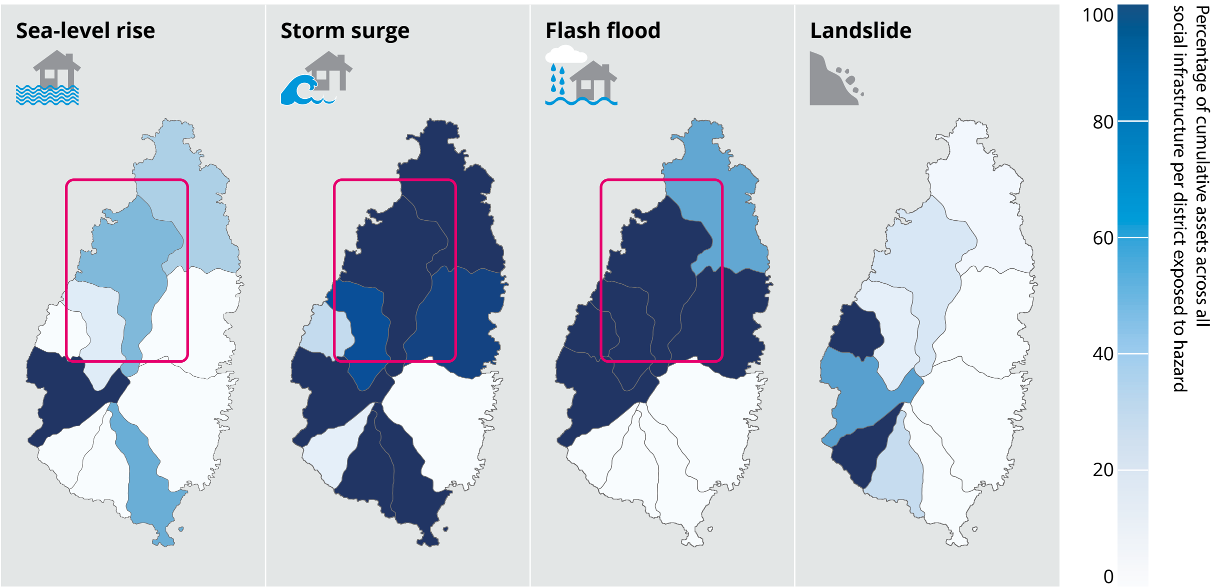
ASSET PRIORITISATION

Adapting civic sector assets against hazard exposure should focus on the Castries waterfront area

Without efforts to adapt Saint Lucia's civic facilities within the Castries waterfront area (Figure 30), achievements in ensuring sustainable development across all 17 dimensions may be significantly undermined. This directly includes all targets established for Peace, Justice and Strong Institutions (SDG 16), Equality (SDGs 5 and 10) and, indirectly, Climate Action (SDG 13), Life below Water (SDG 14), and Life on Land (SDG 15).

Given the current exposure of civic facilities, substantially more civic adaptation measures will have to be formulated and included in Saint Lucia's National Adaptation Plan, especially for Castries' civic waterfront assets.

Figure 31:
Cumulative social infrastructure exposure to different hazards



Despite recent civic risk-reduction measures – for example a project to digitise the ground floor land registry department[37] containing all land-based legal documents – many civic departments' critical IT-backup systems remain at ground floor level in the waterfront area. Further measures could entail relocating critical IT systems to less-exposed areas. Physical adaptation measures (e.g. seawalls, coastal defence and temporal physical structures) can be beneficial for Castries' city waterfront due to the high density of critical assets exposed in a confined space.

DISTRICT PRIORITISATION

At the district scale, social infrastructure adaptation must consider multiple hazard impacts

By examining the spatial patterns of exposure across all hazards, Figure 31 shows that Castries is the district with the largest cumulative number of social infrastructure assets exposed. Without exposure-based development planning within the Castries district, the number of exposed social assets may rise further as population expansion and poorly planned land development degrades habitat and increases the potential of flood damages. Mitigating against the potential hazard exposure of new social developments is hence critical. Risk-reduction measures can include proposed redevelopments within the Castries district, as suggested within the Castries Action Plan. Besides investments in more green spaces and walkways, which can be used as flood zones to protect surrounding critical assets, Castries redevelopment should include drainage and design standards to reduce potential inundation.

National Adaptation Plan

This analysis provides evidence to enable prioritisation where and which hazards to focus on for regional adaptation measures:

NAP 200: Where to place additional emergency shelters to increase emergency response capacity

NAP 256: Where to focus regional assessments of water-related health issues

NAP 263: Where to develop programs to determine detailed impacts of coastal hotel development

NAP 233: Which regions and which hazards to focus on to ensure that schools which also double as emergency shelters are climate-resilient

14

NATURAL ENVIRONMENT EXPOSURE

Saint Lucia's natural environment assets include the country's forest reserve, wetland, rangeland, barren, water ecosystem, and agricultural assets. Collectively, these natural assets provide critical services such as air, food, or timber, and ecological functions such as carbon storage, climate modulation, and nutrient cycling. Together, the island's natural environment area is comprised of over 600 km^2, more than 50 percent of which is exposed to one or more of the four hazards, potentially reducing both the quality and quantity of services delivered by critical natural assets.

National Adaptation Plan

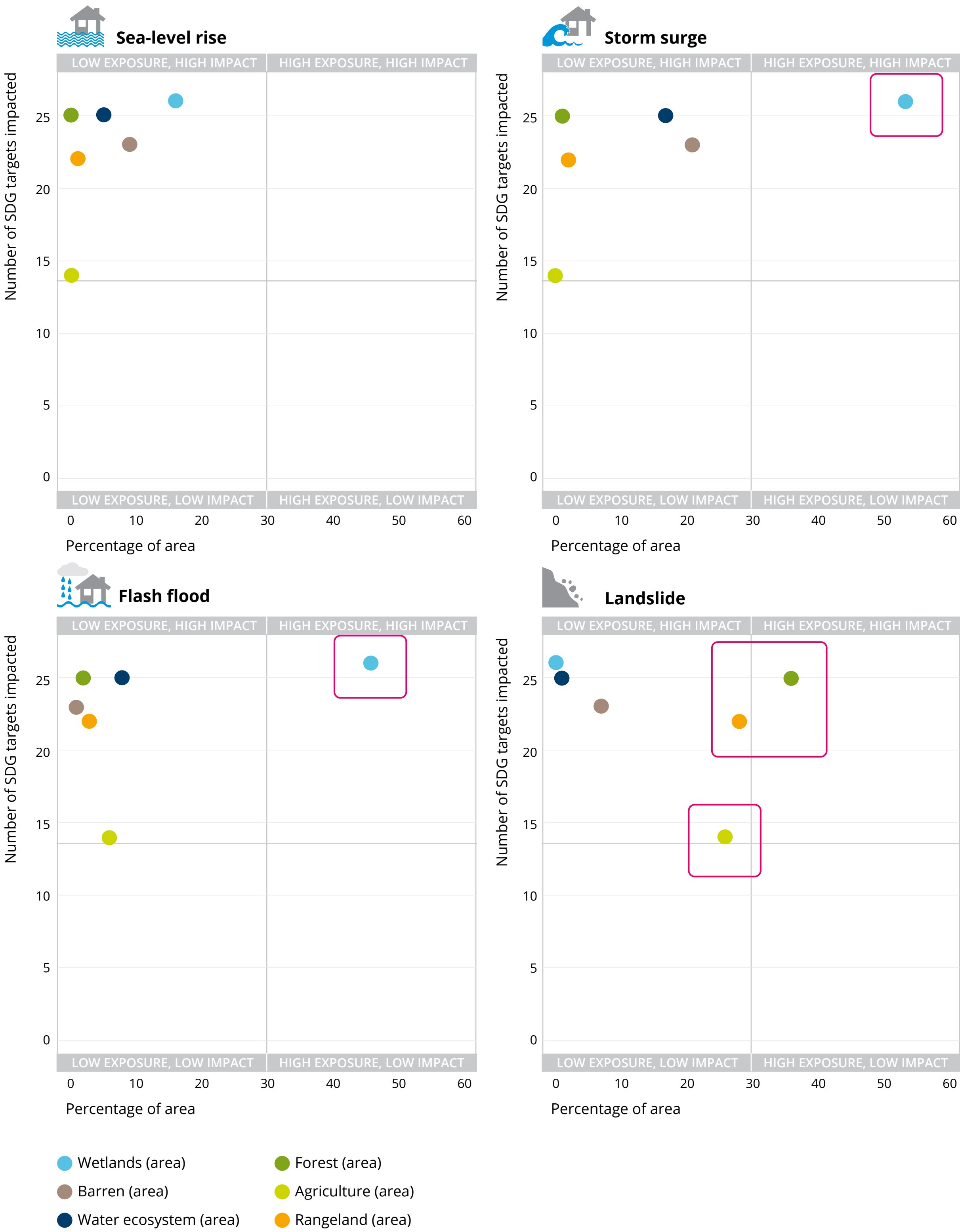
Implementing adaptation measures **209–216** on increasing coverage of sustainably managed and protected ecosystems can reduce hazard exposure and have direct and indirect SDG co-benefits.

SECTOR PRIORITISATION

At the sector scale, protecting wetlands and forests can safeguard the largest range of critical services delivered by the natural environment

Figure 32 shows the large percentage of wetland area exposed to storm surges and flash floods, with 55 percent and 45 percent of total area exposed, respectively (Figure 32, top right and bottom left). Multi-hazard events, such as combined storm surges and flash floods, can result in 100 percent of Saint Lucia's wetland area exposed. Together with potential losses of habitat from water-based ecosystems such as ponds (20 percent of the water-based ecosystem area is exposed to storm surges), this wetland exposure can hamper the island's ability to respond to climate change impacts. Non-substitutable services such as nutrient recycling or habitat protection may be lost, influencing at least the achievement of 25 targets established in the SDGs. Besides inundation-based hazards, landslides can expose more than 35 percent of Saint Lucia's forest area as well as more than 20 percent of the country's agriculture and rangeland (scrub, grassland) (Figure 32, bottom right). Reduced service delivery from the agricultural and forest sector can result in socio-economic losses, with 10 percent of the national labour force employed in the two sectors.

