

# Technology Needs Assessment - Sierra Leone



**Sierra Leone**

**UN**   
**TECHNOLOGY**

UNITED NATIONS TECHNOLOGY BANK  
FOR LEAST DEVELOPED COUNTRIES



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## List of acronyms

<b>AfCTA</b>	African Continental Free Trade Area
<b>AI</b>	Artificial Intelligence
<b>ARISE</b>	Accountability and Responsiveness in Informal Settlements for Equity
<b>ASTI</b>	Agricultural Science and Technology Indicators
<b>BBC</b>	British Broadcasting Corporation
<b>CBD</b>	Convention on Biological Diversity
<b>CCTV</b>	Closed-circuit television.
<b>CGIAR</b>	Consultative Group on International Agricultural Research
<b>CIA</b>	Central Intelligence Agency
<b>COMAHS</b>	College of Medicine and Allied Health Services
<b>CORAF</b>	The West and Central African Council for Agricultural Research and Development / Le conseil Ouest et Centre Africain pour la Recherche et le développement agricoles
<b>DSTI</b>	Directorate of Science, Technology, and Innovation
<b>EDCTP</b>	European & Developing Countries Clinical Trials Partnership
<b>EEZ</b>	Exclusive Economic Zone
<b>EU</b>	European Union
<b>EVI</b>	Economic and Environmental Vulnerability Index
<b>FAO</b>	Food and Agriculture Organization of the United Nations
<b>FTE</b>	Full-time equivalent
<b>GDP</b>	Gross Domestic Product
<b>GEDI</b>	Global Entrepreneurship Development Institute
<b>GEI</b>	Global Entrepreneurship Index
<b>GII</b>	Global Innovation Index
<b>GIS</b>	Integrated Geographic Information System
<b>GMO</b>	Genetically modified organism
<b>GNI</b>	Gross National Income
<b>GOSL</b>	Government of Sierra Leone
<b>HAI</b>	Human Assets Index
<b>ICT</b>	Information Communication Technology
<b>IDA</b>	International Development Association
<b>IFAD</b>	International Fund for Agricultural Development
<b>IFC</b>	International Finance Corporation
<b>ILO</b>	International Labour Organization
<b>IMBO</b>	Institute of Marine Biology and Oceanography
<b>IMF</b>	International Monetary Fund
<b>IoT</b>	Internet of things
<b>IPAM</b>	Institute of Public Administration and Management
<b>IPR</b>	Intellectual Property Rights
<b>IRENA</b>	International Renewable Energy Agency

<b>IsDB</b>	Islamic Development Bank
<b>ITU</b>	International Telecommunication Union
<b>LIDAR</b>	Light Detection and Ranging
<b>LEAP</b>	Limkokwing Accelerator Platform
<b>MOPED</b>	Ministry of Planning and Economic Development
<b>MTI</b>	Ministry of Trade and Industry
<b>NaCOVERC</b>	National COVID-19 Emergency Response Centre
<b>NARCC</b>	National Agriculture Research Coordination Council
<b>NDDP</b>	National Digital Development Policy
<b>NEET</b>	Not in Education, Employment or Training
<b>NIDS</b>	National Innovation and Digitalisation Strategy
<b>NU</b>	Njala University
<b>QAERP</b>	Quick Action Economic Recovery Programme
<b>RBDS</b>	Resilient Business Development Services
<b>SDGs</b>	Sustainable Development Goals
<b>SERP</b>	Socio-Economic Response Plan
<b>SLARI</b>	Sierra Leone Agricultural Research Institute
<b>SMEs</b>	Small and Medium Enterprises
<b>Solar PV</b>	Solar photovoltaic
<b>STEM</b>	Science, Technology, Engineering, and Mathematics
<b>STI</b>	Science, Technology, & Innovation
<b>SWOT</b>	Strengths, Weaknesses, Opportunities, Threats
<b>TIP</b>	Technology Implementation Plan
<b>TNA</b>	Technology Needs Assessment
<b>TRIPS</b>	Trade-Related Aspects of Intellectual Property Rights
<b>UNCDF</b>	United Nations Capital Development Fund
<b>UNCTAD</b>	United Nations Conference on Trade and Development
<b>UNDESA</b>	United Nations Department of Economic and Social Affairs.
<b>UNDP</b>	United Nations Development Programme
<b>UNESCO</b>	United Nations Educational, Scientific and Cultural Organization
<b>UNICEF</b>	United Nations International Children’s Emergency Fund
<b>UNIDO</b>	United Nations Industrial Development Organization
<b>UNSG</b>	United Nation Secretary General
<b>USAID</b>	United States Agency for International Development
<b>USL</b>	University of Sierra Leone
<b>USSD</b>	Unstructured Supplementary Service Data
<b>WECARD</b>	West and Central Africa Council for Agricultural Research and Development
<b>WEF</b>	World Economic Forum
<b>WHO</b>	World Health Organization
<b>WIPO</b>	World Intellectual Property Organization
<b>WTO</b>	World Trade Organization

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## Foreword

It is now widely recognized that technology can be a fundamental tool in helping Cambodia move away from commodity dependence to sectors with higher productivity and skill intensity.

This is particularly crucial in light of the SDGs and 2030 Agenda, especially in Sierra Leone where we are already experiencing the impacts of climate change. Thoughtful, strategic, and substantial investments in technologies such as renewable energy and ideas such as circular economy technology, science and innovation can offer a path to sustainable development for Sierra Leone which allows it to protect and strengthen its nature and biodiversity as it works towards securing sustainable futures for its citizens.

The government of Sierra Leone has conducted this TNA with the support/partnership of the UN Technology Bank to produce this Technological Needs Assessment as a guide to help navigate this structural transformation from a technological perspective. Not only does it rest assured that the people of Sierra Leone have the right to participate in the 4th Industrial Revolution, actively and to their own benefit, but it also puts forward that without the participation of people from the LDCs, such movement would not be a genuine and truly systemic societal shift.

As it stands, the findings of the report are closely in line with the STI policies and strategies of Sierra Leone government and focuses specifically on areas of core issues such as agriculture, energy, and education.

This TNA also reflects the huge hope and potential of the young people and women of Sierra Leone in the fields of science, technology, and innovation. 60% of Sierra Leoneans are aged 24 years and younger, and so investing in their future should be the foundation of planning.

The exciting and innovative findings of this report are an invaluable tool for Sierra Leone to engage with hope and energy in contributing to Agenda 2030 and bettering the quality of life of its/our people. It includes learning relevant for other LDCs across Africa, Asia, and Central America.

## Acknowledgements

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## Executive Summary

This report analysis science, technology, and innovation (STI) in Sierra Leone and presents results of a technology needs assessment (TNA) that examined the potentials to use technologies to address its development needs. The report identifies priority sectors for technological solutions and presents specific technology suggestions that can contribute to development in the country. The purpose of this project is to identify science and technology gaps and priority needs, where Sierra Leone can take advantage of technological opportunities to contribute to sustainable development and enhance quality of life.

This work was conducted by Small Globe Inc. with input from the Directorate of Science, Technology, and Innovation (DSTI) and the Ministry of Planning and Economic Development (MOPED). The representatives of the United Nations Capital Development Fund and the United Nations Industrial Development Organization (UNIDO) who are based in the country were also regularly consulted.

The project involved a thorough desk review of the wider historical, economic, political, environmental, and social context of Sierra Leone and a systematic analysis of the STI system in the country. It also involved mapping the main public and private sector organisations active in STI and submitting a survey to a stakeholder group representing diverse organisations. The survey asked the stakeholders to identify the main priority sectors that can meet development needs in the country. The survey also asked stakeholders to indicate challenges that need to be addressed and potential technologies to address them. Finally, the stakeholders were asked to provide input into a strengths, weaknesses, opportunities, and threats (SWOT) analysis of the STI system in Sierra Leone. The survey was sent to 108 stakeholders, and 45 responded, representing a 42% response rate.

Sierra Leone is rich in natural mining resources and has fertile land for agriculture. The years since independence in 1962 have been characterized by intermittent political unrest, but with the new millennium the country has been more stable. Unfortunately, it has had serious public health crises, including the 2014-2015 Ebola outbreak. Its economy had robust economic growth in the years before the COVID pandemic and is heavily depended on agriculture. It has a young population with median age under 20 years. Poverty is a pressing problem in the country and Sierra Leone's progress in meeting most of the sustainable development goals (SDGs) has been limited.

The government has developed the Medium-Term National Development Plan, 2019-2023 which aligns well with meeting the SDGs. Key priorities include development of human capital – with a particular focus on improved access to quality education - food security and improved health outcomes. These will be achieved through actions to improve the economy, enhance infrastructure and to strengthen governance and accountability. There is a particular emphasis on digital development, and digital technologies are emphasised as enabling technologies in most development sectors.

While Sierra Leone doesn't have a specific science and technology policy, its government has started to build components of a STI system and, in recent years, there has been an evolution of institutions promoting STI. The government established DSTI to support its STI mandate across all ministries. DSTI has, amongst other things, prepared a National Innovation and Digitalisation Strategy (NIDS) for 2019-2029. The Ministry of Information and Communications has also led work on developing National Digital Development Policy. A Sierra Leone's performance in STI needs, however, to be strengthened. Its output in the scientific literature is low and it is particularly weak in cross-cutting strategic technologies that could fuel digital development in the country. Its global ranking in readiness to harness frontier technologies is also low, which could undermine its ambitions to build a digital economy.

The government's commitment must be accompanied by allocation of required resources. Funding for STI activities is low in the country. Policy development of strategic sectors also needs to be better grounded through research and extensive consultations and informed by the realities in the country. More resources, better grounded policies, and a focus on integrating the different components can ultimately lead to greater knowledge flow in the system and a stronger innovation record.

The results of the survey submitted to a diverse group of stakeholders conveyed a clear message that technologies are expected to play important roles in addressing development needs in the country. The stakeholders identified a few priority sectors to focus on with agriculture, energy, education, health, and infrastructure being ranked as the most important sectors for promoting development. This ranking aligns closely with the strategic focus of the Government of Sierra Leone's Medium-Term National Development Plan.

The stakeholders identified a wide range of challenges to which technologies could be applied. For example, low productivity in agriculture, negative effects of climate change calling for the use of renewable energy and green infrastructure, limited access to distance education requiring improved eLearning systems, and limited access to health services. They also suggested numerous technologies that could address these challenges. Digital technologies feature centrally in the survey respondents' suggestions. This aligns directly with the government's emphasis on digital development in its Digitalisation Strategy.

To start to see the suggested technologies in action and harness technologies to meet development needs in the country, the recommendations below are presented. They are divided into recommendations aimed generally at strengthening the STI system in Sierra Leone, and recommendations aimed at defining the next steps in the TNA process.

### Recommendations to strengthen the STI system

**Recommendation A1:** The Government of Sierra Leone is to develop an **overarching evidence-based STI strategy** for the country, anchored on the Medium-Term National Development Plan, to systematically **support research and innovation activities** in priority areas. A fund tied to the strategy should be set up that provides **competitive grants** aimed at solving targeted development needs in the country. The strategy should focus on **breaking down silos** and encourage domestic collaboration to address development challenges.

**Recommendation A2:** The Government of Sierra Leone should, together with multilateral organisations/donors explore options to **strengthen internet access** in the country. This is particularly needed in rural areas.

**Recommendation A3.** Substantially **strengthen STEM skills** development throughout the education system through a special skills development program supported by multi-laterals and other donors.

**Recommendation A4.** The Government of Sierra Leone should work with the banking system and multilaterals/donors to support **youth entrepreneurship** by establishing a funding mechanism aimed at start-up development and to strengthen intermediaries (e.g., hubs, accelerators, and incubators) in Sierra Leone.

**Recommendation A5.** The start-up community in Sierra Leone should spearhead, together with the government, the **development of a start-up act** that wholistically addresses challenges for the development of technology-based start-ups.

## Recommendations for next steps for the TNA process

**Recommendation B1.** The UN Technology Bank for the Least Developed Countries is to support government representatives and other stakeholders in Sierra Leone to **prioritize** no more than three to five **technologies to implement**.

**Recommendation B2.** The UN Technology Bank is to support Sierra Leone to **develop detailed Technology Implementation Plans (TIPs)** for the prioritised technologies, which are customized to the features of the technologies and the wider context in Sierra Leone.

**Recommendation B3:** The UN Technology Bank is to **support the authorities to start implementing** the prioritised technologies together with stakeholders in Sierra Leone.

**Recommendation B4.** The UN Technology Bank is to **encourage South-South collaboration** in implementation of the technologies.



# CHAPTER 1

## Contextual Background

## 1.1 Introduction

This report analyses technology needs and technology potential for the Republic of Sierra Leone. It includes a review of the status of science, technology, and innovation (STI) in Sierra Leone; and a technology needs assessment (TNA) to identify priority technologies to address Sierra Leone's development needs. The purpose is to identify science and technology gaps and priority needs, where Sierra Leone can take advantage of technological opportunities to contribute to sustainable development and enhance the quality of life in the country.

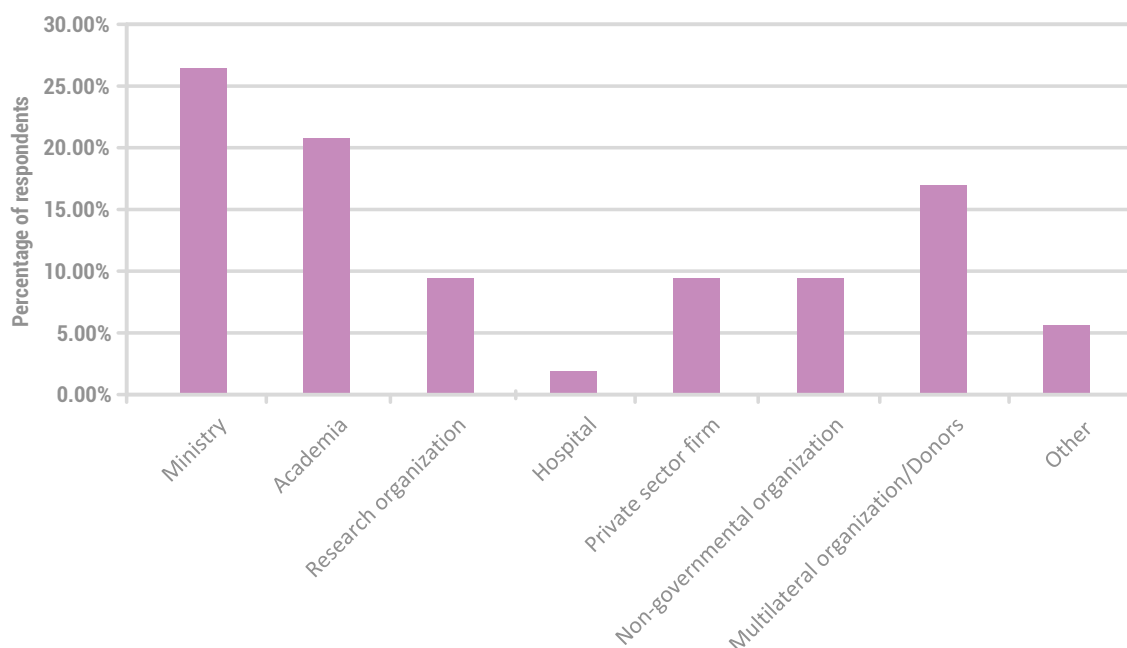
## 1.2 Methodology

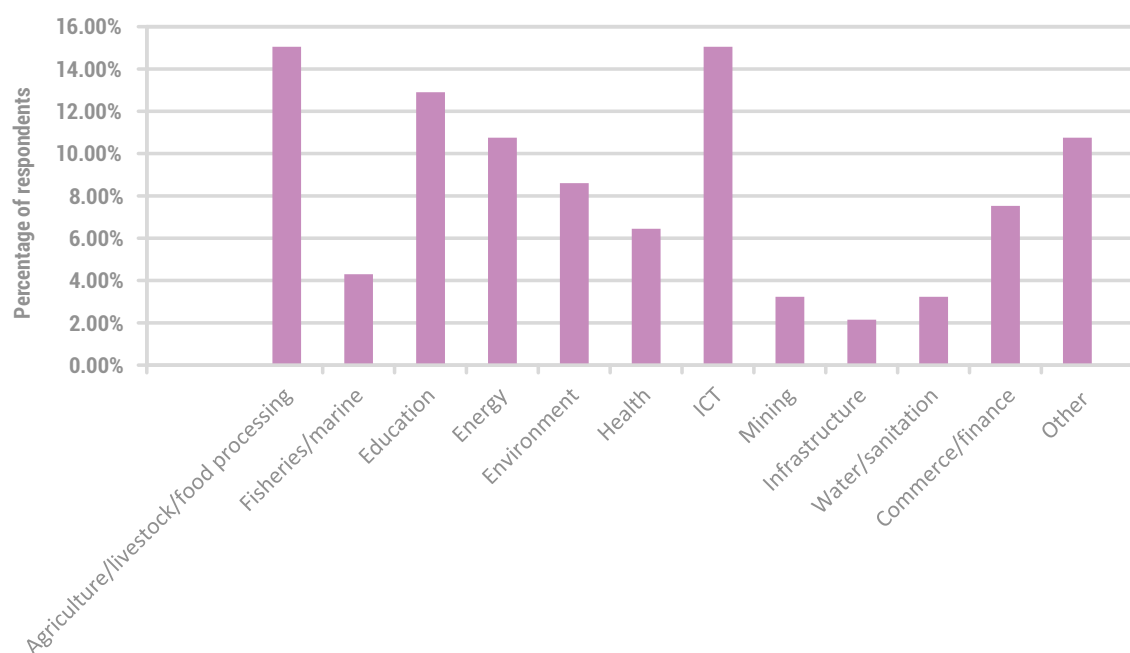
This TNA was conducted using mixed methods. The process started by carrying out detailed desk reviews. The first review was focused on gaining insight on the wider historical, economic, political, environmental, and social context of Sierra Leone, and on its development priorities. The second review involved a systematic examination of the STI system in Sierra Leone. These background analyses included reviews of policy documents from the Government of Sierra Leone, reports from multilaterals, academic publications, material from the websites of a variety of organisations, and newspaper articles and other documents describing STI-related initiatives.