Figure 32:
Natural environment sectors exposed to different hazards. The y-axis represents the quantity of targets of the Sustainable Development Goals (SDGs) directly and indirectly affected by different sectors; the x-axis represents the percentage of national sectoral area exposed to each hazard



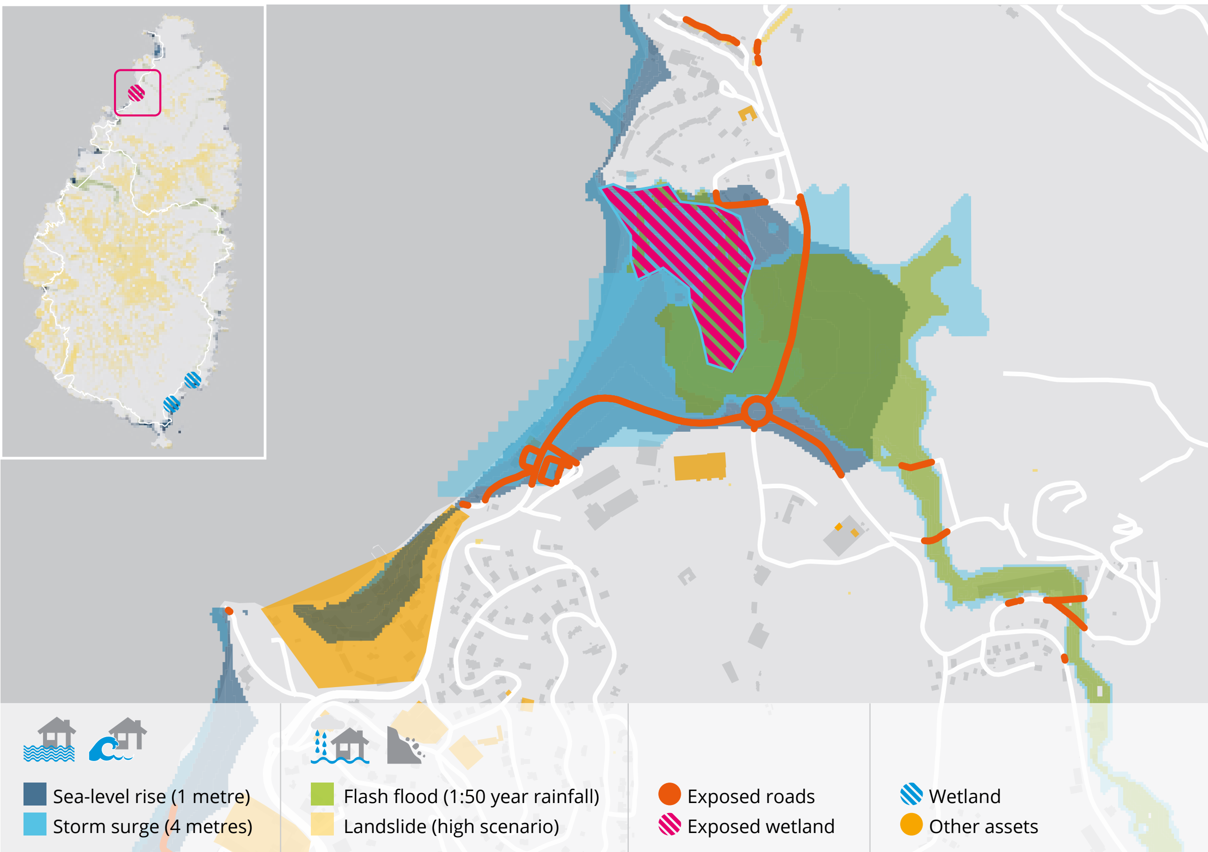


Figure 33:
Wetland area exposed to different hazards

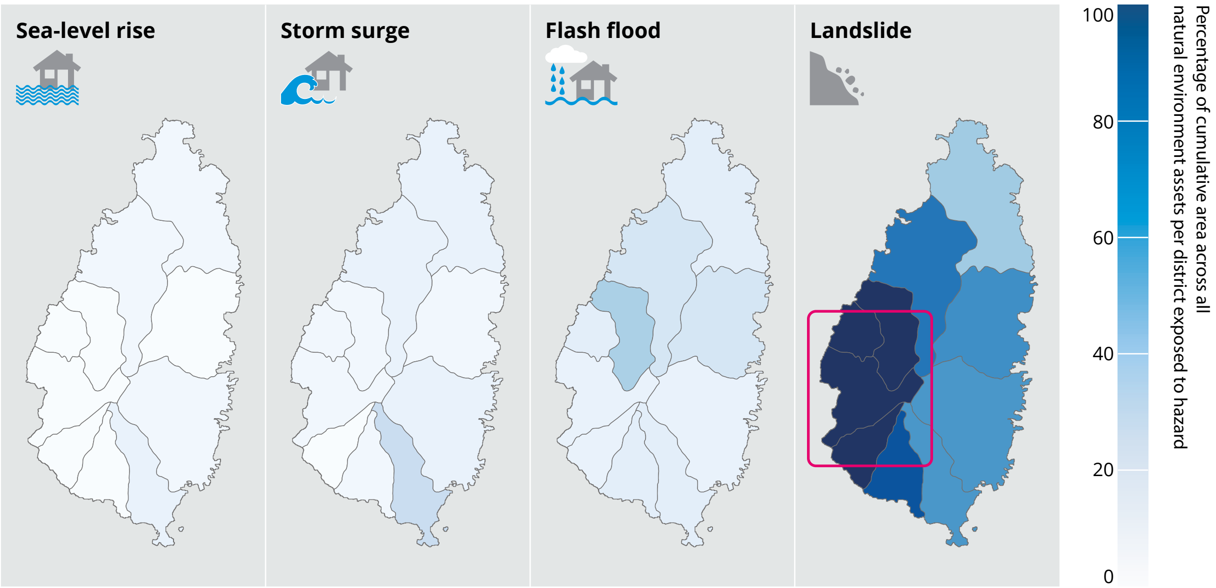
ASSET PRIORITISATION

Comparing specific wetland assets in Saint Lucia, protecting those located in the Choc area is most beneficial to reducing exposure against the multiple hazards of sea-level rise, storm surges, and flash floods

The Choc wetlands, defined by rare mangrove species, are likely to withstand inundations of moderate severity and can thus act as natural flood protection to critical physical infrastructure concentrated in the area (Figure 33). In doing so, wetlands enable areas of high socio-economic importance to be less affected by inundation events, as some of the water can be absorbed by the ecosystem. Wetland conservation can thus represent an inexpensive natural flood protection option for the island.

In the Choc area, conserving wetlands may reduce inundation on the nearby Castries – Gros Islet Highway, the key link between the North and the South of the island. This link provides access to over 27 thousand vehicles per day,[38] which in addition to people movement, enables the transport of cargo, including food, hospital equipment, and fuel. With reference to sustainable development, failure to protect these wetlands can directly impact the ability of Saint Lucia to achieve resilient cities (SDG 11), Climate Action (SDG 13), and to conserve and sustainably manage ecosystems (SDGs 14 and 15).

Figure 34:
Cumulative ecosystem exposure to different hazards



Adaptation options for wetland conservation include enforced land-use planning as well as legislative and regulatory policies to guide planning. Unless the approval of new development projects surrounding the wetland areas Choc and Vieux Fort considers the high socio-economic value provided by these natural ecosystems – for example in terms of the natural flood risk protection to critical roads – long-term adaptation costs may skyrocket, putting at risk the economic feasibility of the new development.

REGIONAL PRIORITISATION

Comparing Saint Lucia's districts, investments in reducing landslide exposure within the forest and agricultural areas is most beneficial in the south-west of the island

The spatial distribution of natural asset exposure is concentrated in the Southwest of the island (Figure 34). Up to 35 percent of the national forest area is potentially exposed to landslides, a large percentage of which is concentrated in Soufriere. Protecting these forests against deforestation not only ensures the continued provision of services such as air purification, habitat provision and the benefits of agroforestry, but also presents an effective way to reduce the occurrence of landslides.

Besides forest protection, ensuring Soufriere adapts its agricultural area against potential hazard exposure (Figure 34) can ensure income for the 21 percent of the labour force employed in agricultural businesses.

National Adaptation Plan

This analysis provides evidence to enable implementation of NAP outcome 1 on 'Enhanced enabling environment for ecosystem-based adaptation'. The analysis can help with implementation of NAP measure:

NAP 203: To help facilitate coastal zone management plans

NAP 185: To spatially define where to place ecosystem-based solutions (soft defences) to protect fisheries livelihoods and infrastructure from climate impacts

NAP 221: To spatially define where to focus adaptation measure evaluations, e.g. on evaluating costs and benefits of hard infrastructure vs natural buffers

15

CROSS-SECTORAL PRIORITISATION

All of Saint Lucia's economic, social, and natural sectors need to prepare for extreme hazards, which can intensify with climate change

For national scale decision-making, prioritisation of risk-reduction measures across economic, social, and natural environment assets can be informed by sectoral exposure-impact analyses.

At the national scale, Figure 35 shows that for inundation-based hazards such as sea-level rise, storm surges, and flash floods, risk-reduction action for civic and transport facilities can provide the largest benefits across all economic, social, and natural assets.

At the district scale, Figure 36 implies that district risk-reduction action might best be focused on adaptation to inundation events in coastal areas, especially the Northwest of Saint Lucia. By visualising the exposure assessment across hazards, Figure 36 shows that the cumulative exposure from hazards is highest for the 4-metre storm surge scenario. For comparison, Hurricane Dorian (2019) resulted in a 7-metre storm surge event in the Bahamas. As proposed in Saint Lucia's NAP, more storm surge scenario assessments must be conducted.

National Adaptation Plan

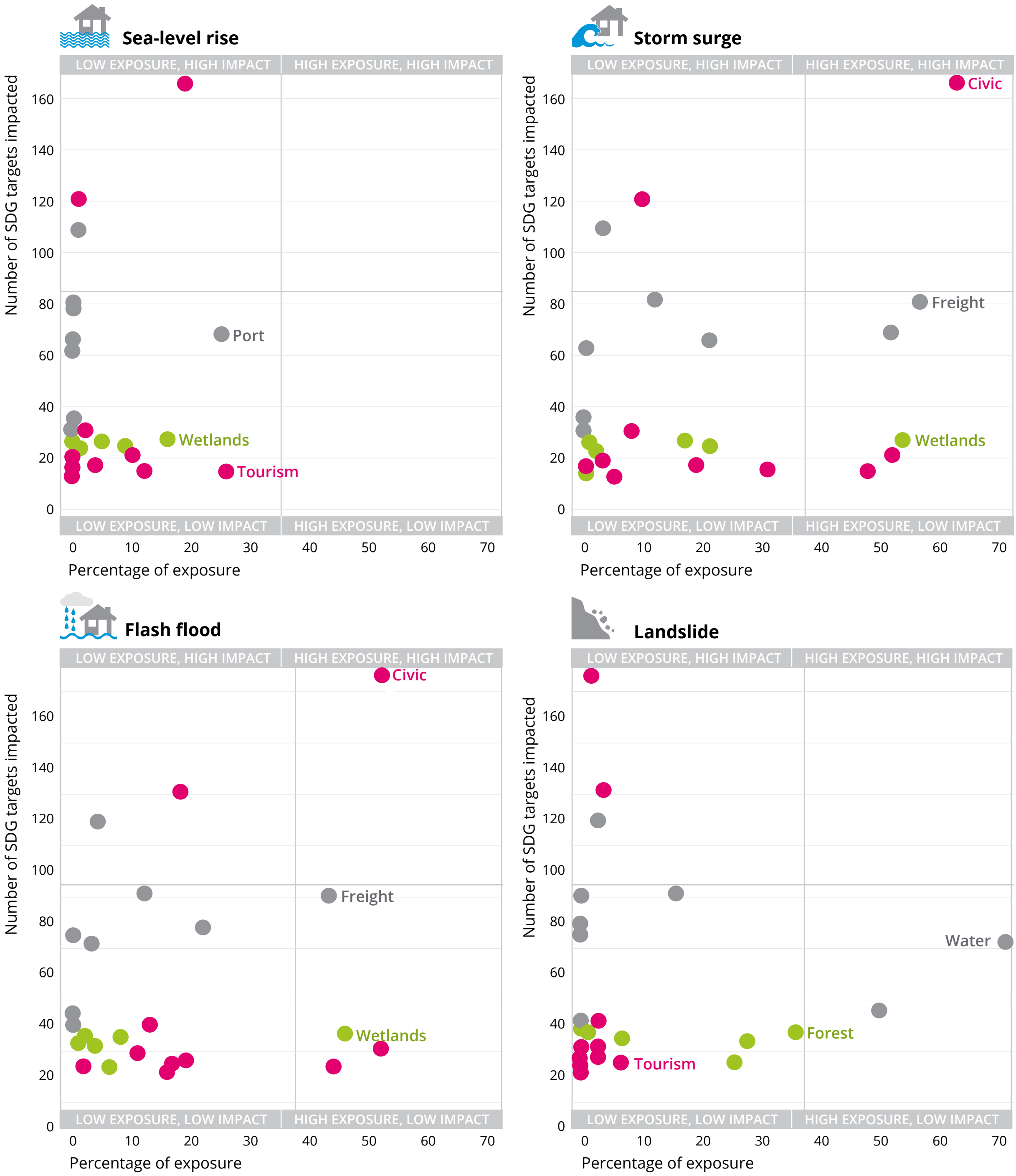
This analysis provides evidence to enable prioritisation of areas for adaptation options:

NAP 192: Facilitating access to assistance and resources for the most socio-economically vulnerable groups

NAP 193: Strengthening enforcement mechanisms to development in hazardous and vulnerable areas

NAP 255–56: Plan to improve healthcare for vulnerable groups, including assessment of both vulnerability and exposure to climate risks

Figure 35:
Economic, social, and ecosystem assets exposed to four different hazards
The y-axis represents the quantity of targets of the Sustainable Development Goals (SDGs) directly and indirectly affected by different sectors; the x-axis represents the percentage of sector capacity exposed to a hazard

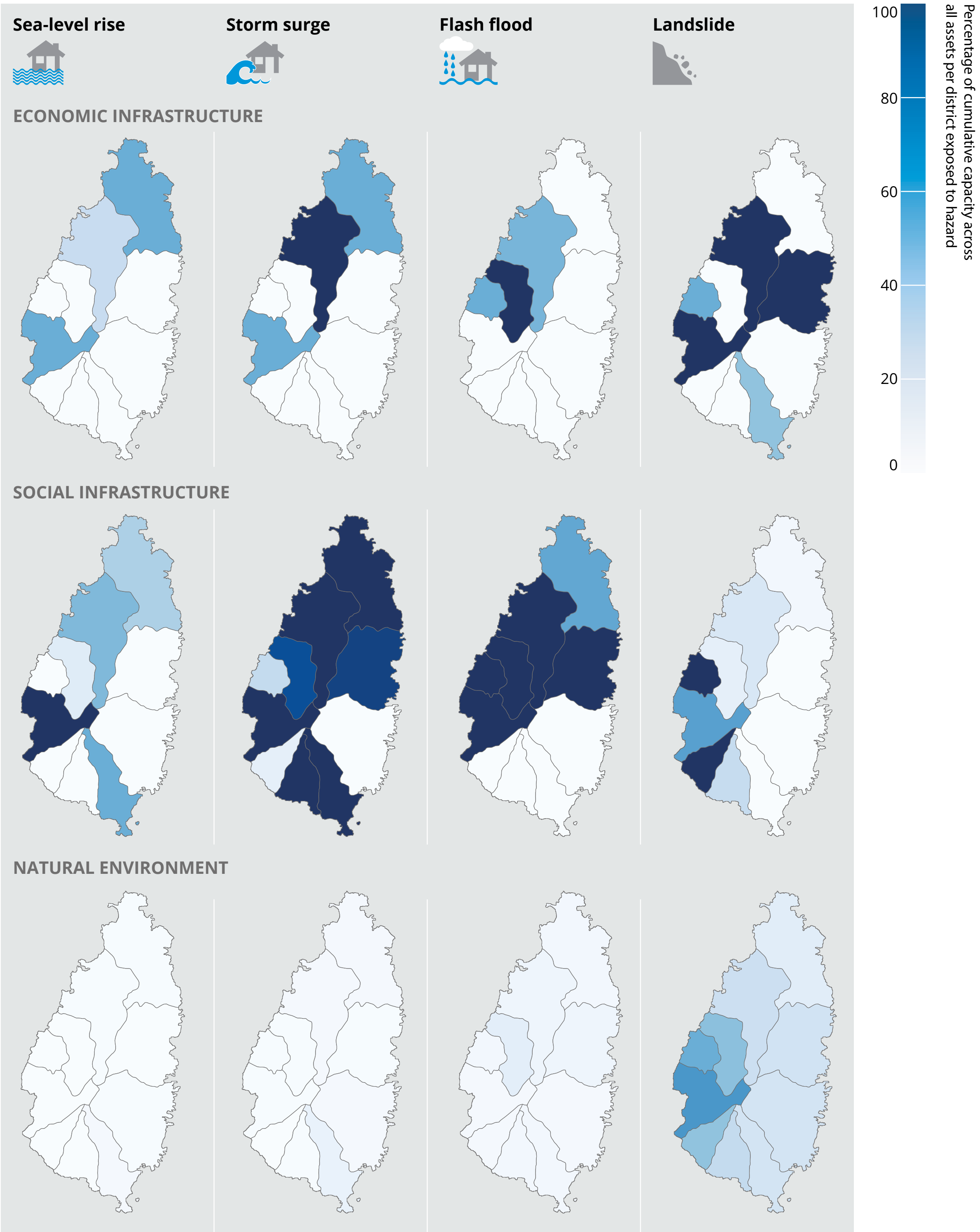


Natural environment
- Wetlands (area)
- Barren (area)
- Water ecosystem (area)
- Forest (area)
- Agriculture (area)
- Rangeland (area)

Economic infrastructure
- Electricity (GWh/year)
- Port (pax/year)
- Airports (pax/year)
- Water (m^3/year)
- Wastewater (m^3/year)
- Waste (tons/year)
- Roads (km)
- Freight (tons/year)

Social infrastructure
- Tourism (assets)
- Retail (assets)
- Emergency (assets)
- Wholesale (assets)
- Manufacturing (assets)
- Healthcare (assets)
- Education (assets)
- Food (assets)
- Finance (assets)
- Civic (assets)

Figure 36:
Cumulative sector exposure to different hazards.



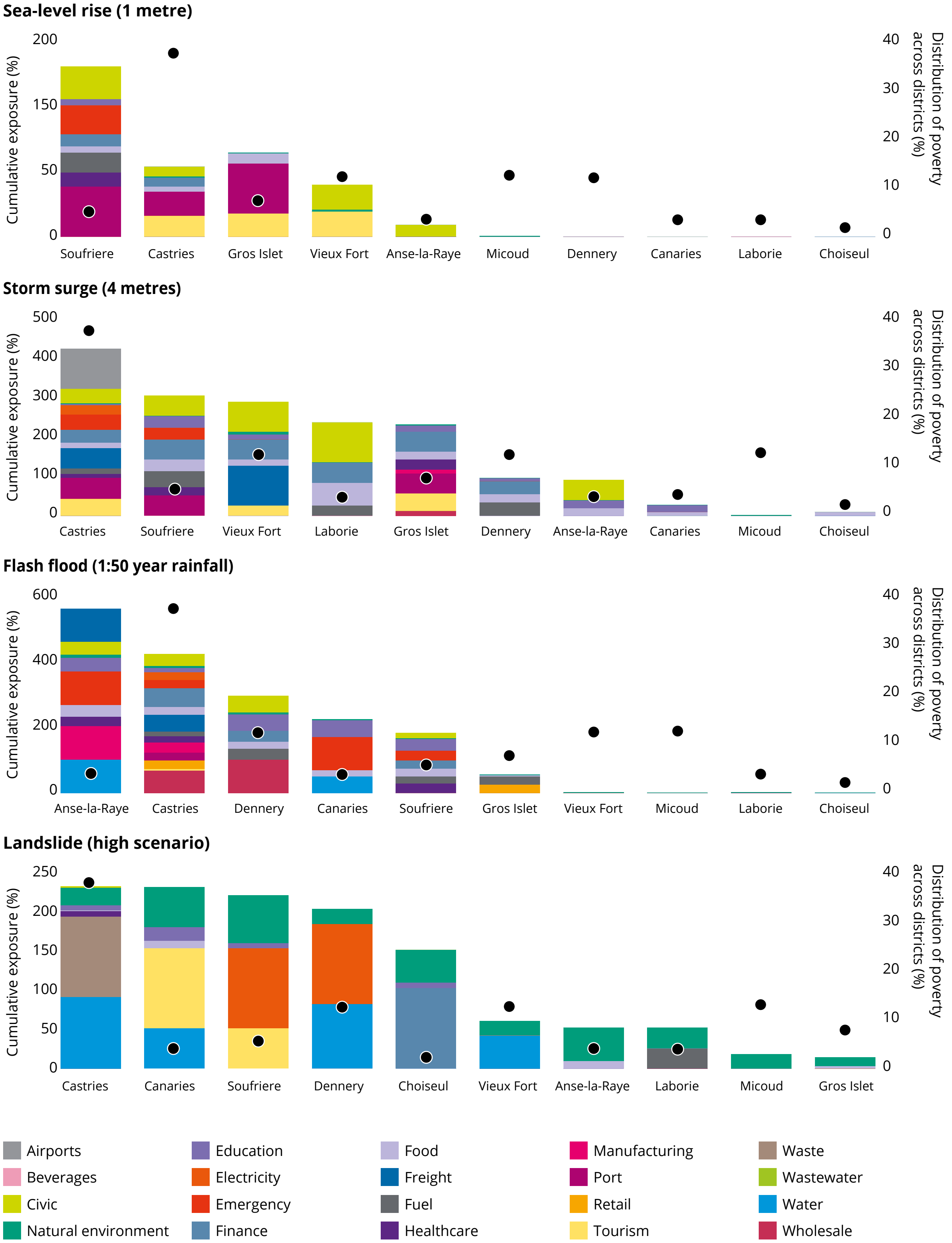
To provide an indication of the region's vulnerability to hazards, results from administrative scale prioritisation can be overlaid with poverty distribution data.[39,40] Figure 37 compares the sectoral breakdown of cumulative exposure per district for each hazard overlaid with the distribution of poverty. For example, Figure 37 shows that in the event of a 4-metre storm surge scenario, cumulative exposure is concentrated in the Castries district with highest poverty distribution.