As a part of the STI review, the main public and private sector organizations active in STI activities in the country were mapped. This mapping helped develop a stakeholder database of those involved in different ways in STI-related activities in Sierra Leone. A survey was developed which asked the stakeholders what they believe are the main priority sectors for meeting Sierra Leone's development needs, to identify challenges that need to be addressed, and specific technologies to address them. The survey also asked the stakeholders to indicate the strengths, weaknesses, and opportunities of the STI system in Sierra Leone, which provided input to conduct a brief evaluation of the country's STI system.

The survey was sent to 108 stakeholders and a total of 45 answered. This resulted in an approximately 42% response rate, which is excellent for a cold call survey. The stakeholders came from different types of organizations (Figure 1) and represented diverse technological expertise (Figure 1). The results from the surveys were analysed using both quantitative and qualitative methods. Based on the results of the survey, the main priority sectors in the country, and potential technologies that could address development needs in these sectors, were identified. A preliminary Technology Implementation Plan was also developed to guide a further discussion on how the TNA findings and recommendations can be implemented.

**Figure 1. Organizational affiliations of the respondents of the stakeholder survey.**



**Figure 2. Sector affiliations of respondents to the stakeholder surveys**

In this work, an emphasis was placed on collaboration with experts in Sierra Leone, with representatives from the Directorate of Science, Technology, and Innovation (DSTI), and the Ministry of Planning and Economic Development (MOPED). The representatives of the United Nations Capital Development Fund (UNCDF) and the United Nations Industrial Development Organization (UNIDO) that are based in the country were also consulted at various stages of the TNA process.

### 1.3 Situating Sierra Leone: Geography and Population

The Republic of Sierra Leone is situated in West Africa. It has borders with Guinea to the north and east and Liberia to its southwest. The land area of Sierra Leone is 71,740 square km with a coastline of about 510 km, and an exclusive economic zone (EEZ) of 157 000 square km.<sup>1</sup> The country is rich in natural resources (e.g.

diamonds, titanium ore, and iron ore) and fertile land.<sup>2</sup> The nation has four distinct regions: coastal plains (covering 14% of the country's area); interior plains (43 percent); plateau (22 percent); and hills and mountains (21 percent).<sup>3</sup> Sierra Leone's coastline is largely low-lying mangrove swamps with several estuaries and sandy beaches. The Sierra Leone Peninsula is an exception and is a thickly wooded mountainous region. Freetown, the country's capital, is located on the peninsula. Beyond the coastal belt is a wooded plateau. The Eastern part of the country is again relatively mountainous and includes the highest point of the country called Loma Mansa or Bintimani Peak. About 74% of Sierra Leone's land area is considered suitable for cultivation on a sustainable basis.<sup>4</sup> The main staple foods of the country are rice and cassava, but the main export crops are cocoa, coffee, palm oil and cashew nuts.<sup>5</sup>

The population of Sierra Leone was estimated

1 FAO (2022). Sierra Leone at a Glance. Food and Agriculture Organization of the United Nations.

2 FAO (2021). Evaluation of FAO's Country Programme in the Republic of Sierra Leone 2021. Food and Agriculture Organization of the United Nations.

3 FAO (2021). Evaluation of FAO's Country Programme in the Republic of Sierra Leone 2021. Food and Agriculture Organization of the United Nations.

4 FAO (2022). Sierra Leone at a Glance. Food and Agriculture Organization of the United Nations.

5 USAID (2021). Sierra Leone 2021. United States Agency for International Development

to be over 7.8 million in 2019.<sup>6</sup> The country is ethnically diverse with identifiable groups including Temne 35.5%, Mende 33.2%, Limba 6.4%, Kono 4.4%, Fullah 3.4%, Loko 2.9%, Koranko 2.8%, Sherbro 2.6%, Mandingo 2.4% and Creole 1.2%. In addition, there are about 5% who have been described as “other Sierra Leone” or “other foreign” (e.g., refugees from Liberia).<sup>7</sup>

The country is largely rural with about 42.5% of the population living in urban areas in 2021.<sup>8</sup> This compares to 50.9% for developing countries, on average, and 34.1% for least developed countries. The capital, Freetown, is the sole large metropolitan area with an estimated population of 1.2 million.<sup>9</sup> The country also has a young population, and the median age was estimated to be 19.4 years in 2020.<sup>10</sup>

Sierra Leone has a tropical climate with two distinct seasons. The dry season (December to April, dominated by winds from the north-east), and the rainy season (May to November).<sup>11</sup> Its annual rainfall is one of the largest for African countries with the rainy season having an average annual rainfall of around 3000 mm.<sup>12</sup> The coastal and southern areas are the wettest with 5,000 mm annual rainfall, while the inland areas receive from 2,000 to 2,500 mm.

The ND-GAIN Country Index ranks countries in terms of vulnerability to climate change and their readiness to improve resilience. Sierra Leone’s overall ND-Gain rank was, in 2019, 156 of 182 countries ranked. Sierra Leone ranked especially high in vulnerability (166 out of 182 countries, or 17th most vulnerable country ranked), and a bit better in readiness to improve

(144 out of 182 countries, or the 49th least ready country).<sup>13</sup> The country is vulnerable to climate change and is expected to experience an increase in temperature, rising sea levels, and more extreme weather. Temperature is estimated to increase by 1.0 to 2.5 degrees Celsius by 2060 and sea levels will rise by 0.1 to 0.56 metres, by 2100 compared to 1980 to 1999 levels.<sup>14</sup> These changes are likely to result in increased coastal floods and erosion and a reduction in the quality of drinking water. There are some indications that there already is increased variability in the rainy season and more frequent occurrences of intense rainfalls and heavy storms.<sup>15</sup> The intense rainfalls can lead to mudslides and a decline in water quality. Climate change is likely to affect Sierra Leone’s agriculture sector, particularly rice production which is a common staple in the country. Rising sea temperature can lead to increased acidification and reduced water quality which can affect fish survival. Fish is the most common animal protein consumed in Sierra Leone. Climate change is therefore likely to negatively affect food security in the country. Human health would be affected by climate change and heavy rainfall can increase the incidences of cholera.<sup>16</sup>

The biodiversity in Sierra Leone differs extensively between the four regions. The vegetation can be classified into categories which include the moist rainforest, semi-deciduous, montane, mangrove, savannah, farm bush and swamp forest with around 15,000 plant species having been identified.<sup>17</sup> Sierra Leone is also rich with fish and around 213 pelagic and demersal species have been identified in

6 UNDESA (2019). World Population Prospects: The 2019 Revision. The United Nations Department of Economic and Social Affairs.

7 CIA (2022). The World Factbook. Central Intelligence Agency. <https://www.cia.gov/the-world-factbook/countries/sierra-leone/>

8 UNDESA (2018). World Urbanization Prospects: The 2018 Revision. New York. The United Nations Department of Economic and Social Affairs.

9 CIA (2022). The World Factbook. Central Intelligence Agency.

10 UNDESA (2019). World Population Prospects: The 2019 Revision. United Nations Department of Economic and Social Affairs

11 UNDP (2022). Climate Change Adaptation, Sierra Leone. United Nations Development Programme.

12 Republic of Sierra Leone (2012). Second National Communication on Climate Change.

13 ND-Gain (2019) Notre Dame Global Adaptation Initiative.

14 Republic of Sierra Leone (2012). Second National Communication on Climate Change.

15 USAID (2016). Climate Change Risk Profile: Sierra Leone Fact Sheet. United States Agency for International Development f

16 World Bank (2022a). Climate Change Knowledge Portal: Sierra Leone.

17 CBD (2022). Sierra Leone – Main Details. Convention on Biological Diversity.

its waters. About 170 mammal species are estimated to be in the country, 70 crop species and 274 bird species. There are 15 primates and all of them are endangered or vulnerable. There are also 18 antelope species and two of them are extinct and 16 are threatened. The numbers of elephants and hippos are also greatly reduced. The population is putting a lot of pressure on the natural ecosystem through direct economic activities such as logging for timber, and trading in bushmeat, but also through pollution, for instance from mining.

## 1.4 Historical Summary

The roots of modern Sierra Leone date to the late 18th-century when British abolitionists and philanthropists created a settlement at Freetown for repatriated and rescued slaves from Britain and Nova Scotia.<sup>18</sup> These early arrivals were augmented by Jamaican Maroons and freed in-transit slaves at the start of the 19th-century. From these early days until 1896, Sierra Leone was a British Crown Colony. During the 19th-century, the British writ expanded through the region surrounding Freetown, with the corresponding overriding of indigenous customs and laws by the colonial authorities. By 1895 the colonial authorities had delineated the boundaries of modern-day Sierra Leone. In the following year the British government created a British Protectorate in the region which authorized the Colony to make laws for the surrounding region. The distinction between the Colony and the Protectorate political entities – which also reflected the different histories of the Creoles (descendants of the freed slaves) and the indigenous peoples – contributed to on-going tensions within Sierra Leone throughout the first half of the 20th-century. By 1951 a movement towards decolonization had emerged and the first parliamentary elections were held in 1957. These political changes led to independence in 1961, with a Westminster-style parliament and membership in the Commonwealth.

The years since independence have been

characterized by intermittent political unrest and serious public health crises. During the early 1960s there were several coups, leading to the proclamation of the Republic of Sierra Leone in 1971.<sup>19</sup> During the 1990s the country experienced a civil war, further coups and intervention by Nigerian-led West African military forces, suspension from the Commonwealth and UN-imposed sanctions. The first decade of the 21st-century saw the eventual stabilization of the country and the arrival and eventual withdrawal of UN peacekeepers. Elections were held in 2002 and again in 2007. The 2007 presidential and parliamentary elections saw a peaceful transfer of power. In 2012 the first elections without UN oversight since the end of the civil war were held and power changed hands again in 2018 through the presidential election held that year. The last decade also saw the Ebola outbreak in parts of West Africa, including Sierra Leone which was challenging for the social and economic development of the country.<sup>20</sup> More recently, public health in Sierra Leone has also been impacted by the COVID-19 global pandemic which will be discussed later in this chapter.

## 1.5 Government Structure

Sierra Leone is a republic. Its 1995 constitution provides for an executive president who is also head of state and of government. The nation is a multiparty democracy with a unicameral parliament.<sup>21</sup> The government wields executive authority. With the approval of the legislature (House of Representatives), the President appoints a cabinet and forms the government. Presidential and parliamentary elections are held at least every five years under a system of proportional representation and universal suffrage. In addition to the Executive (President and Cabinet) and Legislative (House of Representatives) branches, Sierra Leone has a Judicial Branch exemplified by the Supreme Court and lower courts.

Currently there are 27 ministries.<sup>22</sup> Some which may be especially relevant for the Technology

<sup>18</sup> BBC (2018). Country Profile, Sierra Leone. British Broadcasting Corporation.

<sup>19</sup> Ibid.

<sup>20</sup> Ibid.

<sup>21</sup> Nexus (2020). Commonwealth Network.

<sup>22</sup> Office of the President (2018). Presidential Cabinet. Government of Sierra Leone.

Needs Assessment are the:

- Ministries of Finance;
- Ministry of Agriculture and Forestry;
- Ministry of Energy;
- Ministry of Health and Sanitation;
- Ministry of Information and Communications;
- Ministry of the Environment;
- Ministry of Marine Resources;
- Ministry of Mines and Mineral Resources;
- Ministry of Planning and Economic Development;
- Ministry of Basic and Secondary Education;
- Ministry of Technical and Higher Education;
- Ministry of Trade and Industry;
- Ministry of Transport and Aviation;
- Ministry of Tourism;
- Ministry of Water Resources.

## 1.6 Economic environment

While rich in a variety of natural resources as noted above, Sierra Leone has an economy dominated by agriculture.<sup>23</sup> The agriculture sector accounts for 60% of the country's gross domestic product (GDP) and 58% of total employment.<sup>24</sup> About 65% of the country's population live in rural areas and most of them (86.1%) are engaged in smallholder subsistence agricultural production.<sup>25,26</sup> While 74% of the total land area is considered suitable for cultivation, most farmers (80% ) cultivate less

than 10% of that land.<sup>27</sup> The national GDP has been reported to be USD 4.1 billion by the World Bank in 2019, with a growth rate of 5.5% in the same year.<sup>28, 29</sup> Growth was driven by increased activity in the agriculture and construction sectors, as well as resumption after the civil war, of production and export of iron ore, the main export product.<sup>30</sup> The GDP per capita was \$PPP 1,718 for 2017.<sup>31</sup> This compares to an average of \$10,845 for developing countries and \$3,010 for least developed countries in the same year. According to the UNDP, the Human Development Index for Sierra Leone in 2019 was 0.452, for a rank of 182 of 189 countries.<sup>32</sup>

Employment and poverty patterns are indicative of the economic environment. A total of 57.9% of Sierra Leone's population over the age of 15 participate in the labour force, and the rate of child labour (5 to 17 years) is 25.2%.<sup>33</sup> <sup>34</sup> Women are relatively active in the labour force and in 2019 57.3% of the female working age population took part in the labour force versus 58.5% of the males.<sup>35</sup> As noted above, Sierra Leone has a largely agrarian economy, augmented by iron ore extraction and export. The service sector is also a significant employment sector, accounting for 38.6% of total employment.<sup>36</sup>

Poverty is a pressing problem in Sierra Leone with about 57.9% of the population living in poverty as defined by the UNDP. The UNDP rates poverty as a multidimensional phenomenon and the main contributing factors in Sierra Leone include deprivation in education (28.9% contribution), deprivation in standard of living (52.4%) and deprivation in health (18.6%).<sup>37</sup>

23 FAO (2021). Evaluation of FAO's Country Programme in the Republic of Sierra Leone 2021. Food and Agriculture Organization of the United Nations.

24 Followed by the service sector (about 55% of GDP) and the industrial sector (at about 9% of GDP). Sierra Leone Medium-Term National Development Plan 2019 – 2023.

25 FAO (2022). Sierra Leone at a Glance. Food and Agriculture Organization of the United Nations.

26 FAO (2021). Evaluation of FAO's Country Programme in the Republic of Sierra Leone 2021. Food and Agriculture Organization of the United Nations.

27 FAO (2022). Sierra Leone at a Glance. Food and Agriculture Organization of the United Nations.

28 It should be noted that even pre-COVID the GDP of Sierra Leone was prone to significant fluctuations year-over-year.

29 World Bank (2020a). GDP growth (annual %) - Sierra Leone. The World Bank Group.

30 World Bank (2021). The World Bank in Sierra Leone. The World Bank Group.

31 World Bank (2020b). World Development Indicators database. The World Bank Group.

32 UNDP (2020a.) Human Development Report Country Profile, Sierra Leone. United Nations Development Programme.

33 ILO (2020). ILOSTAT database. International Labour Organization.

34 UNSD (2020). Global SDG Indicators Database. United Nations Statistics Division

35 ILO (2020). ILOSTAT database. International Labour Organization.

36 Ibid.

37 UNDP (2020). Human Development Report Country Profile, Sierra Leone. United Nations Development Programme.

Agriculture is clearly a vital component of the Sierra Leone economy. It employs about 65% of the national work force (about 75% of the population) with women as the predominant agriculture work force.<sup>38</sup> In addition to agricultural crops, the agriculture sector encompasses the fisheries. Sierra Leone has one of the world's richest fishing grounds, and fisheries account for about 10% of GDP.<sup>39</sup> Marine fisheries employ 500,000 people in Sierra Leone either directly or indirectly.<sup>40</sup> There are concerns that there are signs of overfishing of some commercially exploited fish stocks.<sup>41</sup> Other key sectors<sup>42</sup> include mining and mineral resources (over 20% of GDP in 2013), energy infrastructure (national electricity generation capacity increased by a factor of nearly 760 between 2016 and 2019), the construction sector<sup>43</sup> and the tourism infrastructure sector. While relatively untapped, tourism provides opportunities to stimulate and attract investment in this sector. The government has identified tourism as one of the diversifying growth sectors for the nation, alongside agriculture and fisheries.<sup>44</sup> It also has put an emphasis on it being environmentally sustainable with

a National Ecotourism policy being unveiled in 2017.

Trade and financial flow statistics for Sierra Leone for 2010 - 2019 are presented in Table 1, along with a comparison with developing countries and least developed countries data from the same source. These data paint a picture of a nation with a somewhat robust export/import economy compared to other developing countries, with higher foreign direct investment, substantially heavier reliance on development assistance, and a reliance on remittances similar to developing countries but lower than that of least developed countries. There is substantial flow of private capital out of the country compared to comparator nations.

The World Bank's Ease of Doing Business rating ranked Sierra Leone in 160th place of 190 countries in 2018.<sup>45</sup> This was down from 148th place in 2017. The low ranking has been attributed to poor infrastructure, limited access to finance and regulatory/administrative barriers.<sup>46</sup>

**Table 1. Sierra Leone - Several Economic Indicators**

Factor	Sierra Leone	Developing Countries	Least Developed Countries
Exports/Imports (% GDP)	56.7	52.4	53.5
Foreign Direct Investment Inflows (% GDP)	5.3	2.0	1.9
Development Assistance Received (% GNI) <sup>a</sup>	13.3	0.3	4.9
Private Capital Flows (% GDP)	- 5.3	-1.3	-2.2
Remittance Inflow (% GDP)	1.58	1.52	4.90

a) GNI = gross national income

38 FAO (2022). Sierra Leone at a Glance. Food and Agriculture Organization of the United Nations.

39 US Department of Commerce (2021). International Trade Administration

40 FAO (2021). Evaluation of FAO's country programme in Sierra Leone. Food and Agriculture Organization of the United Nations.