Unless substantial risk-reduction focuses on Castries, the district is likely to experience significant development losses, as numerous economic and social infrastructures are simultaneously exposed. In a hazard event, the poorest are likely to be hit worst, being unable to substitute essential services.

Combined district ranking using exposure and poverty distribution can form the basis for a prioritised approach to distributing funds across districts. For example, to help distribute funds for more detailed site-specific storm surge assessments, Figure 37b can provide the relevant evidence.

Figure 37:

Prioritisation of areas based on percentage of exposed assets




FREEDOM BAY
ZAKA Art
Martha's Table
Piton Warm Waterfall
Sugar Beach 1 km

Photograph by GIS (GoSL Information System) Library

16 ADAPTATION MEASURES

In line with the Sendai Framework for Disaster Risk Reduction and Saint Lucia's National Adaptation Plan, decision-makers can utilise data and evidence to gain a deeper understanding for building resilience to climate change-related hazards

Adaptation solutions, summarised in Figure 38, involve different time and financial commitments and provide different co-benefits for sustainable development and the achievement of the National Adaptation Plan.

In Saint Lucia's coastal areas with high critical infrastructure density, natural flood management solutions such as mangroves or wetland areas represent effective barriers to inundation events such as sea-level rise, storm surges or flash floods, while prioritising environmental and ecosystem conservation. In areas susceptible to landslides, afforestation can represent an effective means to reduce the occurrence of this hazard due to the retaining strength of root systems. Re-grading and re-vegetating areas have already improved slope stability on Eastern Caribbean islands and have been regarded as a simple, cost-effective, and community-based risk-reduction solution.[41]

Such natural flood management solutions are highly aligned with the National Adaptation Plan's strategic outcome 1 on 'Enhancing the enabling environment for ecosystem-based adaptation' and 3 on 'Strengthening ecosystem-based adaptation'. Besides reducing hazard exposure and contributing to the NAP, increasing the coverage of sustainably managed and protected ecosystems can have direct and indirect co-benefits for Saint Lucia's progress on the Sustainable Development Goals, specifically SDGs 13, 14, and 15.

Although more capital-intensive to design, build and maintain, large physical flood defence barriers such as seawalls can provide effective defences against coastal flooding. Especially in areas of high critical infrastructure and building density as in Castries, such physical structures allow safeguarding the development co-benefits of critical infrastructures located in the capital, including enabling imports and exports or ensuring national governance, justice, and effective policy enforcement. Temporary defences represent the quickest response to inundation events on the island, and can be utilised on short notices by the National Emergency Management Organisation (NEMO).

Environmental flood barriers	• Environmental barriers such as mangroves or wetland areas prioritise the natural environment and ecosystems, and can promote recreation activities and tourism growth. • The construction of wetlands in low-density coastal zones can contribute natural flood defences to neighbouring areas.
Physical flood defence	• Large-scale, permanent structures such as sea walls provide strong defence against inundation but are implemented at a higher financial cost. • Temporary flood defenses are flexible and can be moved on short notice to where there is an immediate threat of flooding.
Resilient design of supplies	• Changing the design of infrastructure supply, for example by increasing septic tank volumes in areas of high flash flood exposure, can provide a relatively inexpensive and adaptive way to compensate for flooding.
Institutional capacity	• Institutional capacity is pivotal to ensure management before, during, and after a hazard. This includes the ability to use hazard exposure modelling to inform decisions, incorporate early warning systems, and to develop emergency and evacuation plans.
Long-term land use and infrastructure planning	• Long-term land-use and infrastructure planning can inform policies that discourage certain developments in areas with high hazard exposure, and encourage land-use that is adaptive to climate change.

Figure 38:
Types of adaptation options to be implemented in Saint Lucia

Effectively implementing such defences will require adequate early warning and management systems. Temporary defences enable the co-benefits of critical infrastructure protection to be achieved at a lower cost. More site-specific analyses are required to ensure such temporary protection reduces hazard exposure.

Design changes include reinforcing the design of existing coastal structures, increasing capacities in areas that are highly exposed, or enforcing established building codes. Such design alterations are inexpensive compared to large flood defences, but must be devised on a specific asset-by-asset basis. Infrastructural design upgrades could include encouraging developers and homeowners to strengthen guttering or drainage (NAP adaptation option #198), implement jetties and landing docks, use increased septic tank volumes to compensate for flooding, or adhere to building design codes (NAP measure #189).

Building institutional capacity, especially at NEMO, represents one of the most long-term investments that ensures nation-wide hazard management across economic, social, and ecosystem assets. Investing in reducing the social vulnerability of particularly poor areas in Saint Lucia can provide an effective means to build resilience, and has shown to be one of the most effective means to both reduce negative hazard impacts and ensure socio-economic co-benefits in vulnerable countries. The training conducted as part of this project on the use of existing hazard maps to the National Emergency Management Organisation (NEMO) has already contributed to NAP measure #201 on developing national emergency plans based on national climate mapping. Increasing the institutional capacity in these organisations is a pivotal aspect of ensuring disaster resilience in the face of climate change.

Long-term, resilient and systematic infrastructure and land-use planning, led by Saint Lucia's recently launched National Integrated Planning and Programme Unit (NIPP), can help ensure that the best available evidence is used to inform effective prioritisation of risk management solutions, while directly responding to the NAP's cross-sectoral adaptation priority of ensuring 'Improved frameworks to facilitate climate adaptation across sectors' and 'Increased generation and use of climate information in national and sectoral decision-making'. This includes comparing and contrasting short-term, incremental measures such as physical temporary flood defences, medium-term measures such as revised building codes, and long-term measures such as re-considering which areas are best suited for which type of land use (NAP measure #187). Such long-term measures involve re-evaluating the types of crop cultivated in the face of reduced overall rainfall from climate change, and the enforcement of policies to ensure new developments are placed in the low-hazard areas. Evidence-based planning for climate-compatible growth, facilitated by the cooperation of numerous different ministries and departments, can help Saint Lucia apply and benefit from global adaptation funds to ensure long-term sustainable growth.

Photograph by Daniel Adshead

17

THE FUTURE OF INFRASTRUCTURE IN SAINT LUCIA

Photograph by Daniel Adshead

An integrated approach to decision-making should be embedded in national infrastructure planning in years to come

The National Integrated Planning and Programme (NIPP) unit, embedded within the Department of Finance, is now tasked with a major responsibility to drive forward this integrated approach to policymaking. Following a model that has been increasingly employed in other countries,[1,42] the unit has a key function in government: coordinating infrastructure planning and decision-making across sectors. The NIPP could also be responsible for monitoring and evaluation of infrastructure performance in years to come. Moving away from a siloed approach to sector governance will ensure that national priorities and targets are established and pursued collectively with the input of all relevant stakeholders in the GoSL, research institutions, and the private sector, and regularly informed by the latest available data. This requires inputs from decision-makers in all roles: public officials, planners, funders, academics, regulators, contractors, and infrastructure users (Figure 39). Results from this assessment suggest that this will provide Saint Lucia with an infrastructure planning approach that will be cheaper, more efficient, and more closely aligned with national goals and international commitments in the long-run. A strong enabling environment in Saint Lucia will facilitate sustainable and resilient infrastructure implementation in the country, requiring continued action to strengthen elements across the infrastructure lifecycle such as regulation, finance, project delivery, operations and maintenance, and human capacity.

Providing decision-makers with the tools required to undertake strategic infrastructure assessment will better equip the Government of Saint Lucia to make effective investments and policy in the future

This report summarises key findings from a nearly year-long infrastructure assessment undertaken by UNOPS and the University of Oxford in collaboration with the GoSL. However, this marks only the beginning of the government's journey toward sustainable and resilient infrastructure planning, which may be altered by the government's shifting priorities, the feasibility of investments and policies, and demand driver uncertainties.

The analytical tools and capabilities developed for this assessment are open-source and are provided freely and transparently to stakeholders with an interest in the future planning of Saint Lucia's infrastructure. Analysts within the NIPP team have begun training on both the long-term infrastructure planning and the geospatial hazard and adaptation components, and will be able to incorporate new data, confirmed projects, and updated projections to ensure that results are as accurate and relevant as possible. This is particularly relevant given the rapidly changing coronavirus situation, which necessitates dynamic updating of models and scenarios to account for the latest impacts of the pandemic. As data becomes available, additional analysis components such as road transport assessment can be incorporated and represented more explicitly in the model.