41 FAO (2019). Aquaculture for food security, livelihood, and nutrition in Sierra Leone. Food and Agriculture Organization of the United Nations.

42 US Department of Commerce (2021). International Trade Administration.

43 This sector is focused on rebuilding post-civil war infrastructure. In 2018 Presidential Infrastructure Initiatives, supervised by the Office of the President, were created to provide leadership, and prioritize vital infrastructure. US Department of Commerce (2021). International Trade Administration

44 US Department of Commerce, (2021). International Trade Administration.

45 World Bank (2020c). Ease of Doing Business Rankings. The World Bank Group.

46 Government of Sierra Leone (2019). Sierra Leone Medium-Term National Development Plan 2019-2023.

## 1.7 Infrastructure

Insight into the infrastructure status and ambitions of Sierra Leone can be gleaned from the Sierra Leone Medium-Term National Development Plan 2019 – 2023.<sup>47</sup> As the plan puts it, “The poor infrastructural landscape in Sierra Leone has had a tremendously negative impact on economic diversification, notably in agriculture, tourism, fisheries, transportation, and services, subsequently limiting economic expansion, foreign direct investment, productivity, and stabilization while creating a regional and global disadvantage.” This view is reinforced by The World Bank, which evaluates the quality of trade- and transport-related infrastructure, in its Logistics Performance Index.<sup>48</sup> The Index showed Sierra Leone to receive a lower score for this indicator than Sub-Saharan countries in general. In 2018 Sierra Leone had a score of 1.82 compared to 2.20 for Sub-Saharan Africa.

The Medium-Term National Development Plan focuses on several key infrastructures for particular attention. These are energy infrastructure, transportation systems (including urban transportation), water infrastructure systems, waste management and ICT. The importance of infrastructure development has been underscored by the President’s creation of a set of short-, medium- and long-term Presidential Initiatives to address infrastructure shortcomings.

**Energy** - As noted above, Sierra Leone has made impressive progress developing domestic electrical generation capacity. However, the supply still falls short of demand. While about 105 MW of generating capacity were connected to the main grid by 2018, the projected demand by 2023 is 260 MW.<sup>49</sup> This value is driven partly by a general increase in demand, but also to recover capacity lost during the civil war years. In total only 26% of the population has access to energy and less than five percent has access to clean cooking

energy.<sup>50</sup> Bioenergy is the most common energy source in the country (80%) which mostly comes from wood and charcoal. A significant increase in electrical generation via hydro power and other renewables (e.g., solar) is anticipated with a goal of it contributing to 65% of the country’s energy by 2023.

**Transport** - The national road system consists of 11,555 km of which about 9% is paved. The total includes about 3,000 km of township roads. The road network is, thus, limited and well below the African average.<sup>51</sup> Urban transportation is mainly road-based, but infrastructure has not kept up with growing demand and existing structures are often in poor repair. Sea and river transport are also areas of potential but are currently underutilized. The passenger volume at Lungi International Airport was 200,000 in 2016. This figure is below the average for the West Africa sub-region.<sup>52</sup> Rail infrastructure is minimal, with the only working line being a privately owned, 200 km-long, narrow-gauge connection between the Tonkolili mines and the port at Pepel.

**Water** - Sierra Leone is blessed with abundant water resources. In addition to its 510 km long Atlantic coastline, there are seven significant rivers which are navigable for part of their lengths. In addition, as discussed above, the rainy season brings between 2,000 mm and 5,000 mm of rainfall, depending on the region of the country. There are also abundant ground water resources throughout most of the country. Even so, access to potable water is not widespread. Only about 48% of the rural population have access to safe drinking water.<sup>53</sup> This is attributed to a combination of sub-optimal planning of water resource use, and obsolete infrastructure for water collection, processing, storage, and distribution. In 2018 the main operational water infrastructure consisted of the Guma Dam, the water supply network for the capital Freetown and seven other urban water supply systems.

47 Government of Sierra Leone (2019). Sierra Leone’s Medium-Term National Development Plan 2019 -2023.

48 World Bank (2018a). Logistics Performance Index. The World Bank Group.

49 Government of Sierra Leone (2019). Sierra Leone’s Medium-Term National Development Plan 2019-2023.

50 IRENA (2021). Energy Profile: Sierra Leone. International Renewable Energy Agency.

51 Government of Sierra Leone (2019). Sierra Leone’s Medium-Term National Development Plan 2019-2023.

52 Ibid.

53 Ibid.

Waste Management – Waste generation in Sierra Leone is high but safe waste disposal mechanisms/systems are “utterly lacking”, according to the Medium-Term National Development Plan. Inadequate and poorly managed sewage systems and landfill sites are a significant challenge, especially in rapidly growing urban areas. This has environmental, health and economic implications. Leaking sewage and landfill can cause contamination of soil and drinking water sources. These can have detrimental effect on health, but also on economic production. Agriculture production can, for example, be impacted by soil and water contamination. There are also lost economic opportunities resulting from a lack of waste management. For instance, recycling can generate revenues. Some investment in sanitation in the provincial cities of Bo, Kenema, and Makeni has improved waste management in these urban centres.

Information and Communication Technologies (ICT) – The Government of Sierra Leone views ICT as an enabling technology that can improve performance across many sectors. Its significance is reflected by the fact that DSTI was created within the Office of the President. The DSTI produced Sierra Leone’s first National Innovation and Digital Strategy in 2019.<sup>54</sup> However, infrastructure is lacking. A country diagnostic by the World Bank on the state of the digital economy in Sierra Leone showed a poor performance of digital infrastructure in the country. The authors of the report argued that the country was experiencing enormous challenges in this domain, compared to its regional peers.<sup>55</sup>

Sierra Leone’s overall Mobile Connectivity Index Score was 38.6 in 2019 and was on par with the score for Sub-Saharan African countries (37.6).<sup>56</sup> The mobile infrastructure score was poor in Sierra Leone and worse than in Sub-Saharan African countries, or 33.3 in 2019

versus 40.1 for other Sub-Saharan countries. Network coverage, was, in 2019, also slightly worse for Sierra Leone (50.3) than for Sub-Saharan African countries (57.1). The 4G coverage has been increasing steeply in Sierra Leone since 2017 and is on par with the coverage in Sub-Saharan countries in general (42 for Sierra Leone versus 45.1 for Sub-Saharan countries). The affordability score was low for Sierra Leone (39) as it was for Sub-Saharan countries in general (35.2). The gender gap in mobile ownership was much worse for Sierra Leone (13.6) than for Sub-Saharan countries in general (51.8) indicating that most women do not have access to mobile phones.

Internet use in Sierra Leone is quite limited, with only 9% of the population making use of this technology in 2018.<sup>57</sup> The average internet use in developing countries for the same year was 43.4%, while it was 18.2% for least developed countries.

Finally, it is important to note that availability and usefulness of ICT infrastructure is tied to other services such as availability and stability of electricity. Thus, there is synergy among a number of the infrastructure categories described in this section.

## 1.8 Education and Skills

Sierra Leone’s allocation to education as a percentage of its GDP has been increasing. It was 2.6% in 2010 but had reached 7.1% in 2018.<sup>58</sup> This is a higher proportion than in Sub-Saharan African countries (4.7%) and in least developed countries (3.1%). There is compulsory education for six years at the primary level and three years at the secondary level, but many students do not go to school. The mean years of schooling in 2019 for men was only 4.5 years, but was even lower for females, or 2.9 years.<sup>59</sup> In comparison, the mean years of schooling was 5.8 years for males in least developed countries and 4.1 years for females.

54 DSTI (2019a). Sierra Leone’s National Innovation and Digital Strategy 2019.

55 World Bank (2020d). Digital Economy Diagnostic: Sierra Leone,

56 GSMA Mobile Connectivity Index.

57 ITU (2020a). ICT Facts and Figures 2020. (International Telecommunication Union) Available at: [www.itu.int/en/ITU-D/Statistics/Pages/stat/](http://www.itu.int/en/ITU-D/Statistics/Pages/stat/)

58 UNDP (2020b). Human Development Report – Data Centre. Government Expenditure on Education (% GDP). United Nations Development Programme.

59 UNDP (2020c) Human Development Report Data Centre. Expected years of schooling. United Nations Development Programme.

According to UNESCO, the literacy rate in the population 15 years of age and above in Sierra Leone was 43.2% in 2018.<sup>60</sup> This is low compared to developing countries (84%) and also compared to least developed countries (64.4%). The UNDP lists the educational index for the country as 0.406 in 2019, which is on par with Sub-Saharan countries (0.429).<sup>61</sup> The skilled labour force in Sierra Leone is small, or about 15.2% of the population based on 2010 to 2019 data.<sup>62</sup> This compares to 33.9%, on average, for developing countries and to 19.6% for least developed countries, on average. The same source shows that 11.2% of youth (15 to 24 years of age) are not in education, employment, or training (NEET).<sup>63</sup> All of these indicators suggest that improving education should be a priority for Sierra Leone and attention needs to be paid to women receiving education and preparing them for the labour force.

“Education is the bedrock of long-term sustainable growth and the transformation of the economy of Sierra Leone.”<sup>64</sup> This statement echoes the subtitle of Sierra Leone’s Medium-Term National Development Plan, which is “Education for Development”. Education is, thus, strongly centred in the nation’s ambitions.

The core structure of the Sierra Leone education system is three years of pre-school (Kindergarten 1 – 3), six years of primary, three years of junior secondary, four years of senior secondary and four years for an undergraduate university degree.<sup>65</sup>

Primary and Secondary Enrolment and Completion - Available data about student participation in, and completion of, primary and

secondary education is ambiguous. While the expected number of years of schooling is fairly high at around 10, the mean number of years of schooling (2019 data) is just 3.7.<sup>66, 67</sup> While enrolment in all levels has increased over time, many children do not commence school at the official primary start age (6 years) and about 10% of primary school-aged children are not enrolled.<sup>68</sup> Completion rates have also been said to have improved. In 2016 the primary completion rate was reported as 74% and that for junior secondary was 61%.<sup>69</sup> However, in 2019 UNESCO reported a 75.8% dropout rate as a fraction of the primary school cohort.<sup>70</sup>

At the secondary level, according to UNESCO, gross secondary enrolment as a percentage of the appropriate age cohort was 42% in 2019.<sup>71</sup> The same source states that 25.6% of the over 25 population has at least some secondary education.

Tertiary and Higher Education Sector – There are two public sector universities in Sierra Leone – the University of Sierra Leone (USL) and Njala University.<sup>72</sup> USL is the oldest university in west Africa, dating its founding to 1827. It has several constituent colleges including the Fourah Bay College, the Institute of Public Administration and Management and the College of Medicine and Allied Health Sciences.<sup>73</sup> There are also two public polytechnics, two public teachers’ colleges and two public technical colleges. In the 2011/2012 academic year, the total enrolment in public tertiary institutions was just over 31,000.<sup>74</sup>

There is also a private higher education sector in Sierra Leone<sup>75</sup> with one private university (the University of Makeni) and 23 private

60 UNESCO (2020). Institute for Statistics Data Centre. United Nations Educational, Scientific and Cultural Organization.

61 UNDP (2020a). Human Development Report Country Profile, Sierra Leone.

62 ILO (2020). ILOSTAT database. International Labour Organization.

63 Ibid.

64 Government of Sierra Leone (2019). Sierra Leone’s Medium-Term National Development Plan 2019-2023.

65 Government of Sierra Leone (2018). Sierra Leone Education Sector Plan 2018-2020.

66 Expected years of schooling is defined as the number of years of schooling that a child of school entrance age can expect to receive if prevailing patterns of age-specific enrolment rates persist throughout the child’s life. UNDP Human Development Report Country Profile, Sierra Leone

67 UNDP (2020a). Human Development Report Country Profile, Sierra Leone

68 Government of Sierra Leone (2018). Sierra Leone Education Sector Plan 2018-2020

69 Ibid.

70 UNESCO (2020) Institute for Statistics. Data Centre. United Nations Educational, Scientific and Cultural Organization.

71 Ibid.

72 Government of Sierra Leone (2018). Sierra Leone Education Sector Plan 2018-2020.

73 USL. The University of Sierra Leone Homepage.

74 Government of Sierra Leone (2018). Sierra Leone Education Sector Plan 2018-2020.

75 Republic of Sierra Leone Higher and Tertiary Education Sector Policy Note, World Bank Report Number ACS4393, 2013

colleges. The private colleges are often sector specific, offering training in subjects like business administration, travel and tourism, information technology, theology, and several other specialized fields.<sup>76</sup>

The fully accredited universities and constituent colleges together with the institutions offering affiliated degrees offer in excess of one hundred first degree programmes and close to that number in Master's programmes.<sup>77</sup>

While the secondary school system graduates many individuals each year who are academically qualified to continue to tertiary education (e.g., about 28,500 in 2016/2017), the number who actually continue is substantially smaller.<sup>78</sup> The explanation is mainly the cost to the individual of studying beyond the secondary education level. The government has introduced student loan supports, but this creates additional pressure on access to institutions which already struggle to accommodate successful applicants.<sup>79</sup>

Resources and Outcomes – Issues of educational outcome have been flagged in the Medium-Term National Development Plan which expresses concerns with quality of education at all school levels.<sup>80</sup> School completion rates remain low – especially for girls<sup>81</sup> – and there are equity issues of variable access and outcomes across national regions and for students with disabilities. Some of these challenges are attributed to the teaching force, but data show that class sizes are large, which may also play a role. For example, the national average of pupil-to-teacher ratio for primary level classes is 61-to-1.<sup>82</sup> Additional resource factors such as percentage of schools with internet access (1% for primary 4% for secondary) no doubt also play a role in limiting student achievement.<sup>83</sup>

The conditions in higher learning institutions are described as “deplorable” in the Medium-Term National Development Plan. The document states that they “lack basic modern facilities for scientific research, innovation, and technological development, and are poorly financed.”<sup>84</sup> It is further suggested that the quality of teacher training does not meet the needs of the educational sector and that the curricula of the tertiary, technical and vocational institutions are not well aligned with the needs of the Sierra Leone society or economy.

## 1.9 COVID-19

COVID cases were detected in Sierra Leone early in the pandemic, with the first case being identified on 31<sup>st</sup> of March 2020.<sup>85</sup> Since then the official case count has been relatively low with around 7,770 cases being identified by the 25<sup>th</sup> of February 2022 and 125 deaths.<sup>86</sup> In early February 2022, close to 152,000 vaccine doses had been administered in the country. Assuming everyone needs two doses of vaccine, the vaccination rate is less than 8% of the population.

The government responded swiftly to the COVID pandemic and even before the first case was identified the President declared, on 24<sup>th</sup> of March 2020, a public health emergency.<sup>87</sup> The government imposed a partial lockdown, including temporary night curfew, policies of social distances and a ban on inter-district travel. The government also set up a screening system at the international airport and other border crossings for travellers and required travellers to quarantine. The government has been reluctant to impose an extended lockdown because of concerns about the negative economic consequences. It has, however, closed schools for extended periods and attempted to educate students through distance learning.

76 Republic of Sierra Leone (2013). Higher and Tertiary Education Sector Policy Note, World Bank Report Number ACS4393, 2013.

77 Government of Sierra Leone (2018). Sierra Leone Education Sector Plan 2018-2020.

78 Ibid.

79 Ibid.

80 Government of Sierra Leone (2019). Sierra Leone's Medium-Term National Development Plan 2019-2023.

81 Women account for only about 39% of tertiary students, although this number has been trending upward. The gender disparity is less pronounced in the universities compared to the polytechnics. Sierra Leone Education Sector Plan 2018-2020.

82 Government of Sierra Leone (2019). Sierra Leone's Medium-Term National Development Plan 2019-2023.

83 UNDP (2020a). Human Development Report Country Profile, Sierra Leone.

84 Government of Sierra Leone (2019). Sierra Leone's Medium-Term National Development Plan 2019-2023.

85 WHO (2020). Sierra Leone confirms first case of COVID-19. World Health Organization.

86 WHO (2022). Sierra Leone. COVID-19 Situation. World Health Organization.

87 UNDP (2020d). UNDP Sierra Leone: Support to the National Response to Contain the Impact of COVID-19, United Nations Development Programme.

The government response also developed the COVID-19 Health Sector Preparedness and Response plan, which focus on five strategies: 1) To strengthen surveillance; 2) Provide facilities for isolation/quarantine; 3) Set up testing; 4) Clinical case management; and 5) provide communication to encourage social mobilisation for behavioural change.<sup>88</sup> One of the lessons from the 2014-2015 Ebola outbreak was that it was important to encourage trust in the health system and, together with the United Nation's Children Fund (UNICEF), the authorities have engaged in an outreach campaign providing education about the disease and prevention approaches.<sup>89</sup>

To coordinate the government's response to COVID the government set up the National COVID-19 Emergency Response Centre (NaCOVERC) which has district offices around the country. The Sierra Leone government also developed a plan to mitigate the economic impact of the pandemic, the Quick Action Economic Recovery Programme (QAERP).<sup>90</sup> <sup>91</sup> The United Nations agencies in Sierra Leone developed the Socio-Economic Response Plan (SERP) to support the government's responses to COVID. The objective is to mitigate the socio-economic impact of the pandemic and try to address pre-existing and underlying conditions for social and economic challenges of COVID.

Several international partners have financially supported the COVID responses in Sierra Leone. The World Bank provided Sierra Leone initially with US\$5 million to strengthen Sierra Leone's emergency preparedness and strengthen the national health system in the country.<sup>92</sup> It recently has, together with its partners, provided an additional US\$18.1 million grant focused on vaccination of the population. The EU also supported Sierra Leone early on with US\$5 million

for various activities including equipping and managing three new isolation and containment centres; supporting contact tracing and providing hand cleaning supplies, masks etc to public health units.<sup>93</sup> The Islamic Development Bank, through UNICEF, has supported Sierra Leone with supplies and equipment to strengthen COVID case management.<sup>94</sup>

The Women Entrepreneurs Finance Initiative is funding women entrepreneurs in Sierra Leone through the Islamic Development Bank. The project is focused on addressing the challenges of women-led small and medium sized firms (SMEs), created by the COVID-19 crisis.<sup>95</sup> It also encourages innovation and digital development aimed at women entrepreneurs. The International Fund for Agricultural Development (IFAD) made special efforts early on in the pandemic to strengthen local food production with US\$6.4 million funding.<sup>96</sup>

During the Ebola outbreak schools were closed in Sierra Leone for months, which had detrimental effects on children's education and resulted in girls disproportionately dropping out of school. This was one of the lessons that Sierra Leone could apply from the Ebola crisis, so just a week after the closure of schools because of COVID, radio lessons started in order to continue the delivery of education. This was supported by a multi-donor initiative including the International Development Association (IDA), United Kingdom's Foreign, Commonwealth and Development Office, Irish Aid, and the European Union (EU).<sup>97</sup>

The pre-COVID GDP growth rate in Sierra Leone was 5.5% in 2019, but with COVID it plunged to minus 2.2% in 2020 with economic activities reducing sharply.<sup>98</sup> The GDP growth in Sierra Leone did recover to 3.2% in 2021 and

88 Showers, W. and Ganson, B. (2020). United Nations COVID-19 Socio-Economic Response Plan for Sierra Leone. International Growth Centre. COVID-19-20144-SLE-1. Available at: <https://www.theigc.org/wp-content/uploads/2021/04/Showers-et-al-October-2020-Final-report.pdf>.

89 UNICEF (2021a). Sierra Leone Humanitarian Situation Report No. 3. United Nations Children Fund.

90 Grieco, K and Yusuf, Y. (2020). Sierra Leone. COVID -19 Series: Working Paper.

91 Showers, W. and Ganson, B. (2020). United Nations COVID-19 Socio-Economic Response Plan for Sierra Leone

92 World Bank (2022b). Sierra Leone COVID-19 Emergency Preparedness and Response Project.

93 Grieco, K and Yusuf, Y. (2020). Sierra Leone. COVID -19 Series: Working Paper.

94 UNICEF (2021b). The IsDB and UNICEF handover supplies and equipment to strengthen COVID-19 response in Sierra Leone.

95 IsDB (2020). Islamic Development Bank receives funding from the Women Entrepreneurs Finance Initiative to invest in supporting women-led businesses amidst COVID-19 crisis

96 Showers, W. and Ganson, B. (2020). United Nations COVID-19 Socio-Economic Response Plan for Sierra Leone.

97 World Bank (2021). Protecting Children from Learning Loss in Sierra Leone. The World Bank Group. July 7, 2021. The World Bank Group.

98 IMF (2022). Real GDP Growth, Annual Percentage Change. International Monetary Fund.

is expected to increase to 5.9% in 2022. The recovery is partly fuelled by growth in the mining sector.<sup>99</sup> According to the International Monetary Fund (IMF), the negative impacts of COVID on Sierra Leone have been far reaching and include shrinking incomes, rising poverty, inequality, and worsening food insecurity.<sup>100</sup> The IMF has approved a US\$50 million loan to support the government's response.

While Sierra Leone has shown some success in managing the COVID pandemic and reducing the spread of the disease, its social and economic costs have been substantial in the country and call for ongoing extra efforts in addressing these. There has been some learning applied from the Ebola outbreak in 2014-2015 which emphasised grounding efforts in the local communities.

## 1.10 Development Agenda

The Government of Sierra Leone presented its top strategic development priorities in its Medium-Term National Development Plan.<sup>101</sup> For the period 2019 – 2023, the Government's top priority is human capital development. It also emphasizes food security and health. There is a particular emphasis on education with a commitment to free quality school education to "enhance human capital development and to facilitate the transformation of the economy."<sup>102</sup>

In addition to the priorities noted above, the Government has articulated four key national goals:

Goal 1. A diversified, resilient green economy.

Goal 2. A nation with educated, empowered, and healthy citizens capable of realizing their fullest potential.

Goal 3. A society that is peaceful, cohesive, secure, and just.

Goal 4. A competitive economy with a well-developed infrastructure.

The current National Development Plan recognizes that earlier efforts were limited, in part, due to a lack of attention to sector coordination. This resulted in duplication of some key functions, while leaving gaps in others. It also notes misalignment between national development activities and regional and global frameworks such as the Mano River Union Strategy, the African Union Agenda 2063, the United Nations 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs), and the New Deal Peacebuilding and Statebuilding Goals. The current National Development Plan intends to avoid these pitfalls.

The national goals mentioned above are supported by a set of policy clusters (see Table 2). These represent seven thematic areas, with an eighth being focused on implementation.

Table 2. Policy Clusters of the Government of Sierra Leone

Policy Cluster Number	Theme
1	Human capital development
2	Diversifying the economy and promoting growth
3	Infrastructure and economic competitiveness
4	Governance and accountability for results
5	Empowering women, children, and persons with disability
6	Youth employment, sports, and migration
7	Addressing vulnerabilities and building resilience
8	Plan implementation

Source: Government of Sierra Leone (2019).

99 Borgen Project (2021). COVID-19'S IMPACT ON SIERRA LEONE. The Borgen Project.

100 IMF (2021). IMF Executive Board Approves US\$50 million Disbursement to Sierra Leone to Address the Continuing Impact of the COVID 19 Pandemic. Press release number 21/69.

101 Government of Sierra Leone (2019). Sierra Leone's Medium-Term National Development Plan 2019-2023.

102 Here, school education refers to basic and senior secondary levels.

Overall, the goals and policy clusters of the National Development Plan prioritize a mix of economic and social development issues. While there is an emphasis on strengthening governance and addressing accountability issues such as corruption and illicit financial flows, there is also a strong focus on education as a path to economic development and empowerment of currently under supported groups (e.g., women and girls, persons with disabilities).

Economic diversification (e.g., enhancing commercialization in agriculture, building a stronger fishery and marine sector, revitalizing tourism, exploring new energy sources such as solar, improving management in the oil/gas/mineral sectors, etc.) is also prominent in the plan, as is infrastructure improvement. There is also an underlying ambition to promote private sector growth. All of these efforts are tied to improving the overall life of the citizens of Sierra Leone.

Each of the policy clusters is supported by a number of sub-goals. Each of these, in turn, is supported by a strategic objective statement, a set of key targets and a set of policy actions. For example, sub-goal 1.2 in policy cluster 1 is “Strengthening tertiary and higher education”. The strategic objective here is to “increase equitable access to quality higher education that promotes research, innovation, and entrepreneurship for growth, stability, and national development.” The sub-goal is supported by four key targets (e.g., “By 2023, improve the quality of research and academic excellence at tertiary levels.”) and 15 key policy actions (e.g., “Establish the Directorate for Science, Technology, and Innovation, initially anchored within the Office of the President.”).

An interesting feature of Sierra Leone’s development agenda is its emphasis on digitization/ICT as enabling technologies. As noted in the previous paragraph, one of the supporting actions for strengthening tertiary and higher education was the creation of DSTI. This Directorate was established in 2018 and in 2019 it published a National Innovation and

Digital Strategy to cover the years to 2029.<sup>103</sup> The Strategy is meant to “guide national transformation through science, technology and innovation; research; and capacity development over the medium to long term”.

The Medium-Term National Development Plan refers, in several places, to the sustainable development goals (SDGs) and the importance of activating civil society organizations and the private sector to achieve them. In the newest Sustainable Development Report from 2020, progress towards achieving SDGs is tracked for each country.<sup>104</sup> The report measures a country’s total progress towards achieving all 17 SDGs. Sierra Leone’s overall SDG score is 51.91. The low overall score reflects that Sierra Leone still has a way to go to achieve the SDGs. This is also reflected in the ranking where Sierra Leone ranks 153 out of 193 countries in its progress towards achieving the SDGs.

While Sierra Leone’s has improved on “climate change”, “life on land” and “partnerships for the goals”, it has declined for “sustainable cities and communities”. On “zero hunger”, “quality education”, “clean water and sanitation” and “decent work and economic growth” the trend has been moderately improving. A further seven SDGs (“no poverty”, “health and well-being”, “gender equality”, “affordable and clean energy”, “industry, innovation and infrastructure”, “life below water” and “peace, justice and strong institutions”) have all been stagnant, while two (“reduced inequalities” and “responsible consumption and production”) have no trend data available. Many of these challenges are discussed in the Medium-Term National Development Plan, so there is alignment between national planning and the SDGs. However, the lack of progress towards achieving the SDGs underscores the importance of promoting the national development agenda.

In general, Sierra Leone still has a way to go to graduate from LDC status.<sup>105</sup> It has not reached the threshold GNI per capita value for graduation, which is \$1,222 or higher. In 2021 the GNI for Sierra Leone was \$532. Sierra Leone also

103 Government of Sierra Leone (2019). Sierra Leone’s National Innovation and Digital Strategy 2019.

104 Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G., Woelm, F. (2020). The Sustainable Development Goals and COVID-19. Sustainable Development Report 2020. Cambridge: Cambridge University Press.

105 UNDESA (2021). The Least Developed Country Category: 2021 Country Snapshots. Department of Economic and Social Affairs of the United Nations Secretariat.

needs to reach the threshold for Human Assets Index (HAI), which is 66 or higher for graduation. The HAI value in 2021 for Sierra Leone was 41.7. Sierra Leone also needs to make progress in its Economic and Environmental Vulnerability Index (EVI), which was 40.3 but needs to be 32 or lower for graduation.

## 1.11 Conclusion

Sierra Leone seeks a future where all of its citizens enjoy a high standard of living, have access to excellent education and strong health services within a well-functioning economy. Key priorities include development of human capital with a particular focus on improved access to quality education, food security, and improved health outcomes. These will be achieved through actions to improve the economy, enhance infrastructure and to strengthen governance and accountability. There is a particular emphasis on digitization as a set of enabling technologies. The Sierra Leone national plans align with the UN Sustainable Development Goals.

Challenges that face Sierra Leone in its pursuit of these ambitions include weak management/governance systems, infrastructure in need of repair and modernization, significant levels of food insecurity and an educational system of uneven quality which is not fully aligned with the needs of the country.



# **CHAPTER 2**

## **Science, Technology, and Innovation in Sierra Leone**

This chapter provides an overview of the Science Technology and Innovation (STI) system in Sierra Leone. Because a field visit to the country could not be undertaken to collect information, it has drawn mainly from publicly available sources. The secondary data were collected through a systematic review of policy documents. Furthermore, other published reports and materials were consulted to understand recent trends and developments in STI in the country.

## 2.1 Promoting STI in Sierra Leone

### 2.1.1 Brief history of promoting STI

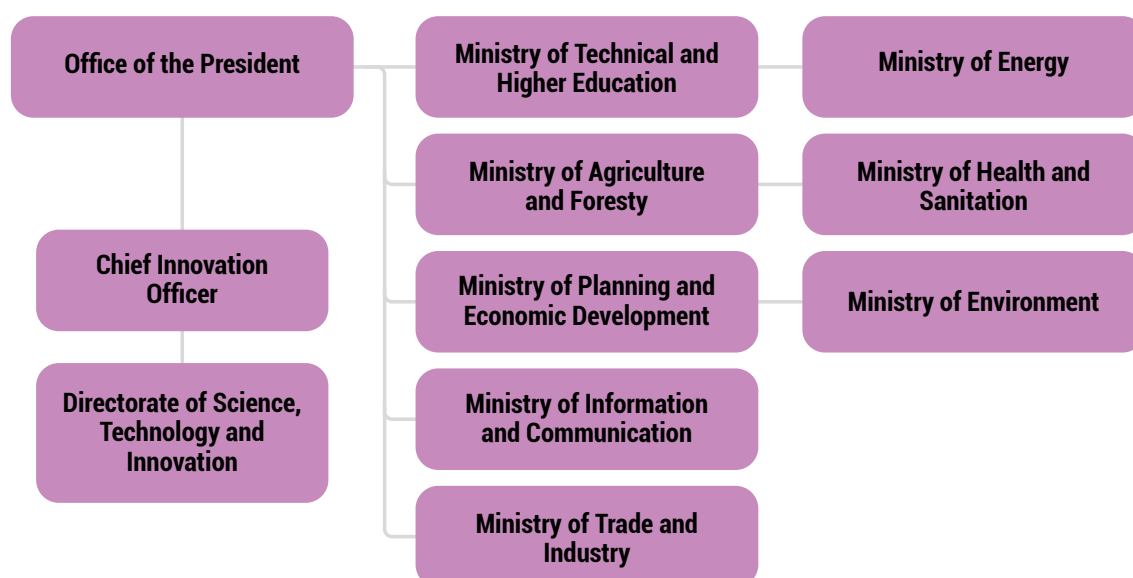
Sierra Leone has a long history of promoting higher education. In 1827 the Fourah Bay College was established as a missionary school.<sup>1</sup> It was the first Western-type higher education institution in West Africa and attracted students from across the region. Sierra Leone also has a long history of research. It opened the Njala Experimental Station in 1910 for agronomic research.<sup>2</sup> In 1934, the Rice Research Station was established. With time, more institutions were established in livestock research, oil palm

research, forestry research and fisheries research. These early institutions have been amalgamated and several of them formed the Sierra Leone Agricultural Research Institute (SLARI), established in 2007.

More recently there has been an evolution of institutions promoting STI in the country. Governmental ministries tasked with promoting STI have changed names and mandates. In 2006, the Ministry of Education, Science and Technology was responsible for promoting STI in the country but now promoting STI has been split among different ministries and institutes (Figure 2.1). On the higher education side, the Ministry of Technical and Higher Education is in charge.

In 2018, a new directorate, DSTI was created. As shown in Figure 2.1 below, DSTI is housed in the Office of the President and executes its functions under the direction of the Chief Innovation Officer, who is also the Minister of Basic and Secondary Education. The vision of DSTI is: “To use science, technology and innovation to support the Government of Sierra Leone to deliver on its national development plan effectively and efficiently; and to help transform Sierra Leone into an innovation and entrepreneurship hub.”<sup>3</sup>

Figure 3. Institutions with strong STI mandates



1 Paracka, D. (2004). The Athens of West Africa: A History of International Education at Fourah Bay College.

2 Momoh, J. (2014). Assessment of Agricultural Research Capacities in Sierra Leone: The Case of Sierra Leone Agricultural Research Institute (SLARI).

3 DSTI. Directorate of Science, Technology, and Innovation. About.

DSTI is expected to support the different Ministries to better utilise science and technology to deliver their goals. To coordinate its efforts, DSTI has also set up an Inter-Governmental Advisory Board. This board is composed of senior government officials from across the various ministries, parliament, and the justice department. Their role is to support and act as enablers of DSTI initiatives. This is crucial because STI by its nature is cross-cutting. Another structure is the Citizen's Advisory Group. The role of this group is to play a consultative role and generate ideas that are grounded in the community. It is made up of members from the private sector and civil society including the informal sector, creative arts, youth, and students. Since these stakeholders will be impacted by the activities supported by DSTI, they are expected to play an important role in supporting its vision.<sup>4</sup> These two boards are critical elements of the governance structure and are intended to promote inclusivity of all the key stakeholders in society.

Among its key partners, DSTI lists UNICEF, Bill and Melinda Gates Foundation, Tony Blair Foundation for Global Change, Ministry of Finance and Statistics Sierra Leone.

## 2.1.2 Policies and other tools to promote STI

### Science and technology policy focus

There is no explicit policy in Sierra Leone aimed at promoting STI in general. There is also no specific government funding that has been established to support research and development activities. The government does, however, provide funding to its public universities and it funds research and development in agriculture.<sup>5</sup>

In its Medium-Term National Development Plan, 2019-2023, there are some mentions of STI related issues.<sup>6</sup> As discussed in Chapter 1, the government's top priority is human capital development, which includes a focus on higher education. In the Plan there is a specific policy

action to improve support for teaching of STI and to expand research output at universities. The establishment of DSTI is also listed as a specific policy action to promote STI. More generally, the Plan addresses a mix of social and economic issues. Its goals to diversify the economy and promote growth and enhance infrastructure and economic competitiveness, can include a strong STI focus. The plan, for instance, discusses the intention to implement science-based management of fisheries to restore fish stocks from overfishing, and to, thereby, strengthen the sector. The Medium-Term plans also recognizes ICT as an enabling technology that can be applied widely in society. It announces that the focus of the government will be on: "Building a digital economy and leveraging ICT tools to stimulate growth in all sectors of the economy." The Plan, for example, discusses the intent to enhance health management through digitalization of health care systems and processes.

As a follow up to the Medium-Term Plan, DSTI developed the National Innovation and Digitalisation Strategy (NIDS) for 2019-2029. The ultimate goal of NIDS is to guide "Sierra Leone's investment policies, and governance frameworks for the country's present and future development."<sup>7</sup> The aim of the NIDS is to promote digitization for all, which includes increasing the use of digital identity; promoting digital economy; and digital governance.