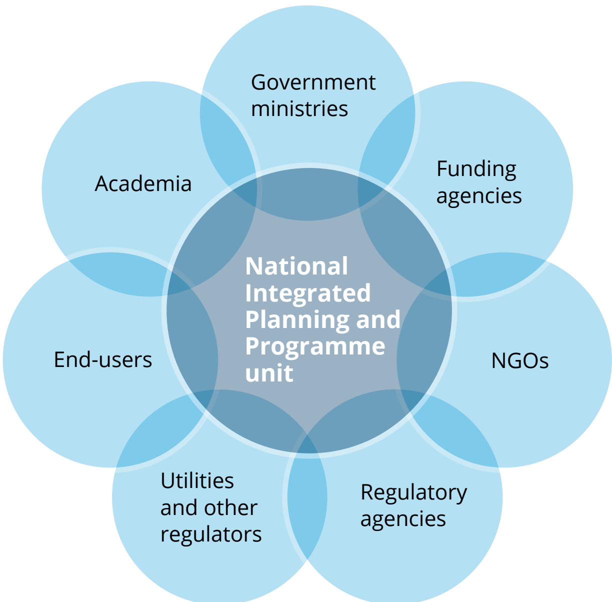


Figure 39:

Role of the National Integrated Planning and Programme unit (NIPP) in coordinating efforts to ensure streamlined and efficient infrastructure development

More extensive training in the use of these tools will accompany the completion and release of this report. Information on new projects may be inputted into the models to determine the demands placed on each infrastructure sector as well as levels of exposure to a range of climate hazards.

This is the time for coordinated action to address challenges and harness the opportunities of sustainable and resilient infrastructure

The challenges facing Saint Lucia in the coming decades are stark: demographic uncertainties, increasing exposure to climate hazards, and the urgent need to ensure reliable, clean, and affordable infrastructure services for the island's residents and visitors. With infrastructure so crucial to the island's development, the consequences of inaction or a business-as-usual approach to infrastructure planning will limit Saint Lucia's social and economic potential. Similarly, responding to the growing threats posed by climate change requires novel thinking and state-of-the-art planning to avoid catastrophic events that cost lives and inflict economic and environmental damage on the country.

The Government of Saint Lucia recognises the need to address these challenges, and has prioritised a number of national and international targets as crucial for ensuring economic, social, and environmental prosperity for the country's future. Infrastructure systems modelling demonstrates that with smart, evidence-based decision-making, these targets can feasibly be met, and that designing a modern, efficient infrastructure network will cost the government less in the long-term.

By taking a progressive stance toward sustainable and resilient infrastructure, Saint Lucia is emerging as a regional leader in tackling development challenges and the climate change crisis.

APPENDICES

Photograph by Claudio Trigueros on Unsplash

APPENDIX A: THE NATIONAL INFRASTRUCTURE SYSTEMS MODEL (NISMOD)

NISMOD BACKGROUND

The recommendations in this report are based on analysis undertaken using the National Infrastructure Systems Model developed by the UK Infrastructure Transitions Research Consortium (ITRC).[43] The ITRC is a collaboration of seven universities and over 50 partners from infrastructure policy and practice, and was launched in 2011 with the aim of developing and demonstrating a new generation of simulation models and methods to inform analysis, planning and design of national infrastructure systems. The consortium was backed by £4.7 million of funding from the UK Engineering and Physical Sciences Research Council (EPSRC) and was later awarded a further £5.3 million to continue the research programme through to 2020. More information on the ITRC programme is available at www.itrc.org.uk.

The NISMOD analysis framework contains a set of components outlined in Figure A1, including projections of future demand based on exogenous drivers (scenarios), a set of user-defined infrastructure interventions to meet this future demand (strategies), and performance metrics designed to assess the success of each strategy.

The full set of data layers on infrastructure networks, demand, and performance is stored in a national infrastructure database, providing a scenario and output repository for the long-term planning and risk and vulnerability models. A visualisation function allows for the presentation of model outputs in the form of maps, time series and other graphics.

TECHNICAL DESCRIPTION: LONG-TERM INFRASTRUCTURE PLANNING

The future performance of the infrastructure systems are simulated using projections of demand for each sector. These modelled demand projections use scenarios to explore uncertainty in a range of possible futures, i.e. due to changes in: the global and national economy; population and demography at national and local scales; climate change; and technological development. Where possible, the same scenarios are used to derive future needs across all sectors, ensuring consistency in assumptions. The uncertainty of these infrastructure needs, inherent in any projection of the future, is represented through different underlying demand driver forecasts i.e. low, moderate and high growth scenarios.

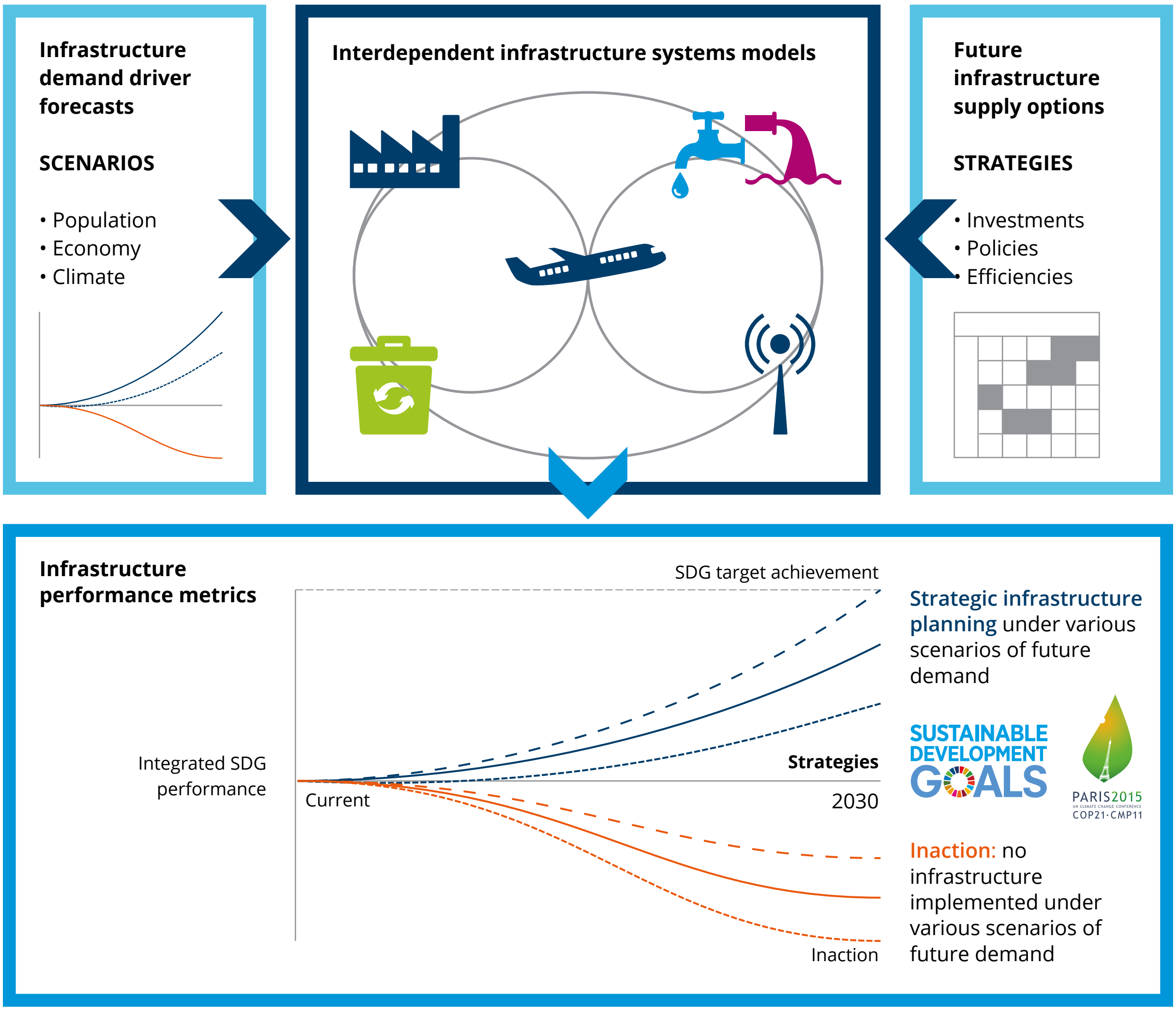


Figure A1:
Schematic overview of the components within the National Infrastructure Systems Model (NISMOD)[44]

The model also encodes the ability of a decision-maker to respond to future needs through the provision of infrastructure strategies. At the most disaggregated level, strategies represent individual interventions that could be introduced by a decision-maker, where interventions include: the introduction of new or enhanced capacity, systems efficiency improvements or interventions that work to moderate demand. NISMOD has the ability to represent individual, or portfolios of interventions, that are aligned with strategy narratives here – described as the overarching narrative of a specific attitude to infrastructure development (across sectors) that then filters down into specific intervention choices (within sectors).

The performance of strategies (in the context of a given scenario) can be described using a series of performance metrics, which include: service delivery, risk reliability and resilience, capital and operating costs and carbon emissions. Such metrics have been chosen to align with the decision parameters of interest to infrastructure decision-makers within government and industry. Alternatively, relevant metrics can inform the development of strategies ex ante to ensure alignment with global agendas such as the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement.

The application of NISMOD for the Saint Lucia infrastructure assessment follows a set of steps that applies this framework. These steps are known as the NISMOD process and have been designed to facilitate a systematic estimation of infrastructure needs and evaluate options for how those needs can be met. These steps are described more fully in the sections below.

Step A: Evaluate current infrastructure systems performance

This step focuses on the assets currently in place, and the associated performance of the infrastructure systems. Relevant datasets were obtained from a range of Saint Lucia's infrastructure stakeholders, including government and service providers, as well as open source datasets where available. This step also involves mapping of infrastructure asset locations.

Step B: Review long-term needs for infrastructure services

Through stakeholder engagement, the main drivers of infrastructure demand for Saint Lucia have been identified: residential population growth and future tourism numbers. Three future population growth scenarios have been developed. This analyses reveals the broad range of uncertainty that should be considered in planning future infrastructure development on the island.