NIDS identifies both short-term (2-3 years) and Medium-Term (3-5 years) activities. The short-term items are the following:

- Rolling out national digital identities to maintain digital identities for 90% of youth and adult citizens;
- Promoting a platform for artificial intelligence (AI) and data science research to strengthen governance and solve development and humanitarian challenges, particularly those related to the achievement of the SDGs and the Medium-Term National Development Plan;

4 DSTI. Directorate of Science, Technology, and Innovation. Advisory Boards.

5 ASTI (2017). Agricultural R&D Indicators Fact Sheet: Sierra Leone. Agricultural Science and Technology Indicators. The International Food Policy Research Institute.

6 Government of Sierra Leone (2019). Sierra Leone's Medium-Term National Development Plan (2019–2023): Education for Development.

7 DSTI (2019a). Sierra Leone National Innovation and Digital Strategy 2019 – 2029. Directorate of Science, Technology, and Innovation.

- Build infrastructure to improve access to internet connectivity and address low internet penetration. This will include setting up a legal framework and hybrid systems;
- Enhance security to ensure cyber security and quantum computing with state-of-the-art encryption methods and information standards;
- Promote entrepreneurship and societal development across universities, government spaces and private enterprises. Create spaces for the best students to access capacity, tools and resources and transform the country into an innovation nation and
- Create organisational architecture to establish new institutions to support digital development such as the Information System Authority and an institution for data protection.

The authors of the document concede that it is intentionally high-level and more in-depth implementation plans will be developed for particular sectors over the medium and long term.

In the Medium-Term the roadmap for the DSTI is to undertake:

- Ecosystem mapping and strengthening;
- Build standards, tools, and metrics for data systems;
- Enhance access to service delivery and digital solutions.

NIDS is in its early stage, so it is premature to talk about its implementation. It is, however, clear that DSTI has identified digitalisation as its strategic technology area.

In late 2021 stakeholders from government, the private sector, academia, and civil society validated a draft National Digital Development Policy (NDDP) developed by the Digital Impact Alliance (DIAL) and the Ministry of Information and Communications.<sup>8, 9</sup> The policy has not yet been released, but an accompanying National Digital Development Strategy has also been drafted. These documents aim to present a coordinated, cohesive approach for a clear digital transformation agenda and promote the development of a vibrant ICT sector. They are

based on consultations with ministries' departments and government agencies, development partners, civil society organisations, academia, service providers and representatives of the private sector. The main categories of activities the documents propose are:

- Promoting governance, coordination, and partnerships to create an enabling environment that supports digital development efforts between different actors in society and across pillars.
- Building digital infrastructure and access to ensure reliable, fast, and affordable digital connectivity; provide an enabling environment and regulation for viability of investment; and foster affordability and uptake among users.
- Enhancing digital skills and human capital development by facilitating the enabling connectivity infrastructure and capacity building in the education sector; mainstreaming ICT skills across formal and non-formal education channels, and further including women; and developing a digital savvy workforce.
- Strengthening digital government where e-government is enabled by increasing administrative efficiency in the public sector with ICT; and developing e-services for businesses and citizens.
- Promoting e-commerce and digital financial services by widening the participation in e-commerce of companies and users to increase the competitiveness of industries; and enhance the digital financing services environment, competition, efficiency, and adoption to further drive financial inclusion.
- Fostering emerging technologies, innovation, and digital entrepreneurship by supporting tech-enabled research and innovation; supporting the digitisation of local industries; fostering knowledge sharing in the ecosystem; and nurturing digital entrepreneurship.
- Strengthening data governance and cybersecurity by increasing awareness and capacity in cybersecurity; deterring and preventing cybercrimes; protecting users and data in cyberspace; and enhancing data sharing and re-use.

<sup>8</sup> FAAPA (2021). Government yesterday introduced its National Digital Transformation Strategy.

<sup>9</sup> MIC (2021). Sierra Leone National Digital Development Strategy - Draft.

To further strengthen cybersecurity the government issued in 2020 the Cybercrime Act which clarifies what are punishable cybercrime offenses and tries to make the digital environment secure in the country.<sup>10</sup>

The Government of Sierra Leone has presented a clear message that it considers digital development to be important for the country and is promoting various strategies to promote it.

### Intellectual property rights focus

Intellectual property rights (IPR) policies and laws can influence STI development. Sierra Leone has a rather recent history in establishing laws and frameworks to protect intellectual property. There are three main intellectual property legislations currently in the country. In 2011, a Copyright Act was legislated; the Patents and Industrial Design Act was legislated in 2012; and the Trademarks Act was legislated in 2014. Prior to 2012 patent applicants in Sierra Leone had to register the patent in the United Kingdom as the legal and institutional infrastructure was non-existent locally. Sierra Leone joined the World Intellectual Property Organization (WIPO) in 1986.<sup>11</sup> The country signed the Paris Convention for the Protection of Industrial Property and the Patent Cooperation Treaty in 1997. Sierra Leone has been a member of the World Trade Organization (WTO) since 1995 and signed the amended the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement in 2017.<sup>12, 13</sup>

While there are some gaps in the IPR system in Sierra Leone, it has relatively modern IP laws. According to a review from DSTI, the challenge of the country's IPR system is lack of clarity in the laws on how they should be administered and enforced.<sup>14</sup> This can challenge innovation activities in the country.

This review on STI policies is not meant to be a complete review of all policies that can shape STI in the country. Rather, it provides examples of some recent initiatives on this front. The review shows that there are gaps in the policy landscape to promote STI in Sierra Leone. There are, for example, no specific policies aimed to promote STI in general. It is clear there are recent efforts in formulating laws and policies meant to promote technology development and innovation. Time will tell how effective they are likely to be in steering further STI development in the country.

## 2.2 Current State of Affairs of STI in Sierra Leone

### 2.2.1 Production in Science

The production of peer reviewed science publications is a measure of the scientific output of a country. As shown in Table 3<sup>15</sup> below, the scientific output of Sierra Leone is low. The data compare the volume of publications in Sierra Leone with several comparator countries in West Africa. The trend shows that between 2015-2019, the number of publications

Table 3. Volume of Scientific Publications in Selected West African Countries.

Country	2015	2016	2017	2018	2019
Togo	144	141	133	181	197
The Gambia	160	163	177	136	180
Niger	161	154	145	171	177
Sierra Leone	98	133	139	134	141
Guinea	98	119	129	91	118
Liberia	45	63	66	80	88

Source: UNESCO Science Report, 2021

10 Government of Sierra Leone (2020). The Cybercrime Act.

11 WIPO. Sierra Leone. World Intellectual Property Organization.

12 WTO. Sierra Leone and the WTO. World Trade Organization.

13 WTO. Amendment of the TRIPS agreement. World Trade Organization.

14 DSTI (2019b). Intellectual Property in Sierra Leone: Status, Prospects and Policy Recommendations. Directorate of Science, Technology, and Innovation.

15 UNESCO (2021). UNESCO Science Report 2021: The Race Against Time for Smarter Development. United Nations Education, Scientific and Cultural Organization.

increased from 98 to 141, an increase of 43%. While this increase might sound impressive, it started from a low publication base. After the initial increase from 98 publications in 2015 to 133 in 2016, the subsequent rate of increase was modest.

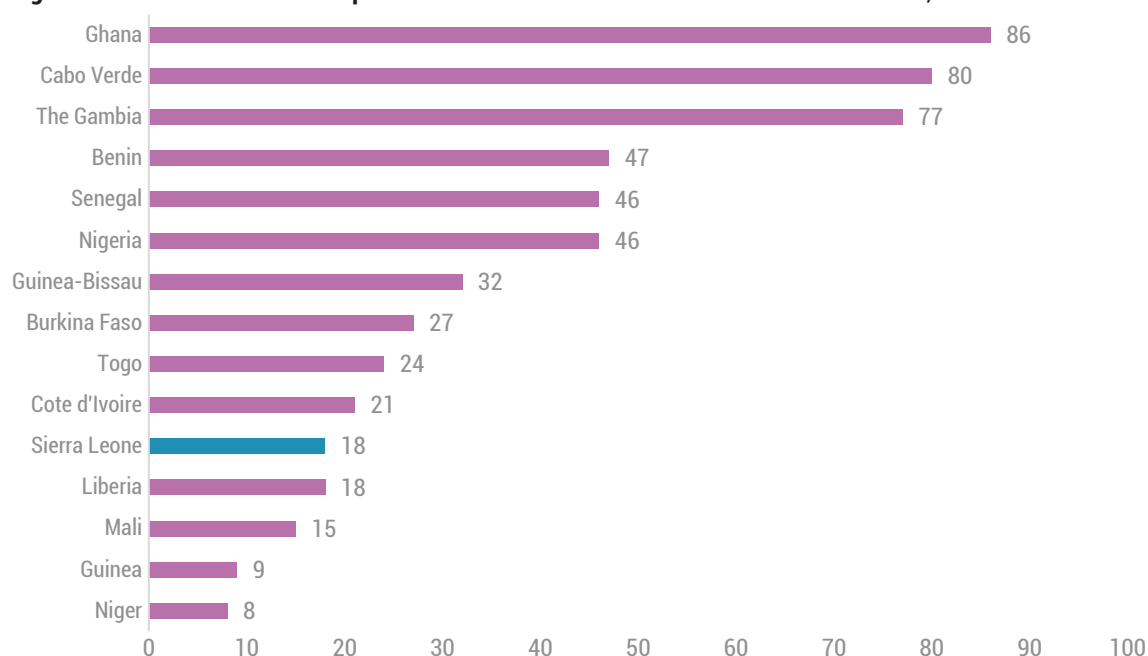
Sierra Leone's publications per million persons is also low as illustrated (Figure 4). The country is ranked eleventh/twelfth out of fifteen countries in West Africa. Note that Sierra Leone and Liberia have the same number of publications per million inhabitants.

Most of Sierra Leone's scientific publications are in health sciences (Figure 5). This can be partly attributed to the Ebola outbreak which hit

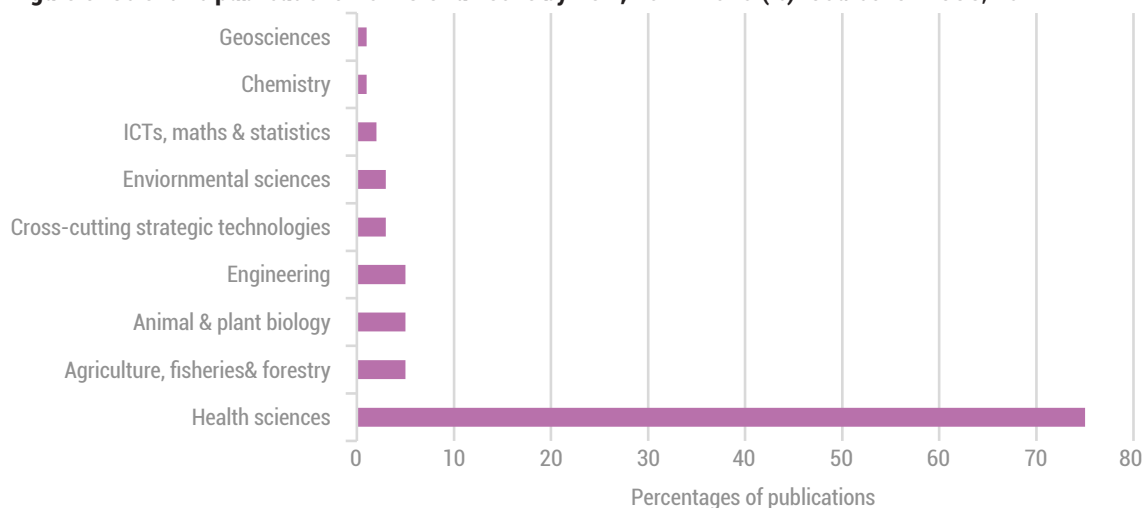
the country in 2014. To address the outbreak, the global community responded by conducting research on the epidemic, with collaborators in Sierra Leone. As a result, health research on the Ebola virus increased by researchers in Sierra Leone who collaborated with researchers from high income countries.

The number of publications in all other scientific fields is low. One of the fields in Figure 5<sup>16</sup> is 'Cross-cutting strategic technologies'. This field refers to strategic technologies that encompass artificial intelligence and robotics, bioinformatics, biotechnology, blockchain technology, energy, Internet of Things, materials, nanoscience and nanotechnology,

**Figure 4. Scientific Publications per million inhabitants in West Africa.** Source: UNESCO, 2021



**Figure 5. Scientific publications from Sierra Leone by field, 2017-2019 (%).** Source: UNESCO, 2021



<sup>16</sup> UNESCO (2021). UNESCO Science Report 2021: The Race Against Time for Smarter Development. United Nations Education, Scientific and Cultural Organization.

opto-electronics, and photonics and strategic, defence and security studies. Only three percent of the Sierra Leonean publications are in 'Cross-cutting strategic technologies.' In addition, two percent of the publications are in 'ICT, math & statistics'. Both of these fields are important for digital development. If Sierra Leone is going to fulfil its objective of building a digital economy, more research in these fields is needed.

International collaboration is important for Sierra Leone's scientific output, just as it is for the other countries in West Africa. Information on the top five partners for scientific co-authorship between 2017-2019 shows that the USA is by far the most significant partner followed by the UK and China (Figure 6).<sup>17</sup> Within the African continent, the country has forged research partnerships with South Africa.

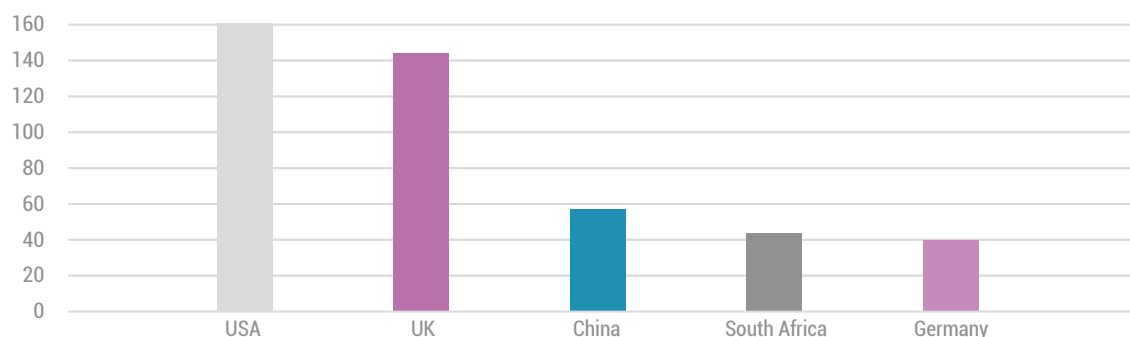
### 2.2.2 Standing in technology

The United Nations Conference on Trade and Development (UNCTAD) published indices in its Technology and Innovation Report, 2021,

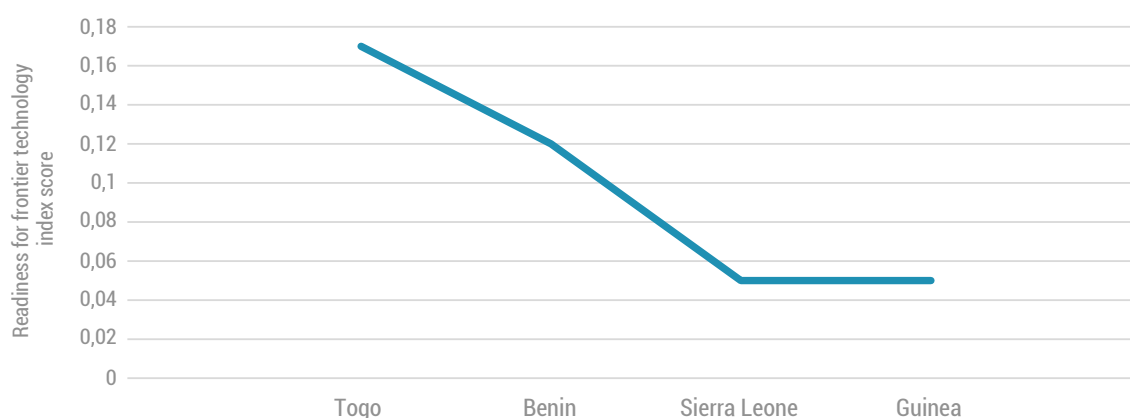
which evaluate countries' readiness to harness so-called frontier technologies.<sup>18</sup> These are new technologies that rely on combining digitalisation with connectivity and thereby they can increase their impacts. The UNCTAD report covers 11 such technologies: "artificial intelligence (AI), the Internet of things (IoT), big data, blockchain, 5G, 3D printing, robotics, drones, gene editing, nanotechnology and solar photovoltaic (Solar PV)." For all countries it is of increasing importance for social and economic development to be able to use, adopt and adapt these technologies. The index is built from evaluating five components: ICT deployment, skills, R&D activity, industry activity and access to finance.

Sierra Leone has one of the lowest Readiness for Frontier Technologies Scores of all the countries in the world (Figure 7).<sup>19</sup> The average score is 0.44, with the United States being the most ready for frontier technologies (score 1.00). Gambia and the Democratic Republic of Congo are the least ready based on this evaluation (score 0.00).

**Figure 6. Top five partners for Sierra Leone for scientific co-authorship.** Source: UNESCO, 2021



**Figure 7. Readiness for Frontier Technologies Indices for select countries.** Source: UNCTAD, 2021



<sup>17</sup> Ibid.

<sup>18</sup> UNCTAD (2021). Technology and Innovation Report 2021. Catching Technological Waves: Innovation with Equity. United Nations Conference on Trade and Development.

<sup>19</sup> Ibid.

Sierra Leone ranks number 151 of the 158 countries ranked in the Readiness for Frontier Technologies rankings (Figure 8).<sup>20</sup> When the different components of the index are examined, it is clear that Sierra Leone does better in the industry ranking than any of the comparison countries but worse on the finance component ranking and on the ICT ranking. Its low ICT ranking may pose a challenge for Sierra Leone building a digital economy,

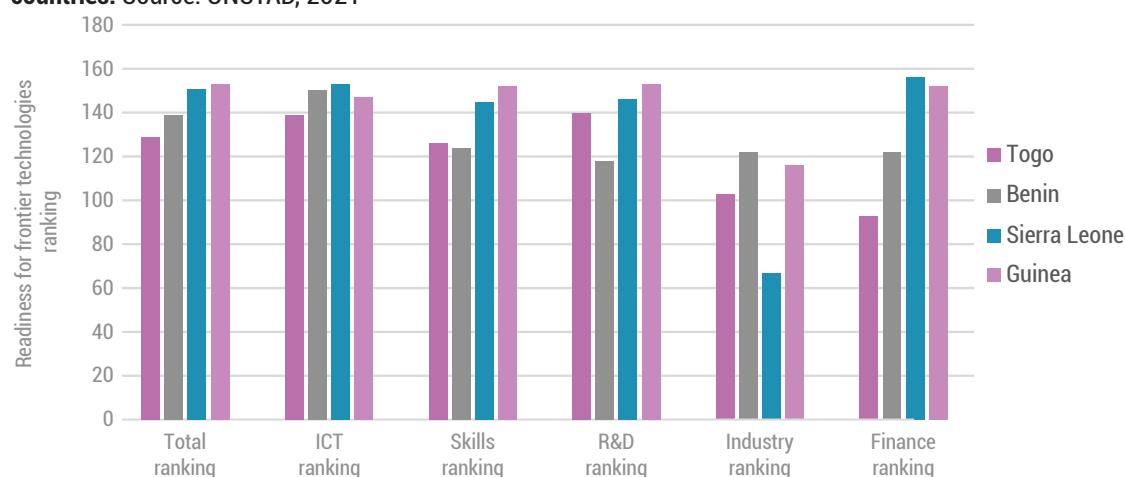
Sierra Leone's technical weaknesses can also be observed in how low a proportion its high-tech exports are of its total manufacturing exports. Statistics from 2018 indicate that only

one percent of its manufactured exports were high tech.<sup>21</sup> Still, the other comparison countries fare no better on this indicator and none of them have more than one percent of their manufactured exports as high-tech goods or services.

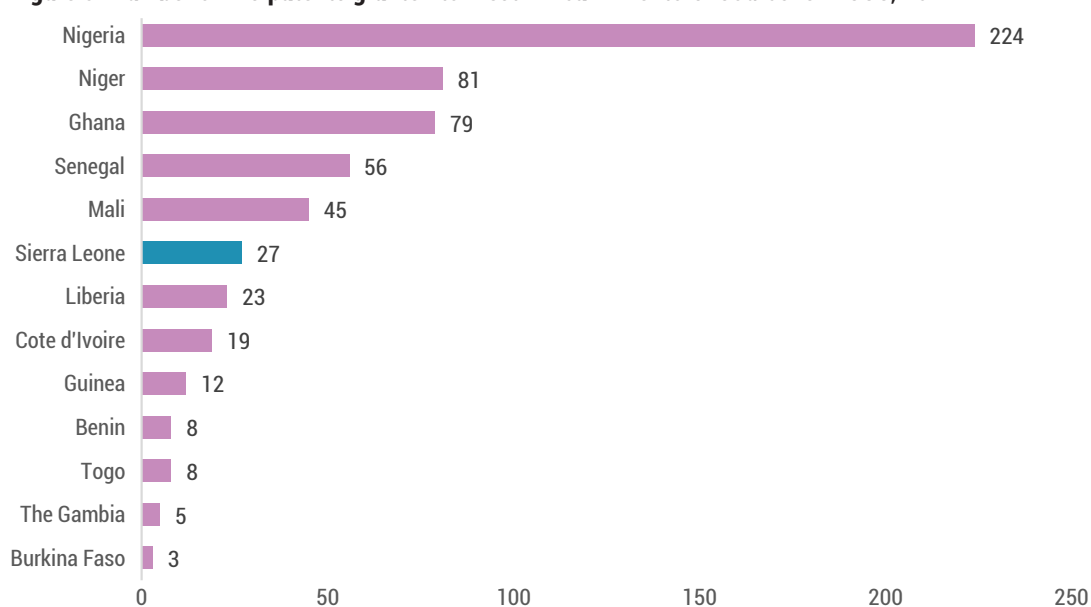
### 2.2.3 Standing in innovation

Sierra Leone has fared relatively well in its patent outputs as Figure 9<sup>22</sup>, below, shows. Between 2015 and 2019, the country has been granted 27 IP5 patents and is in 6<sup>th</sup> place of West African countries in terms of the number of IP5 patents.<sup>23</sup>

**Figure 8. Ranking of different components of the Readiness for Frontier Technologies Indices for select countries.** Source: UNCTAD, 2021



**Figure 9. Number of IP5 patents granted to West African inventors.** Source: UNESCO, 2021



20 UNCTAD (2021). Technology and Innovation Report 2021. Catching Technological Waves: Innovation with Equity. United Nations Conference on Trade and Development.

21 World Bank (2018b). High-technology exports (% of manufactured exports).

22 UNESCO (2021). UNESCO Science Report 2021: The Race Against Time for Smarter Development. United Nations Education, Scientific and Cultural Organization.

23 IP5 patents refers to US Patent and Trademark Office, European Patent Office, Korean Intellectual Property Office, Japanese Patent Office, and State Intellectual Property Office of the Peoples Republic of China.

The available data from the Global Competitiveness Reports, that are published by the World Economic Forum (WEF), can be used to evaluate Sierra Leone's innovation performance (Table 4).<sup>24</sup> It must be noted that Sierra Leone was not included in the 2019 and 2020 reports. Sierra Leone's innovation ranking is low compared to other countries. It seems, however, to be improving slightly. In 2015/2016, Sierra Leone placed 131 in Innovation Capability of 140 countries ranked. In the most recent year where Sierra Leone's performance was ranked, it placed 124 of 140 countries. Its ranking in Higher Education and Training is stagnant but Sierra Leone's Technology Readiness has improved slightly. It is still relatively low compared to other countries, which will be an obstacle to acquire and diffuse technology from international or local sources. Sierra Leone's overall competitiveness ranking is low globally and has not improved.

Sierra Leone is not ranked in the Global Innovation Index Report, a publication of the World Intellectual Property Organisation and Cornell University, which ranks the innovation performances of about 130 economies. The Global Innovation Index (GII) ranks the innovation ecosystem performance of economies around the globe each year while highlighting innovation strengths and weaknesses and particular gaps in innovation metrics.

The available evidence suggests that the innovation standing of Sierra Leone is low globally. There may be some indication pointing to it improving slightly but more evidence is called for to establish this.

## 2.2.4 Main initiatives in promoting STI

As stated earlier, Sierra Leone aspires to increase development through investments in advanced technologies. This section summarises some of the technology initiatives that are ongoing or have recently been undertaken. This discussion is not meant to present a complete list of technology initiatives in Sierra Leone but rather give examples of current technology initiatives. DSTI has been given the mandate to support technology endeavours by the Government of Sierra Leone and to help transform the country into an innovative society. The discussion here limits this list to initiatives that DSTI is involved with as it works with all the ministries in the Sierra Leone Government.

DSTI is implementing a wide range of technology projects. Some are meant to improve government efficiency and service delivery. Projects that are meant to provide technology solutions in multiple fields include:

- **GoSL (Government of Sierra Leone) Appointment App.**<sup>25</sup> The app was created to help government workers manage their schedules, and activities. It is supposed to streamline the process of setting up meetings with both government and non-government employees, so government support is efficient and effective.
- **Integrated Geographic Information System (GIS) Sierra Leone.**<sup>26</sup> An integrated and interactive GIS platform which will use technology, software, and devices to collect, label and model data that can inform real-time

Table 4. Ranking of selected STI indicators in Sierra Leone. 2015-2018.

Indicators	2015/2016	2016/17	2017/18	2018
Innovation capability	131	130	125	124
Higher Education and Training	132	133	132	N/A
Technology Readiness	137	132	128	N/A
Competitiveness	137	132	130	134
Number of countries rank	140	138	137	140

Source: UNESCO Science Report, 2021

<sup>24</sup> WEF. Global Competitiveness Reports, World Economic Forum, Available at: [www.weforum.org/gcr](http://www.weforum.org/gcr).

<sup>25</sup> DSTI. GoSL Appointment App. Directorate of Science, Technology, and Innovation

<sup>26</sup> DSTI (2019c). DSTI Sierra Leone's Integrated GIS Portal launched at NIDS wins \$773,000 grant from the Gates Foundation. Directorate of Science, Technology, and Innovation

government and development partner decision making. The project is designed and implemented by DSTI together with Statistics Sierra Leone and supported by a grant from the Bill & Melinda Gates Foundation.

- **Drone Corridor.**<sup>27</sup> The drone corridor is a segregated area and airspace where drones and drone solutions can be tested for use to support different sectors in the country. This project is supported by UNICEF Sierra Leone and UNICEF's Office of Innovations in New York. The project explores the use of aerial drones in several fields including medical deliveries, emergency response activities, agroforestry, and geospatial mapping as a start. It is carried out by the Civil Aviation Authority and DSTI, together with UNICEF.

There is a large emphasis by the government of Sierra Leone on using technology in education. Some examples of these initiatives include:

- **Free Quality Education Project.**<sup>28</sup> This project is implemented by the Ministry of Basic Education and Senior Secondary Education with support from the World Bank, Irish Aid, Foreign and Commonwealth Office and the European Union. It includes the development of an interactive dashboard to monitor and assess the learning outcomes for the country's quality of education.
- **Giga.**<sup>29</sup> The Government of Sierra Leone, the International Telecommunication Union (ITU) and UNICEF signed an agreement to collaborate on Giga. It is a UNICEF-ITU global initiative to connect every school to the Internet, and every young person to information, opportunity, and choice. The objectives of Giga are to improve Human Capital Development in Sierra Leone by connecting schools to the internet. The National Steering Committee is led by the Minister of Basic and Senior Secondary Education and has representation from many other ministries, including the Ministry of Planning and

Economic Development and the Ministry of Technical and Higher Education.

- **Digital Learning Hub.**<sup>30</sup> In response to the difficulties for schools and universities to offer face-to-face learning during COVID, the government of Sierra Leone developed and launched several digital learning initiatives which are intended to support remote learning in schools and universities. These hubs are also intended to provide opportunities for the current workforce to acquire the skill sets for roles during and post-COVID. This project is implemented by the Institute of Public Administration and Management (IPAM) at the University of Sierra Leone with support from UNICEF.

In health, Sierra Leone has for example, initiated:

- **Drone Medicine Transportation.**<sup>31</sup> UNICEF and the DSTI are testing drones that could deliver medicine and vaccines. The Bill and Melinda Gates Foundation supported DSTI with a grant of \$131,130. This grant assisted the plan for a viable and cost-effective drone-delivery system for Sierra Leone's medical supply chain. The project is a continuation of the Drone Corridor project but only focused on health.

In the environment field Sierra Leone has, for example, the project:

- **GEN-350.**<sup>32</sup> The GEN-350 project is technological innovation, applied in Sierra Leone, among other countries, that produces drinking water out of the air. The Israeli company Watergen created the generator as a part of its work to provide affordable water to countries that lack clean drinking water. The GEN-350 can produce up to 900 litres of water a day and uses electricity for its operation. It has been applied at a girl's school in Sierra Leone and is an innovative way to address the challenge of access to clean water supplies.

27 UNICEF (2019). Drones for Good Corridor launched as drones take flight to deliver medicine to remote areas in Sierra Leone. United Nations Children Fund.

28 TPV (2020). Sierra Leone's President Julius Maada Bio launches Education Project, signs US\$ 66 Million Education Multi-Donor Trust Fund.

29 ITU (2020b) Giga: Connecting Every School to the Internet. International Telecommunication.

30 DSTI (2019d). Notice for Expressions of Interest for Digital Learning Hubs Project; Hosting and Training. Directorate of Science, Technology, and Innovation.

31 Franklin, A. (2021). The improvement of technology in Sierra Leone. The Borgen Project.

32 Schmidt, L. (2020). Technological Innovation in Sierra Leone. The Borgen Project.

Sierra Leone has also some initiatives to promote technology development by businesses. They include:

- **Ease of Doing Business.**<sup>33</sup> This is an integrated and coordinated Presidential initiative for facilitating an effective and transparent business environment in Sierra Leone. It is implemented by DSTI and the Ministry of Trade and Industry (MTI).
- **Mapping the Digital Entrepreneurship Ecosystem.**<sup>34</sup> The DSTI ecosystems unit undertook a mapping of the entrepreneurship ecosystem in the country. The mapping initiative focused on digital entrepreneurship. The exercise was supported by development partners such as the UNCDF and UNIDO.

In addition, the World Bank has recently committed US\$ 50 million for digital transformation in the country, with the Ministry of Information and Communications as the implementation agency.<sup>35</sup> Sierra Leone is clearly experimenting with a variety of technological solutions. Besides government funding, other sources of funds are international agencies such as the World Bank, UNICEF, UNIDO and UNCDF. There are also several philanthropic organisations such as Bill & Melinda Gates Foundation, and the Tony Blair Foundation for Global Change, which are supporting STI development in the county.

## 2.3 Main actors in STI

### 2.3.1 Main public sector STI actors

The main public sector actors that produce scientific research are the University of Sierra Leone (USL) and Njala University (NU). Another key player is the Sierra Leone Agricultural Research Institute (SLARI).<sup>36, 37</sup>

#### University of Sierra Leone (USL)

The University of Sierra Leone is the largest public university.<sup>38</sup> Its main scientific research and teaching arms are Fourah Bay College

and the College of Medicine and Allied Health Services. (COMAHS). Besides these colleges, it also houses the Institute of Public Administration and Management (IPAM).

**Fourah Bay College.** The university's Department of Chemistry conducts research in air pollution monitoring which is funded by the International Atomic Energy Association. On the other hand, the Faculty of Engineering and Architecture is involved in engineering design and energy. This includes projects for designing, fabrication and performance evaluation of a solar-powered chicken egg incubator, cooking stoves, and a pico pumped storage hydropower system for rural electrification. In energy, the department is involved in solar energy research, biofuels research and energy efficiency and conservation.

Fourah Bay College also houses the Institute of Marine Biology and Oceanography (IMBO). IMBO is effectively also the faculty of fisheries, with teaching and research programmes.

**College of Medicine and Allied Health Services (COMAHS)** conducts clinical trials on infectious diseases such as Ebola, malaria, and Lassa Fever. Through its research efforts, it has managed to forge collaborations with other institutions in the US and the UK. Its vaccine trials are funded by the European & Developing Countries Clinical Trials Partnership (EDCTP). COMAHS has established strategic links with relevant stakeholders such as the Ministry of Health and Sanitation and provides advice on health policy in order to improve the overall health systems reconstruction process. Another ongoing research project at COMAHS is the Accountability and Responsiveness in Informal Settlements for Equity (ARISE) research partnership. This five-year partnership has an overarching aim of working with informal communities (slums) and policy stakeholders to enhance health systems accountability, equity, and wellbeing through participatory action research.

33 DSTI (2020). DSTI and Ministry of Trade and Industry will use technology to make Sierra Leone better for business. Directorate of Science, Technology, and Innovation.

34 UNCDF (2021). Mapping the Digital Entrepreneurship Ecosystem (Part 2). United Nations Capital Development Fund.

35 World Bank (2022c). Sierra Leone: Digital Transformation Project.

36 Tarawallie, M. I. (2015), Sierra Leone research and knowledge systems, a rapid literature review.

37 Economist (2014). Higher Education case Studies in Sierra Leone. The Economist Intelligence Unit.

38 USL University of Sierra Leone. <https://usl.edu.sl/>.

### Njala University (NU)

Njala University offers education to undergraduate and postgraduate students for careers in a wide range of fields including engineering.<sup>39</sup> In agricultural research, NU has an association with SLARI and participates in flagship research such as the Smallholder Commercialisation programme and the West African Agriculture Productivity Programme.<sup>40</sup> These programmes have received substantial funding from international donors such as the World Bank and the Food and Agriculture Organization of the United Nations (FAO).

Unfortunately, the website of USL and NU provide limited information. For example, there are no annual research reports that capture research activities of the institutions. There is also a lack of information regarding the number of students who are registered in science, technology, engineering, and mathematics (STEM).

### Sierra Leone Agricultural Research Institute (SLARI)

Agriculture is the largest contributor to the economy of Sierra Leone and SLARI is a key actor. SLARI is the principal research centre with an extensive network of research centres.<sup>41</sup> Table 5 summarises these research centres and research areas.

Agricultural R&D indicators in Sierra Leone are shown in Table 6<sup>42, 43</sup> below. The table compares the country's agricultural R&D indicators with select countries in Africa: the Gambia, Guinea, and Namibia.

As the results show, Sierra Leone had a low R&D expenditure, 0.24% in 2014, which is well below the recommended 1% target that is set by the African Union and the United Nations.<sup>44</sup> It, however, has a relatively high percentage of researchers with MSc and PhD degrees.