Step C: Establish a vision for future infrastructure performance

Through the evaluation of policy documents and targeted stakeholder interactions in country, with the explicit intention of tying national infrastructure goals to Saint Lucia's identified challenges, and in a broader sense, to the agenda of sustainable development as defined by the UN Sustainable Development Goals (SDGs) and the Paris Agreement, a vision for Saint Lucia's future development has been identified. This vision has been encoded through a series of quantitative targets for each sector that corresponds with acceptable levels of infrastructure performance in the Saint Lucian context.

Step D: Identify strategic alternatives for delivering the vision

Further consultation and analysis was carried out to identify potential specific investment and policy options that are either confirmed, that are proposed in policy documents or that are potential measures which could be used in Saint Lucia (as demonstrated in other countries or regions). This set of potential interventions was used to formulate different strategies within the model, in alignment with the identified targets in the previous step. A National Infrastructure Strategy outlined the selection and sequencing of interventions required to meet these targets by a given date. A business-as-usual strategy was developed to maintain current infrastructure system performance using current technologies. A case of inaction demonstrated the infrastructure performance implications of not implementing future investments or policies.

Beyond these three strategies, infrastructure decision-makers have the option of developing additional strategies based on a set of priorities or objectives. The full list of interventions identified during this process are set out in Appendix B.

Step E: Analyse the scale and timing of strategic alternatives

Based on data inputs from Steps A-D, the model calculates a number of metrics on the performance of strategic infrastructure investments both sectorally and cross-sectorally. In particular, each strategy can be analysed by assessing its ability to meet future needs (for each of the given future scenarios of demand developed in Step B).

Step F: Recommend adaptive pathways of policies and investments

Finally, the portfolios of investments and policies have been visualised and analysed as adaptable pathways, illustrating the sequencing of infrastructure interventions contained in a set of strategy portfolios. The results from these analyses are included in the main text of the report, aiming to provide guidance to decision-makers, increasing the robustness of choices about infrastructure given future uncertainties, and to optimise performance both at a sector level and within the infrastructure system as a whole. Examples of these analyses are presented in the main document. The analyses described in this report forms part of a broader infrastructure assessment for Saint Lucia using NISMOD. The breadth specifically arising from the appraisal of a selection of different infrastructure strategies (investment and policy portfolios) that have been developed around specific strategy narratives.

The results of this extended work will be further developed, with publication as an academic manuscript planned.

TECHNICAL DESCRIPTION: ADAPTATION PLANNING

1. Comprehensive datasets

In the application of Step 1, the following datasets and assumptions were used for the four hazard scenarios:

For the sea-level rise and storm surge analyses, digital elevation data was used from NASA[45] to calculate the exposure of Saint Lucia's infrastructure system. Sea-level rise is represented for the year 2100 with a 1-metre rise (chosen as the upper-end estimate from the Intergovernmental Panel on Climate Change (IPCC)[46], which is regarded as applicable for the Caribbean region[30,47]. Consistent with other papers, which assessed the exposure of assets to storm surges[48], this assessment represents storm surge by a 4-metre inundation scenario chosen as an average value for Caribbean countries for a 1 in 100-year storm event[31] (For more information on average and peak values in Caribbean SIDS see Atlas of Probable Storm Effects in the Caribbean Sea from the Organisation of American States[49]).

For the flash flood analysis, model outputs from Jetten[33] have been used, which are based on a digital elevation model, digitised rivers, roads and buildings, a soil map, and a land use map. This assessment analyses flash flood exposure associated with a 1:50 year rainfall event (category 4/5 hurricanes and large tropical storms).

For the landslide susceptibility analysis, hazard maps created by Van Westen[34] were used, which are based on statistical modelling with Weights of Evidence (WOE) analysis as well as Spatial Multi-Criteria Evaluation (SMCE). This assessment focuses on analysing the exposure of areas with high landslide susceptibility.

Both the flash floods and landslide susceptibility reports[33,34] highlight that the scale of the maps is not appropriate to utilise it for local or detailed scale analysis. Thus, this assessment takes a national-level perspective and identifies areas of priority rather than specific design implications. More detailed hazard maps should be constructed to inform design implications, which will further require – amongst others – information on soil characteristics, such as soil depth, hydrological and geotechnical properties.

2. Infrastructure modelling

Data on economic infrastructure assets was collected from national reports and stakeholder interactions. Due to lack of a complete social infrastructure database in Saint Lucia, Open Street Map (2018) data was extracted and classified according to different categories. The OSM data was combined with datasets directly obtained from relevant ministries. In case of discrepancies, ministry data was prioritised. Data for natural environment assets was based on a 2009 land-use map provided by the Forestry department. All data was verified with local stakeholders.

Hazard exposure was calculated using various units to allow for comparability, namely: 'percentage of capacity exposed' for economic infrastructures, 'percentage of total assets exposed' for social infrastructures, and 'percentage of total area exposed' for natural environment assets.

3. Evidence-based decisions

Prioritisation analyses were based on a combined score of sector exposure and impact. The sector SDG impact metric builds upon the direct and indirect sector influences on the targets of the SDGs.[4] This influence methodology is adapted to a larger range of sectors in Saint Lucia. St Lucia's NAP was used to assign adaptation options to sectors.

Photograph by FFelix (UNOPS)

APPENDIX B: PROJECT DETAILS

The following tables provide a detailed breakdown of all infrastructure interventions considered for the long-term planning component of this analysis. For each sector, assets currently in operation are listed along with their potential capacity or contribution to national supply – note that in this report, projects are not always recommended for implementation at their full capacities. Projects are then listed according to possible implementation date: first, those providing additional capacity to the sector, and second, those leading to demand reductions or efficiencies in the sector. Each project is categorised as **confirmed** (the government has plans to implement the investment or policy, or is doing so already); **proposed** (the intervention has been included in policy proposals or studies); or **potential** (the intervention has been demonstrated in other contexts and may be appropriate for implementation at a later date). Sources have been provided for all projects.

1. Electricity				
Expected	**Size (annual GWh)**	**Description**	**Status**	**Source**
Current	611	Diesel generation – Cul de Sac	Operational	50, 51
Current	7	Solar PV (utility)	Operational	50, 51
Current	0.3	Solar PV (small-scale)	Operational	50, 51
Additional capacity				
2022	21	Solar PV at Micoud	Confirmed	50
2022	29.4	Dennery wind farm	Confirmed	50

Expected	Size (annual GWh)	Description	Status	Source
Additional capacity				
2023	42	Initial large-scale solar deployment	Proposed	17
2023	85.8	New diesel generation plant	Potential	50
2024	16.8	Feasible solar deployment up to 28 MW	Proposed	17
2025	111.7	Geothermal – Phase 1 implementation	Proposed	50
2028	85.8	New diesel generation plant	Potential	50
2028	8.8	Distributed small-scale solar PV	Proposed	50
2030	24	Anaerobic digester potential of 2–3 MW or up to 6% of the energy mix	Proposed	14
2030	69.2	Natural gas retrofit of installed diesel supply	Proposed	17
2032	131.4	Local or regional waste-to-energy facility	Potential	52
2035	111.7	Geothermal – Phase 2 full implementation	Proposed	50
2035	24	Expansion of anaerobic digestion capacity	Potential	14
2040	29.4	Potential wind expansion	Potential	50
2045	42	Potential large-scale PV expansion	Potential	50
Demand reductions and efficiencies				
2020	–3.7	Implementation of energy efficiencies in buildings: • 15% reduction in space cooling and ventilation demand for new construction from the baseline • 10% reduction in lighting demand • 20% increase in efficiency in government buildings	Proposed	13
2021	–9.8	Implementation of energy efficient appliances and street lighting (LEDs) • 10% reduction on estimated energy demand of new appliances • 60% reduction on street lighting	Proposed	13
2022	–8.1	Feasible consumption reductions in hotels	Proposed	17
2025	–6.1	Implementation of transmission efficiency improvements: Reduce system losses to 5% by 2030 (currently 6.34%)	Proposed	13
2030	–35	Waste heat recovery	Potential	59

2. Water					
Expected	**Supply capacity (m^3/year, thousands)**	**Storage capacity (m^3, millions)**	**Description**	**Status**	**Source**
Current	11,615	1.1	Theobalds treatment plant	Operational	50
Current	10,151		Other water treatment plants	Operational	50
Current	204		Raw intakes	Operational	50
Current	11,682		Private desalination plants	Not included	50
Additional capacity					
2019	1,500	1.6	John Compton desilting and rehabilitation project	Confirmed	50
2019	1,659		Thomazo WTP expansion	Confirmed	50
2019	2,323		Dennery redevelopment	Confirmed	50
2020	9,956		New desalination plant	Proposed	50
2021		4.5	Grace and Beausejour storage	Confirmed	50
2021	5,262		Vieux Fort redevelopment	Confirmed	50
2025		5	New dam construction	Potential	50
2030	3,319	1	John Compton dam expansion	Potential	50
2035	2,814		Effluent reuse	Potential	50
Demand and loss reductions					
2020	–311		Greywater reuse and rainwater harvesting in new builds	Proposed	53
2022	–551		Greywater reuse in hotels	Proposed	54
2024	–4,481		Water loss reductions, Phase 1	Proposed	55
2025	–904		High-tech recycling in industry	Proposed	53
2032	–2,199		Water loss reductions, Phase 2	Proposed	55

3. Wastewater				
Expected	**Treatment (m³/ year, thousands)**	**Description**	**Status**	**Source**
Current	453	Beausejour treatment plant	Operational (under-capacity)	22
Current	2,489	Castries sewerage network	Collection only	21
Current	8,656	Septic tanks	Collection only	50
Current	3,184	Pit latrines	Collection only	50
Additional capacity				
2020	0	Castries sewerage network expansion	Potential – collection only	50
2020	0	Extend on-site treatment to all residents	Potential – collection only	50
2021	2,285	Beausejour network expansion – full capacity utilisation	Proposed	50
2021	1,156	New Castries treatment plant	Proposed	50
2023	2,000	Community-based wetlands – based on pilot study of Fond d'Or Watershed	Potential	25
2026	2,000	New treatment plant – South	Potential	50
2028	2,000	Community-based wetlands – expansion	Potential	25
2030	60	Anaerobic digester – sewage sludge	Proposed	14
2032	1,000	Beausejour treatment capacity expansion	Potential	50
2035	2,629	Castries sewage treatment – expansion	Potential	50
2040	2,738	New treatment plant (equivalent to Beausejour capacity)	Potential	50
2045	2,738	New treatment plant 2 (equivalent to Beausejour capacity)	Potential	50
Demand reductions and efficiencies				
2020	–311	Greywater reuse in new builds	Proposed	53
2022	–551	Greywater reuse in hotels	Proposed	54
2025	–904	High-tech recycling in industry	Proposed	53