**Table 5. SLARI research and research areas**

Name of Research Centre	Research Focus Area
Njala Agricultural Research Centre	Roots, tubers, and legumes
Rukupr Agricultural Research Centre	Cereal research
Keneman Forestry and Tree Crops	Forestry
Teko Livestock Research	Livestock
Magbosi land and Water Research Centre	Soil and water quality

Source: UNESCO Science Report, 2021

**Table 6. Comparison of Sierra Leone's and select African countries agricultural R&D indicators, 2014 (Million PPP dollars (2011 constant prices)).**

	Sierra Leone	The Gambia	Guinea	Namibia
Agricultural Research Spending	15.3	5.1	7.7	38.8
Spending Intensity	0.24%	0.80%	0.30%	3.09%
Agricultural Researchers (FTE)	123.7	60.4	240.7	99.7
Share of researchers with MSc and PhD degrees	73%	72%	42%	58%

Source: ASTI, 2017

39 The Economist Intelligence Unit Limited, 2014, Higher Education case Studies in Sierra Leone.

40 NA. Njala University. <https://www.njala.edu.sl/>

41 SLARI. Sierra Leone Agricultural Research Institute <https://www.slari.gov.sl>.

42 Spending intensity measures agricultural research expenditure divided by agriculture GDP.

43 ASTI (2017). Agricultural R&D Indicators Fact Sheet: Sierra Leone. Agricultural Science and Technology Indicators. The International Food Policy Research Institute.

44 Ibid.

The main source of funding for SLARI is government which provided 80% of funding between 2009-2014. There are donors such as Le conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles (CORAF) /West and Central Africa Council for Agricultural Research and Development (WECARD) and the Consultative Group on International Agricultural Research (CGIAR) who fund research activities and postgraduate training of researchers. SLARI seems to suffer from insufficient research capacity across disciplines such as irrigation, biotechnology, and climate change. SLARI collaborates with Njala University and the University of Sierra Leone in agricultural and fisheries research.

Compared to other research performing organisations, SLARI is relatively well resourced and has been able to attract donor funding.<sup>45</sup> However, according to a recent publication by Conteh (2020) SLARI faces several challenges due to limited funding, deficiencies in facilities, equipment, and low agricultural research investment.<sup>46</sup> The paper mentions that a large proportion of the SLARI budget goes into staff salaries, and limited funds are available for operating costs. As a result, field and laboratory work suffers leading to empty research laboratories and the limited equipment available in some of the centres being obsolete. Furthermore, in recent times, SLARI is experiencing a mass exodus of highly qualified and experienced staff to other organizations which have better conditions to do research. According to the paper, this has limited SLARI's contribution to agricultural development in Sierra Leone.

### 2.3.2 Main private sector STI actors

According to a report by Jonas Brunschwig (2018), the technology driven firms in Sierra Leone that can play a role in stimulating innovation are telecommunications companies

such as Orange (French owned) and Africell (Lebanese owned).<sup>47</sup> There was no information on private companies that conduct formal research and development, nor information on industrial research laboratories or institutions. This does not mean firms are not innovating but there is a lack of data from R&D surveys to capture business expenditure on R&D.

There are some other firms in Sierra Leone including Solar Era Holdings, Teleficient, Easy Solar, Aptech Africa and Energen WAP and SEforALL in the energy sector. Many of these work in solar energy and in providing solutions to energy needs in rural settings. Others are Sierra Rutile working in mineral sands; Capitol Food in food processing; Cerra Services in transportation services; and Mosabi which mixes fintech and edtech.<sup>48</sup> In fintech there are also several start-ups including InvestED, MyPay, Noory, SaloneBuy, and Ace Money Transfer.<sup>49</sup>

Sierra Leone's industry structure is dominated by primary sectors such as agriculture, mining, and tourism, which are classified as low technology sectors and are generally not research intensive. The manufacturing sector remains small, contributing only 2 percent to GDP, in 2012, 4.5 percent in 2016 and 4.9 percent of GDP in 2017 before decreasing to 0.3 percent of GDP in 2018.

To diversify the economy, the World Bank provided a \$40 million grant from the International Development Association (IDA) to support investment and growth of Small and Medium Enterprises (SMEs) in non-mining productive sectors.<sup>50, 51</sup> The Sierra Leone Economic Diversification Project will help strengthen the enabling environment by promoting reforms to facilitate business entry and operation. It will facilitate strategic public investments to improve competitiveness and private investments; support SMEs and entrepreneurs; and build capacity of public institutions and private

45 Momoh, J. (2014). Assessment of Agricultural Research Capacities in Sierra Leone: The Case of Sierra Leone Agricultural Research Institute (SLARI).

46 Conteh A.R. (2020). Strengthening the Role of Research in Agricultural Development Programmes in Sierra Leone.

47 Brunschwig, Jonas (2018). Innovation Diplomats, Freetown, Sierra Leone.

48 Startup list Africa. Top start-ups in Sierra Leone.

49 Lewis S.E (2021), Top fintech companies in Sierra Leone.

50 UNSG (2019). Report of the Implementation of the Least Developed Countries (LDC) Programme of Action 2011-2020. United Nation Secretary General.

51 World Bank (2020e). Sierra Leone: \$40 Million to Support SME Investments and Economic Diversification

sector operators. Improving the business environment could lead towards the creation of more innovative start-ups.

In agriculture, the Sierra Leone Chamber of Industry and Agriculture is the primary private sector association. The Chamber, together with other agriculture associations is represented in the National Agriculture Research Coordination Council (NARCC). The NARCC is a coordinating body that brings together key stakeholders in agriculture such as the private sector, universities, and agricultural research institutions such as SLARI. The major players in agriculture are Addax Bioenergy, Biopalm SL Limited and Bengal Agro SL Limited.<sup>52</sup> According to Conteh (2020) the participation of the private sector in agricultural research is limited. This may partly be because agricultural firms are small and are not likely to have the capacity to conduct and fund research.

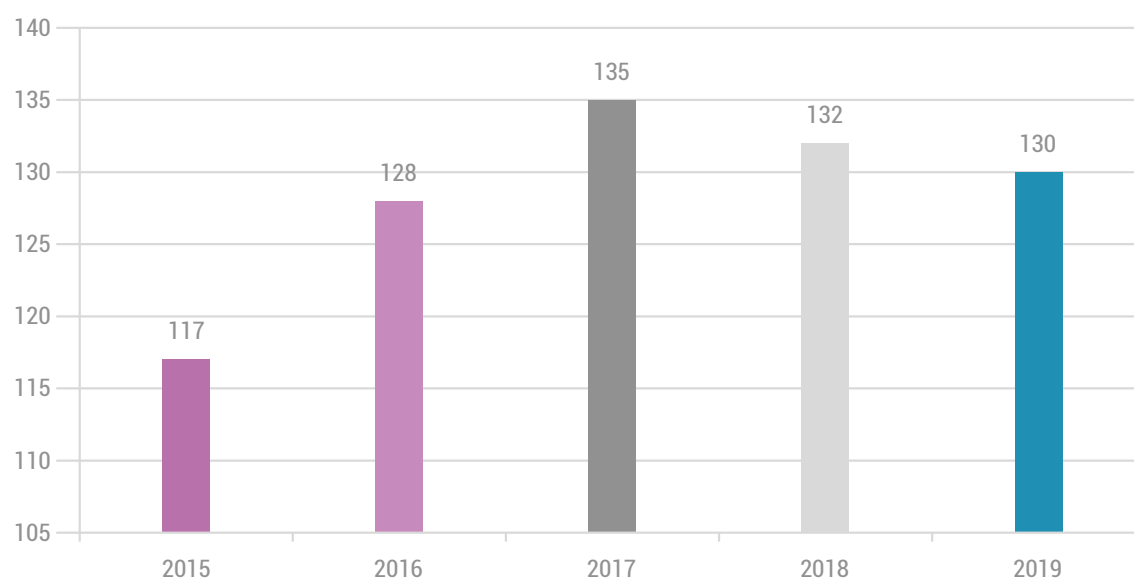
Besides stimulating digital innovation, one of the goals of DSTI is to promote entrepreneurship and to make Sierra Leone an innovation nation.<sup>53</sup> A Least Developed Countries Report

by UNCTAD (2018) underscores the importance of entrepreneurship in economic development.<sup>54</sup> The report presents a compelling case for a structural transformation-centred approach to entrepreneurship policy in least developed countries.

According to the Global Entrepreneurship Index (GEI), Sierra Leone is ranked low in entrepreneurship (Figure 10). The GEI is published by the Global Entrepreneurship Development Institute (GEDI).<sup>55</sup> The GEI is a composite indicator of the health of the entrepreneurship ecosystem in each country. As Figure 10 shows, the country's ranking has declined from 117 (out of 130 countries) in 2015, to 130 (out of 137 countries) in 2019, a small improvement from the lowest ranking of 135 in 2017.

The entrepreneurial environment in Sierra Leone was also investigated by Brunschwig in 2018.<sup>56</sup> He concluded that the entrepreneurship environment is still nascent. One of his findings is that the country lacks experience in supporting start-ups and providing them with an enabling environment which includes

**Figure 10. Ranking of Global Entrepreneurship Index of Sierra Leone.** Source: Global Entrepreneurship Reports, 2015-2019.



52 Mannah, E. A. and Gibril Y.V. (2012). Skills Gap Analysis for Private Sector Development in Sierra Leone Sierra Leone.

53 DSTI. About. Directorate of Science, Technology, and Innovation

54 UNCTAD (2018), The Least Developed Countries Report: Entrepreneurship for Structural Transformation – Beyond Business as Usual. United Nations Conference on Trade and Development.

55 Acs, Z.; Szerb, L.; Autio, E. (2017). The Global Entrepreneurship Index. In Global Entrepreneurship and Development Index 2016.

56 Brunschwig, Jonas (2018). Innovation Diplomats, Freetown, Sierra Leone.

mentorship, funding, and other needed resources. As a result, the most promising entrepreneurs often leave the country and are attracted to other regional markets such as Lagos in Nigeria, or Accra in Ghana to develop their entrepreneurial solutions.

### Innovation/entrepreneurship support organizations

To create an enabling environment, several innovation and entrepreneurship support organisations have sprung up. The table below (Table 7) lists some of the organisations that support innovation.

These organisations offer support to technologists and entrepreneurs such as co-working spaces, access to power and internet. They also provide basic mentoring and coaching in entrepreneurship and technology consulting services, support networking and organise events such as entrepreneurship forums, weeks or, pitching nights. Some of their activities are

focused particularly on women or youth entrepreneurship. These organisations also play an advocacy role in terms of influencing changes to the business environment to make it better aligned to the needs of start-ups. GEN Sierra Leone is an example of an incubator that has links to international incubators/ accelerators and can connect start-ups internationally.<sup>57</sup>

Venture capital for funding early-stage start-ups is also limited. To support early-stage ventures, Cordaid, from the Netherlands, established the Stability Investment Fund which eventually became a shareholder of the International Finance Corporation (IFC).<sup>58</sup> The IFC set up a West Africa Investment Fund for the West Africa Region.

Currently, SMEs are facing challenges such as low access to information, poor infrastructure, limited access to finance, and weak capacity to scale up businesses. These constraints disproportionately impact women entrepreneurs as in most countries they do not have as good

**Table 7. Innovation and Entrepreneurship Support Organisations..**

Type of Innovation & Entrepreneurship Support Organisation	Name of Organisation
Incubator	Human Capital Incubator
	Agro-business Incubator
	Innovation SL/GEN Sierra Leone
Accelerator Labs	UNDP Accelerator Lab
	SLG Accelerator
	Limkokwing Accelerator Platform (LEAP)
	Resilient Business Development Services (RBDS) accelerator, Cordaid
	Innovation SL
SME Development	Small and Medium Enterprises Development Agency
	Invest Salone
Hub/Funding	Sensi Tech Hub
	Innovation Axis
	Aurora, Sensi Hub
Others	CRIBS-Sierra Leone LTD. [Centre for Research, Innovation and Business Solutions
	Student Entrepreneurship Program Sierra Leone

Source: UNESCO Science Report, 2021

<sup>57</sup> GEN. Sierra Leone. <https://www.innosl.com/gen-sierra-leone/>.

<sup>58</sup> CORDAID (2015). CORDAID in Sierra Leone: An Overview.

access to finance and other inputs for their businesses as men do. As mentioned above, in 2020 the World Bank supported a \$40m project and hopes to address these challenges through public goods investment, SME and start-up acceleration, and early-stage financing.

Another interesting point that is worth mentioning is the observation that was made by Brunschwig in his report. He argued that technologists and entrepreneurs who are supported by NGOs and donor agencies tend to focus on social innovations which might not have a viable business model.<sup>59</sup> The donors set agendas and priorities, with entrepreneurs adapting their solutions to the priorities of donors, whose funding is geared more towards social innovation.

According to Brunschwig, academia is lagging behind in supporting entrepreneurship and does not have innovation spaces. The exception is Limkokwing University (a Malaysia-based university with a local branch in Freetown which initiated a LEAP programme, an entrepreneurship acceleration platform and has forged partnerships with the entrepreneurship support organisation Innovation SL.

## 2.4 Evaluation of STI

To explore the STI system in Sierra Leone further and to identify potential strengths, weaknesses, opportunities and threats for the system, questions asking the stakeholders to evaluate the STI system were included in the stakeholder survey conducted for the TNA.

### 2.4.1 Strengths

When the respondents were asked what they thought are the main STI strengths in Sierra Leone, they provided diverse answers. Several respondents were critical of the STI situation in the country and said there were no strengths, or as one of the respondents said: "The lack of it all." The main strengths indicated were:

**Political will.** Several respondents indicated that a strength for the STI system in the country was the will of the government to promote STI. By starting to build more STI infrastructure and developing strategies for digital development,

the government is signalling the importance it places on STI. Continued emphasis on STI development, policy coherence and increased resources will need to be mustered by the government to more successfully promote STI development.

**Young population.** Many of the respondents remarked that the young population of Sierra Leone was an asset for the STI system in the country. As discussed in the previous chapter, the population of Sierra Leone is relatively young. Many are also technology savvy and educated in technological fields. It is important for the country to cultivate an environment that allows young people to pursue STI activities, for example, by supporting structures such as accelerators and incubators that can promote the development of start-up firms.

**DSTI.** Several of the respondents commented that the establishment of DSTI is a strength for the STI system in the country. It is an asset to have a dedicated organization with the mandate to promote technology development in the country. Its location in the Office of the President and mandate to work with all ministries can encourage technological development in many areas. For this to be realized, it is important to ensure that DSTI has the human and financial resources to be able to work on the prioritization of the government and is not shaped too much by donor prioritization.

**Human resources.** Several of the respondents indicated that it is a strength for Sierra Leone that there are many well educated people in technical fields. There is an increasing professional expertise that can be relied on for further STI development. This includes people who are driven to engage in innovative activities. One respondent wrote, for example: "We have a desire to innovate." The government emphasis on education is likely to enhance human resources in the country and ensure that there is a critical mass to empower STI development.

### 2.4.2 Weaknesses

When the survey respondents were asked what the main weaknesses in their STI systems were, they provided a long list. The main ones were:

<sup>59</sup> Brunschwig, Jonas (2018). Innovation Diplomats, Freetown, Sierra Leone.

**Weak technical infrastructure.** Several of the respondents indicated that the access to the internet needs to be improved and the cost was too high, and this can burden STI activities. They mentioned low mobile and smart phone penetration and lack of proper ICT infrastructure being challenges in the country. They also said that the internet access needed to be more equitable and affordable. The message was also conveyed that inconsistent electricity increased these challenges.

**Limited skills.** Even though the number of people educated in technology fields has increased in the country, limited STI skills was considered a weakness in Sierra Leone's STI system. The stakeholders expressed the concern that not enough emphasis was placed on science, technology, engineering, and mathematics (STEM) subjects in the country's education system. As one respondent said: "Our education system is not inclusive of STI. Teachers are barely literate in their disciplines/topics." The sentiment was also expressed that the curriculum of schools and colleges was too academic and there was often the lack of access to ICT in schools. Some also noted that the high level of illiteracy was a weakness for the STI system. Clearly, there are inconsistent perceptions of the strengths and weaknesses of the STI system, expressed by survey respondents.

**Limited resources.** Several of the respondents indicated that limited financial resources and investment in STI was a weakness for the system. As one respondent said: "The weakness is the availability of funds to carry out activities". There were remarks that the government did not place a strategic emphasis on the STI sector as a development priority and there was still limited support for emerging innovators. The message was that more financial resources were acutely needed to establish a well-functioning STI system in the country.

**Unconnected STI structure.** Some of the respondents said that the components in the systemic structures that allow the development of innovation are disconnected and need strengthening in Sierra Leone. Until recently there was no strategy in place to promote any fields within the STI system. So far promoting

digital development is at the beginning stage and needs to be well grounded in the realities of the country's STI system. There are also too many silos in the STI system and there are, for example, weak linkages between academia and the private sector in the country.

### 2.4.3 Opportunities

The survey respondents generally seemed optimistic about the opportunities for the STI system in Sierra Leone. Many answered the question by making positive remarks such as: "Very positive", "Enormous", "Great opportunities", and "Diverse and vast". One respondent said: "Sierra Leone is a virgin landscape when it comes to the areas of Science, Technology, and Innovation development. The opportunities are enormous and endless." More specifically the respondents suggested:

**Opportunity for a restart.** Several stakeholders felt the time was ripe to change the status quo in all sectors of the economy. With a better educated population there was an opportunity to harness technologies. As one respondent remarked: "Improvement of performance of the various sectors once the human capital base has been developed." Another respondent said that there were opportunities to integrate technology solutions in all the sectors. The message was conveyed that the population's education has improved and that the willingness of the people of Sierra Leone to learn was clearly established.

**Sectoral opportunities.** Several respondents mentioned that some particular sectors of the economy could create opportunities for STI development in Sierra Leone. One respondent, for instance, said: "There is a chance to set us up to progress [by] making full use of digital technology." Another respondent remarked that the existence of precious natural resources could contribute to technological development in the country. Other respondents mentioned that the agricultural and energy sectors could provide opportunities for STI development in the country.