4.Solid waste				
Expected	**Supply capacity (tonnes/year)**	**Description**	**Status**	**Source**
Current	298,360 (remaining)	Landfill (Deglos)	Operational	50, 56
Current	9,924	Recycling and reuse	Operational	27, 50
Current	859	Other treated	Operational	27, 50
Current	23,274	Unmanaged	Estimated	57
Additional capacity				
2020	21,900	Waste incinerators to waste from Vieux Fort dump site	Confirmed	50
2022	6,415	Household compost initiative	Potential	58
2023	17,483	Export of plastic waste stream to facility in Martinique	Potential	27, 50
2023	79,467	New landfill site to replace Deglos (equivalent capacity and lifespan)	Potential	50
2024	29,345	New compost production facility (St. Vincent model) • Designed to treat majority of organic waste (45% of total minus household compost)	Potential	26, 27, 50
2025	5,563	Glass recycler	Potential	27, 50
2027	7,947	Paper and cardboard recycler	Potential	27, 50
2030	30,000	Anaerobic digestion facility	Proposed	14
2032	40,000	Local or regional waste-to-energy facility	Potential	52
2035	30,000	Expansion of recycling facilities	Potential	27, 50
2035	15,000	Expansion of anaerobic digestion capacity	Potential	14
2040	20,000	Long-term regional waste treatment solutions	Potential	50
2043	79,467	New landfill site to replace previous	Potential	50
Demand reductions				
2020	–19,081	Household waste prevention programme of 0.5% per year • Based on reductions of up to 12.5% seen in the EU, or 16% in the UK	Potential	50, 60

Photograph by FFelix (UNOPS)

APPENDIX C: FOCUS PROJECTS

The GoSL has approved a number of new development projects on the island, which will foster future economic and social development. However, they also place demands on the infrastructure system and the environment, and can be vulnerable to the impacts of climate hazards. The National Infrastructure Systems Model can support the impact analysis of such projects in the areas of long-term infrastructure capacity and hazard risk assessment.

In this report, five focus projects are assessed, representing a sample of tourism, transportation, economic, and social infrastructure types. Where floor space or numbers of users have been determined or estimated, demands for infrastructure services created by the new developments are calculated. This is based on the following assumptions:

- For electricity, the median source energy use intensity (EUI), calculated by equivalent building type (e.g. airport terminal building, warehouse/ distribution, hospital – general medical and surgical) per unit of floor space per year. For hotels, the annual number of guests based on room type (4 guests per family room, 2 guests per luxury adult room), based on an average occupancy rate of 75 percent.[61,62]
- For water, the average water use coefficient by building type as determined by previous studies.[63,64]
- For wastewater, an average water to wastewater conversion of 76 percent, as applied in similar studies.[65]
- For solid waste, per-capita based assumptions based on type of building or facility, proposed by previous studies.[66,67]
- Road transport requirements have been considered for several projects but have not been quantified here.

A hazard map is provided for each project, indicating the exposure of the planned developments to potential climate risks.

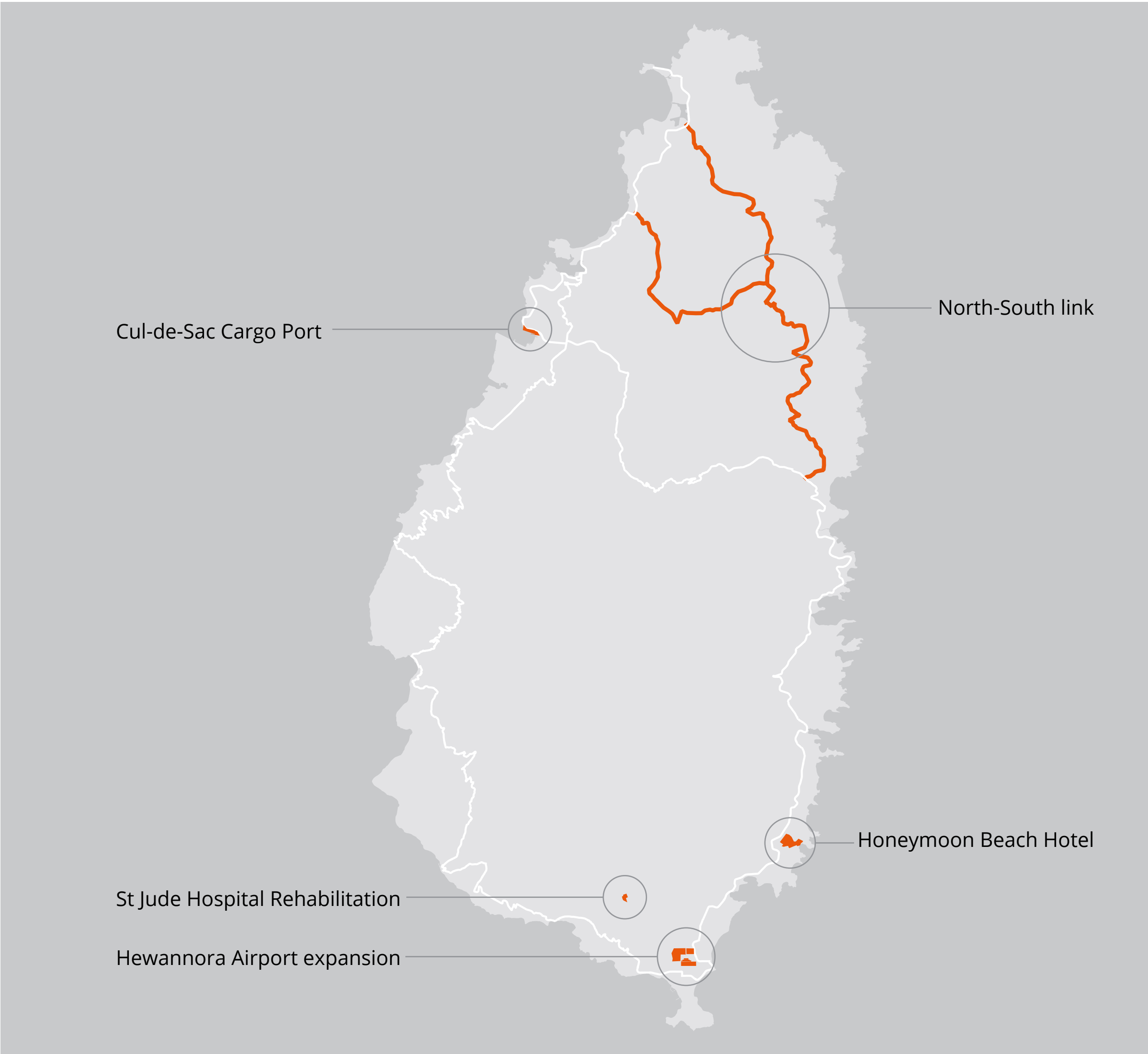


Figure C1:
Geographical location of focus projects

1. HONEYMOON BEACH RESORT

Tourism – hotel

Commencing in 2020

Size and key facilities

- 209 acres
- 330 rooms (250 family all-inclusive, 80 luxury adult)
- 18-hole golf course

Estimated infrastructure needs: (annual demand)

10.8 GWh → 2.7% of current national electricity demand

67 thousand cubic metres → 4.4% of current tourist water demand

51 thousand cubic metres → 9 million toilet flushes

348 tonnes → 32 garbage trucks

Additional access roads and parking

Project description

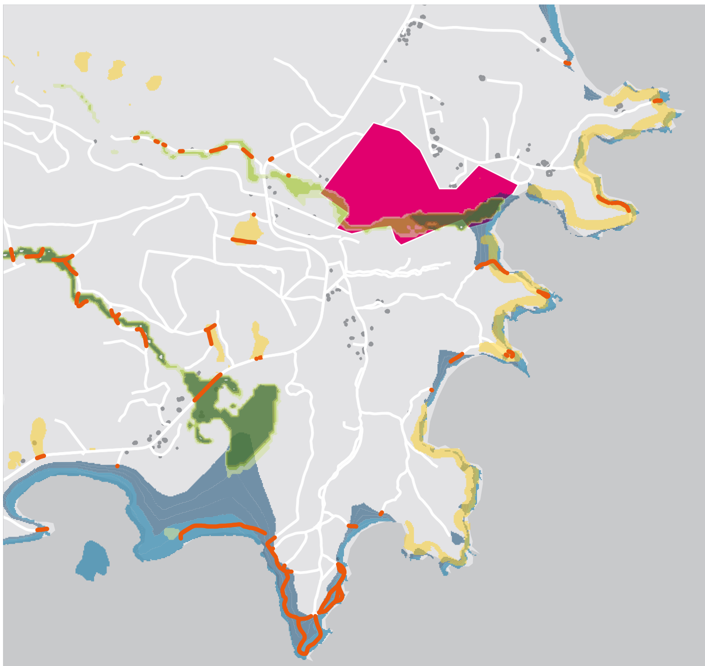
The Honeymoon Beach Resort is proposed as a luxury, resort destination to be located on approximately 209 acres of land in Canelles, Micoud. The Developer is the Caribbean Galaxy Real Estate Ltd, a subsidiary of the Galaxy Group. The Resort will consist of residences and two hotels managed and branded by AMResorts (Apple Leisure Group).

Key SDG impacts

8 DECENT WORK AND ECONOMIC GROWTH: The resort is expected to contribute to Saint Lucia's tourism economy and create 500-600 full time permanent jobs for local residents.

6 CLEAN WATER AND SANITATION: The developer has confirmed a desalination plant as part of the facility, meaning that the resort will not burden Saint Lucia's already-stressed municipal water supply system.

14 LIFE BELOW WATER: On-site wastewater treatment will minimise the project's environmental impact and contribute to cleaner seas and beaches.



1 metre sea-level rise

4 metres storm surge

Flash flood (1:50 year rainfall)

Landslide (high scenario)

Exposed roads

Figure C2:
Hazard exposure, Honeymoon Beach Resort

2. HEWANORRA INTERNATIONAL AIRPORT EXPANSION

Transport – air

Expected completion by 2021

Size and key facilities

- Expansion by approximately 250 percent
- New terminal building
- Expanded taxiway and parking
- Upgraded road infrastructure and traffic management

Estimated infrastructure needs:

Note: these numbers relate to the infrastructure needs of the airport facility itself, not the island-wide needs of tourism growth led by the airport expansion

19.6 GWh → 4.9% of current national electricity demand

175 thousand cubic metres → 14% of current commercial water demand

133 thousand cubic metres → 23 million toilet flushes

572 tonnes → 52 garbage trucks

Road access to be incorporated in project design

1 metre sea-level rise

4 metres storm surge

Flash flood (1:50 year rainfall)

Landslide (high scenario)

Exposed roads

Project description

The Hewanorra International Airport Project is a USD $175 million investment to re-develop Saint Lucia's international airport, incorporating significant enhancements to present facilities and improvements to customer experience. The project encompasses three thematic areas with improvements to airside, terminal and road access – traffic management systems.

Key SDG impacts

The expansion will modernise the island's largest airport, incorporating efficiencies and cutting-edge aviation technology.

The expanded airport will meet needs of Saint Lucia's growing tourism industry and will underpin the broader national macroeconomic development goals.

Access to this important facility will be improved through road infrastructure upgrades and revamped ground transportation systems.

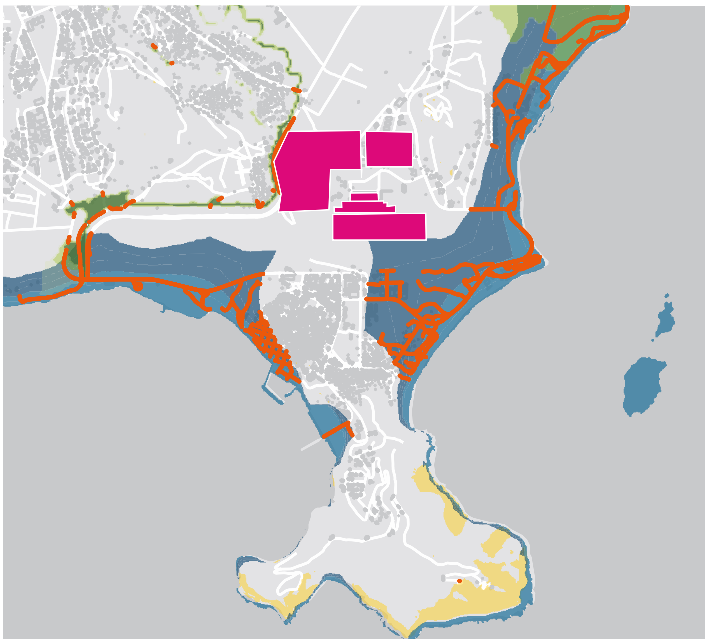


Figure C3:
Hazard exposure, Hewanorra International Airport Expansion

3. CARGO PORT, CUL-DE-SAC

Transport – ship (cargo)

Relocation work beginning 2021, fully operational by 2025

Size and key facilities

- Container terminal area (50,000 m^2)
- General cargo area (14,250 m^2)
- Buildings, services, and parking area (5,750 m^2)

Estimated infrastructure needs:

- 1 GWh → 0.2% of current national electricity demand
- 12 thousand cubic metres → 13% of current port demand
- 9 thousand cubic metres → 1.6 million toilet flushes
- Additional industrial and cargo waste

Project description

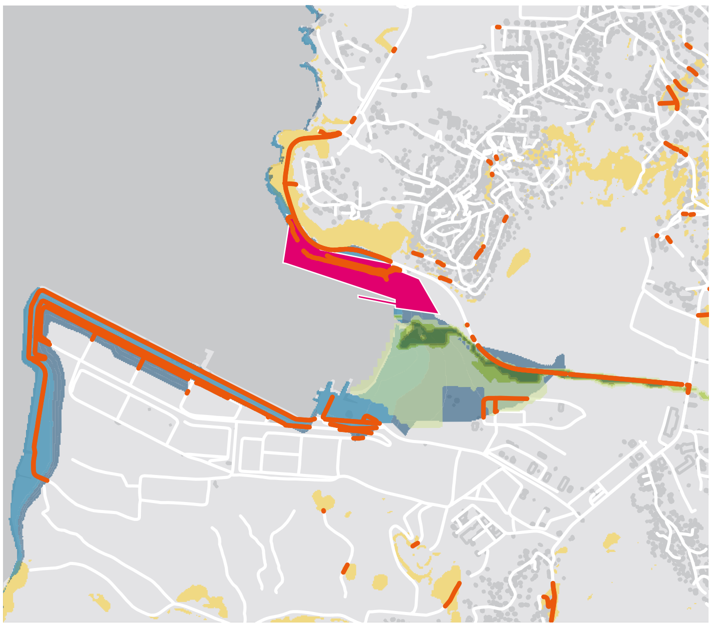
The relocation of the cargo services of Port Castries to Cul-de-Sac aims to separate cargo and cruise which currently operate from the same space at the Castries Waterfront. A dedicated location for cargo handling would aid in alleviating the conflicts of resources and space to accommodate both services, address compromises in occupational health and safety, improve efficiency and productivity as each service has a dedicated space within which to operate, ensure dedicated berthing areas for cargo which currently competes with cruise ship arrivals.

Key SDG impacts

17 PARTNERSHIPS FOR THE GOALS: The relocated cargo port will contribute to increased trade integration, regionally and globally.

8 DECENT WORK AND ECONOMIC GROWTH: As a small-island country, Saint Lucia's economy will benefit from dedicated cargo port capacity to import and export goods without compromising its cruise ship arrivals.

2 ZERO HUNGER: The project will provide enhanced agricultural productive capacity by expanding access to international markets.



- 1 metre sea-level rise
- 4 metres storm surge
- Flash flood (1:50 year rainfall)
- Landslide (high scenario)
- Exposed roads

Figure C4:
Hazard exposure, Cul-de-Sac Cargo Port

4. ST. JUDE HOSPITAL REHABILITATION

Social infrastructure – health

Commenced in 2010, work ongoing

Size and key facilities

- 5,717 m^2
- 90-bed facility with parking, concrete walkways, access roads, and green space

Estimated infrastructure needs:

7.7 GWh → 1.9% of current national electricity demand

20 thousand cubic metres → 2% of current government demand

15 thousand cubic metres → 2.6 million toilet flushes

109 tonnes → 10 garbage trucks

Road access and parking

Project description

The St. Jude Hospital project will replace the old facility, a section of which was destroyed by fire in September 2009, rendering the facility non-functional. Since the fire, the hospital has operated at the National Stadium, though under challenging conditions. Services include medical, maternity, paediatric, emergency, orthopaedic and surgical for inpatients and a range of day clinics for outpatients.

Reconstruction of the hospital commenced in September 2010. There are three completed buildings: Ambulance, Morgue and Warehouse.

Key SDG impacts

3 GOOD HEALTH AND WELL-BEING: The facility will improve medical and health services for local residents.

10 REDUCED INEQUALITIES: The new hospital will provide access to care for disadvantaged residents in the island's south who currently rely on a temporary hospital facility.

Improved health outcomes lead to a more productive workforce with enhanced livelihoods.

1 metre sea-level rise

4 metres storm surge

Flash flood (1:50 year rainfall)

Landslide (high scenario)

Exposed roads

Figure C5:
Hazard exposure, St. Jude Hospital Rehabilitation

5. NORTH-SOUTH ROAD

Transport – road

2035 (potential)

Size

- Option 1 consists of four links totalling 32.15 km.
- Option 2 consists of four links totalling 19.94 km, a little more than half the length of Option 1.

In terms of metres and percentage of the total road length exposed:

- 198 metres/ 1% exposed to storm surge (4-metre)
- 1800 metres/ 6% exposed to flash floods
- 1410 metres/ 4% exposed to landslides

Project description

The North-South Road (Option 1) aims to provide a new route along the east coast of Saint Lucia from north of Dennery to Gros Islet. Connections to Castries, Choc Bay, and Rodney Bay are provided.

A 20-year projection shows that in 2035, 830 to 972 diverted vehicles per day are expected to travel between Dennery and Gros Islet. The majority of 2035 diverted vehicles, in the order of 4,355 to 5,100 per day, are projected to travel between Dennery and Castries.

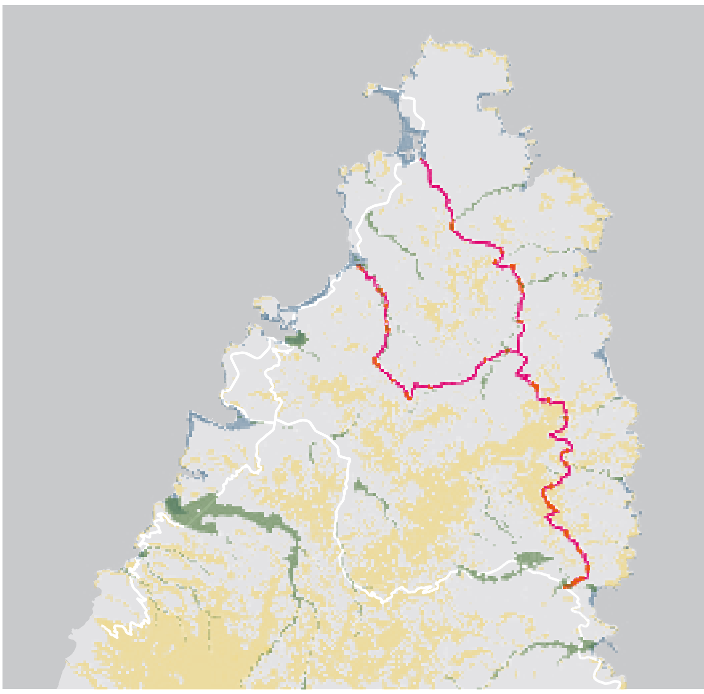
Key SDG impacts

11 SUSTAINABLE CITIES AND COMMUNITIES — The access road will reduce traffic along the busy Rodney Bay-Castries route, allowing for faster commutes to the capital city.

13 CLIMATE ACTION — An easing of congestion in this urbanised part of the island may be linked to reduced vehicle emissions.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION — A more efficient road network will facilitate transport of the island's waste to management facilities.

Figure C6:
Hazard exposure, North-South Road



1 metre sea-level rise
4 metres storm surge
Flash flood (1:50 year rainfall)
Landslide (high scenario)
Exposed roads

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