**Market opportunities.** There was also some mention that addressing market demands could provide opportunities for the STI sector. Sometimes addressing pressing development

demands can lead to capacity building and further STI activities. The comment was also made that the market that was open to STI entrepreneurs was huge. A population of close to eight million and access to neighbouring countries' markets, such as the market in Nigeria create opportunities to market technology-based projects and services widely. Sierra Leone has also signed and ratified the establishment of the African Continental Free Trade Area (AfCFTA), which will open an even a larger market for the country,

Several respondents also remarked that the strengths of the STI system discussed above, political will and a young tech savvy population, provided opportunities for the STI system in the country. There are clearly many potentials for Sierra Leone to pursue STI intensive development. Prioritizing which sectors and technologies to pursue is an important step towards strengthening the STI system and realizing those technologies in action.

#### 2.4.4 Threats for the STI system

There are several internal and external threats for STI development in Sierra Leone.

**Lack of proactive STI direction.** Without more proactive direction by the government there is the risk that a STI system will not be able to evolve in the country. As resources for STI development are limited, there is a dire need to prioritise research and innovation activities and target those that are likely to benefit local development. This requires a prioritisation process and strategic development that is evidence-based and informed by local realities. Without this process, there is a risk that efforts to promote STI activities will not amount to much as they will be spread around according to the flavour of the day.

**Low STI investment.** Low investment in STI activities is an internal threat that certainly limits options for research and innovation activities in the country. With weak support both to research and innovation activities there is a risk that researchers, innovators, and entrepreneurs will leave the country. Sierra Leonians with good ideas to solve local development challenges will feel impelled to pursue their careers in countries with better STI support.

This brain drain will diminish the benefits the country can reap from existing investment in STI in the country and curtail its ability to address its development challenges.

**Health outbreaks.** In the last decade Sierra Leone has had to deal both with an Ebola outbreak and the COVID-19 pandemic. This has demanded additional resources to be channelled to the health system, closures of schools and plunges in economic activities. Under these conditions it is difficult to fund and govern STI development, which can be detrimental for the evolution of a STI system in the country.

**Vulnerability to climate change.** As mentioned above, Sierra Leone ranked especially high in vulnerability to climate change. There is the risk of increasing temperature, rising sea levels and flooding and mudslides due to extreme weather. These could impact the lives of millions of people in the country and lead to increased food insecurity and negatively affect human health. While such dire climate change impacts are an opportunity to engage researchers and innovators in the country, they are also a fundamental threat and as a result can thwart the development of Sierra Leone's STI system.

## 2.5 Conclusion

The discussion in this chapter shows that Sierra Leone has started to build components of a STI system. The government has taken some steps in using STI to address social and economic challenges and improve government efficiency. The government emphasizes education and has set up the DSTI with direct access to the Office of the President. This is important because it shows the government's commitment to STI. Such commitment must however be accompanied by allocation of required resources. As a dedicated directorate, DSTI can act as a champion and lead the STI agenda in partnership with other government departments, the private sector, and NGOs. This will require skilful coordination to integrate the STI efforts including the introduction, transfer, and diffusion of technology. To be able to engage in effective technology development, more systematic evaluations need to be carried out on the conditions in any particular priority sector.

Policy development of strategic sectors needs to be grounded and informed by the realities in the country. Better grounded policies and focus on integrating the different components can ultimately lead to more knowledge flow in the system and a stronger innovation record. In the next chapter some of the potential development sectors that Sierra Leone can pursue to address its challenges are identified, and specific technologies suggested that could add value to the technological development in the country.



# CHAPTER 3

## Technology analysis in Sierra Leone

The objective of this chapter is to identify technologies that can address development challenges in Sierra Leone. The results will provide input into a dialogue the authorities in Sierra Leone can have on what technologies the country plans to pursue in its development efforts. The chapter will be heavily based on the results from a survey submitted to various stakeholders in the country as a part of this TNA.

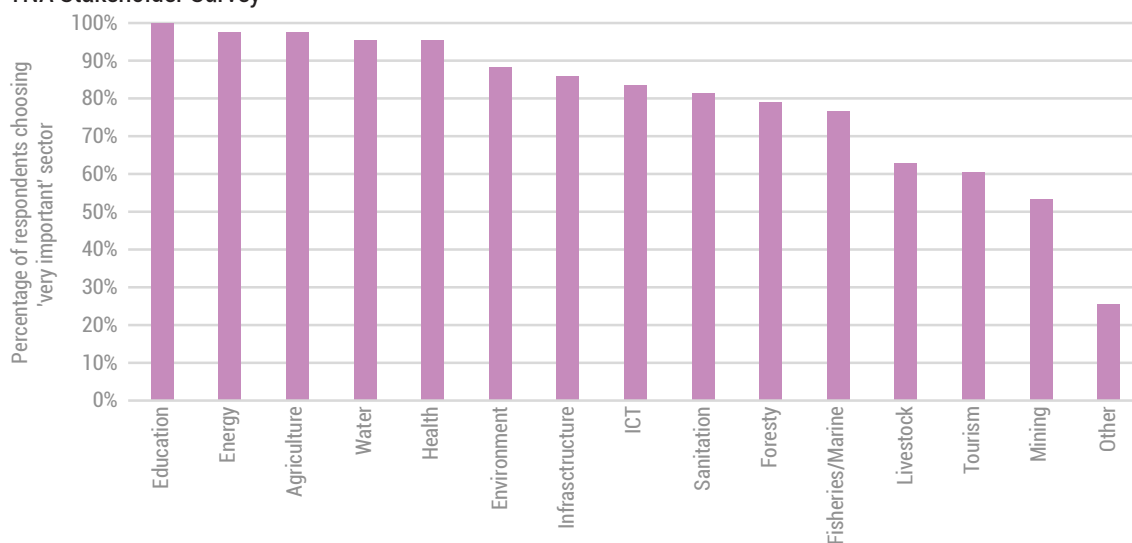
### 3.1 Development needs in Sierra Leone

While the stakeholders considered all the sectors be important to some extent, there was a broad consensus on the importance of pursuing development needs in the top sectors listed in Figure 11. For example, all, or almost all, respondents indicated that it was very important for Sierra Leone to meet development needs in education, energy, and agriculture, and around 95% said it was very important to address development needs in water and health. In comparison, 54% thought it was very important for Sierra Leone to pursue needs in the mining sector. Other sectors of medium importance were the environment, infrastructure, ICT, and sanitation sectors. Most of the respondents who indicated that other sectors were important for Sierra Leone mentioned that the private sector, including SMEs, was important. Others mentioned good governance and human resources as being important for addressing development needs.

The sectors were then ranked to identify the five most important sectors for promoting development in Sierra Leone (Table 8). Agriculture, energy, education, health, and infrastructure were the most highly ranked sectors. The three sectors that ranked the lowest in terms of importance for promoting development were forestry, mining, and livestock.

The priority sectors identified by the stakeholders align well with the government's prioritisation presented in the Sierra Leone's Medium-Term National Development Plan, 2019-2023.<sup>1</sup> The collection of policies and programmes referred to as Cluster One in the National Development Plan is called 'Human Capital Development.' This aligns well with education being ranked high as a priority sector. Cluster Two is 'Diversifying the Economy and Promoting Growth.' Strategy number one, within Cluster Two to achieve this, is 'Improving the productivity and commercialization of the agricultural sector'. This fits well with agriculture being the top ranked sector to address development needs according to the stakeholder survey. Energy features centrally in the government's planning and is an important part of 'Cluster Three: Infrastructure and Economic Competitiveness.' Health is ranked number four by the stakeholders, and it aligns well with the government's goal of 'Health care improvement' under 'Cluster One: Human Capital Development.' The mismatches

**Figure 11. Importance of Sierra Leone meeting development needs in different sectors.** Source: Results from TNA Stakeholder Survey



<sup>1</sup> Government of Sierra Leone. (2019). Sierra Leone's Medium-Term National Development Plan, 2019-2023: Education for Development.

**Table 8. Ranking of most important sectors for promoting development in Sierra Leone**

Rank	Sector
1	Agriculture
2	Energy
3	Education
4	Health
5	Infrastructure
6	ICT
7	Water
8	Environment
9	Tourism
10	Fisheries/marine
11	Sanitation
12	Livestock
13	Mining
14	Forestry

Source: Results from TNA Stakeholder Survey.

between the stakeholders' rankings and the government's policy emphasis are the fisheries/marine sector, and the tourism sector. They are emphasised heavily in the government planning but received a low ranking by the stakeholders.

The stakeholders generally agreed (97%) that technology is highly important for Sierra Leone to meet its development goals and national priorities. This reflects a strong expectation for technology to address development needs. In general, most stakeholders did not think that it was clear which sectors the government has prioritised with only 36% of respondents indicating that the priorities were clear. Not quite half the respondents (45%) felt that the government's technology priorities aligned well with the technology needs in the country. The stakeholders' views were split on the issue of whether the focus on supporting technology development should only involve supporting digital technologies with under half (47%) of stakeholders agreeing with the statement that promoting technology development in Sierra Leone should only involve a focus on digital technologies.

There was firm support (97%) for the notion that promoting technologies should involve a gender focus. The respondents also felt strongly (97%) that it was important to pay attention to equity issues when promoting technologies. There seems to be a strong expectation for technologies to be inclusive and attempt to address inequities.

The survey results conveyed a strong message that technology should be harnessed to address development needs in Sierra Leone. The respondents prioritized a list of sectors which are particularly important for local development and confirmed that development needs can be addressed by incorporating technological solutions in these sectors.

### 3.2 Potential technologies to address development challenges

The stakeholders were consulted on the main challenges that technologies can address in the sectors they had prioritised and to suggest potential technologies that can address these challenges. The respondents were requested to suggest specific technologies rather than

broad categories of technologies. This section discusses the results for the five sectors they considered the most urgent development sectors in the country. In Appendix A, the whole list of suggestions for all listed sectors is presented.

### 3.2.1 Agriculture

Table 9 lists the main categories of technologies suggested by the stakeholders in agriculture and provides examples of some specific technologies suggested in each category.

**Table 9. Main challenges and suggestions for technologies in agriculture sector.**

Activity	Challenges	Examples of specific technologies
Mechanisation	Labour intensive and hard work to till the land and grow the crops	<ul style="list-style-type: none"> <li>• Simple and efficient farm machines and equipment for land preparation</li> <li>• Tractors equipped with GPS, seed, fertilizer, and pesticide application equipment</li> </ul>
Crop control	Low yield reduces agricultural output	<ul style="list-style-type: none"> <li>• Technologies to improve seedlings</li> <li>• Breeding to increase crop yield;</li> <li>• Technologies to measure soil quality and amount of nutrients</li> <li>• The use of organic fertilizers</li> <li>• Technologies to improve crop varieties</li> <li>• Genetic technology to increase yield of crops</li> <li>• GMO to make seeds more climate-resilient</li> <li>• Precision farming</li> <li>• Apps to guide farming processes</li> <li>• E-farming</li> <li>• Blockchain</li> <li>• Using advanced greenhouses</li> </ul>
Pest control	Pests and disease infestation ruins crop performance and yield	<ul style="list-style-type: none"> <li>• Pesticide, herbicide</li> <li>• Biological pest control</li> <li>• Breeding to increase disease resistance</li> </ul>
Irrigation	Irrigation techniques are often inefficient and use too much water	<ul style="list-style-type: none"> <li>• Sub-soil and surface irrigation</li> <li>• Drip irrigation</li> </ul>
Crop management	It is difficult to efficiently plan crop production	<ul style="list-style-type: none"> <li>• Technologies for more efficient use of farmland</li> <li>• Technologies to assist decisions on which crops to grow, which farming methods to use etc.</li> <li>• E-monitoring of delivery of farming supplies/inputs</li> <li>• Using artificial intelligence to help crop rotation</li> <li>• Climate smart technologies</li> </ul>
Environmental management	Environmental pollution is a challenge for the agricultural sector	<ul style="list-style-type: none"> <li>• Waste management and use</li> <li>• Bioremediation</li> </ul>
Preserving & Processing	It is difficult to obtain maximum value out of agricultural production, to prevent spoilage and maximize value added production	<ul style="list-style-type: none"> <li>• Harvesting and post-harvest operation technologies</li> <li>• Food preservation technologies</li> <li>• Investment in storage and process to avoid waste</li> <li>• Cold chain technologies</li> </ul>
Marketing	It is difficult for farmers to market their products and get information on the market prices	<ul style="list-style-type: none"> <li>• Market access and information</li> <li>• Mobile money</li> <li>• E-commerce for farmers</li> <li>• E-banking</li> <li>• E-vouchers, apps to link farmers to markets</li> <li>• Fintech</li> <li>• Unstructured Supplementary Service Data (USSD) solutions to give farmers access to market information</li> </ul>
Information dissemination	Farmers need fast and reliant access to farming information, for example on weather, how to plant, what to plant, soil, etc.	<ul style="list-style-type: none"> <li>• Up-to-date websites with farming information</li> <li>• Apps aimed at providing farmers with agricultural information</li> </ul>
Training	Using technology intensive tools can be difficult	<ul style="list-style-type: none"> <li>• Training on the use of technology devices</li> </ul>
Network communication	In rural areas it can be challenging to get access to reliable and affordable networks	<ul style="list-style-type: none"> <li>• Reliable, equitable, and affordable internet</li> </ul>

Source: Results from TNA Stakeholder Survey

Some of the suggestions are general suggestions such as ‘Technologies to improve seedlings’. Several respondents suggested that Sierra Leone needed more technologies that allowed mechanisation of agriculture. Farming requires many labour-intensive and difficult tasks, including preparing the ground for planting. New tractors can be equipped with new technologies to make agriculture easier.

There were many suggestions for crop control to increase yield. Several respondents mentioned using biotechnology to modify the plants. Others suggested using more ICT intensive methods such as apps, e-farming and blockchain technologies. Pest control was also one area where respondents suggested to rely on modern biotechnologies.

Planning agricultural production to optimise outputs is difficult and needs to take many factors into account, including environmental conditions. More complex technologies that include modelling components can provide a useful contribution to planning.

Another area that many respondents emphasised was the use of technologies to facilitate marketing of farm products. With, for example, better access to information on market pricing, farmers may be able to put their products on the market when the price is to their advantage.

Based on this, there was a strong theme that agricultural technologies can open many new opportunities in Sierra Leone. There are a variety of technologies that can facilitate different components of agricultural production. Some of the suggestions are quite technology intensive and it may take some time for farmers in rural areas of the country to gain access to them and the necessary skills to use them effectively, whereas others are likely to be more easily available. As women are active in agriculture in Sierra Leone, those technologies are likely to benefit them, to increase their quality of life and income.

### 3.2.2 Energy

Table 10 presents the main energy technologies that the survey respondents suggested. The most common theme by far was reference to renewable energy technologies, particularly solar energy.

According to the stakeholders, relying on solar energy is a promising strategy to increase the energy supply in the country without a high environmental cost. Some stakeholders mentioned that there was a particular demand for solar energy and other renewable energy sources in rural areas. Several stakeholders also mentioned that hydro energy was important to meet development needs in the country.

**Table 10. Main challenges and suggestions for technologies in energy.**

Activity	Challenges	Examples of specific technologies
Providing renewable energy	Limited access to affordable energy and environmentally friendly energy sources.	<ul style="list-style-type: none"> <li>• Implementing renewable energy e.g., microgrid or off grid powerplant</li> <li>• Solar energy</li> <li>• Battery storage for solar energy</li> <li>• Hybrid solar technologies</li> <li>• Green hydro energy</li> <li>• Technologies to generate power from waste</li> <li>• Tri-generation systems</li> </ul>
Energy distribution	The energy distribution is inefficient and costly	<ul style="list-style-type: none"> <li>• Improve electricity distribution network</li> <li>• Efficient transmission to reduce costs</li> <li>• Pre-paid energy meters</li> <li>• Artificial intelligence to improve energy access and distribution</li> <li>• E-energy</li> </ul>
Energy conservation	Energy use can be inefficient and wasteful	<ul style="list-style-type: none"> <li>• Energy efficiency technologies</li> <li>• Improve efficient, safe, and clean cooking stoves</li> <li>• Technologies for monitoring energy management and use</li> </ul>
Energy management	The payment system is inefficient and insecure	<ul style="list-style-type: none"> <li>• Technologies for billing to minimise theft and increase sustainability</li> </ul>

Source: Results from TNA Stakeholder Survey

Several respondents mentioned the importance of improving the energy dissemination system to make it more efficient and prevent blackouts. One suggested to use pre-paid energy meters, but others suggested more high-tech solutions such as e-energy and the use of artificial intelligence solutions. Related to this was the theme of using technologies to promote energy conservation. With too many Sierra Leonians lacking access to energy it is important to use the available resources in as sustainable a way as possible.

There are several technology options available to increase energy supply in Sierra Leone. Some, such as solar energy are likely to be already applied in the country but to enhance access to clean and sustainable energy supplies, there is scope to expand the use of such renewable energy sources. With emphasis on renewable energy and energy conservation, several of the technologies can contribute to enhance the environmental conditions in the country.

### 3.2.3 Education

A diverse set of technologies can, according to the stakeholders surveyed, enhance education in Sierra Leone (see Table 11).

Several stakeholders mentioned that it was essential to improve electrical and network infrastructure in Sierra Leone so it could take advantage of educational technologies. This was specially emphasised for rural areas which suffer from non-existent or unreliable electricity or mobile/internet access. The focus on rural areas can increase educational opportunities for rural youth and women.

Online education technologies and e-learning were also suggested by the stakeholders. This was certainly the case in remote areas which may not have many schools, but it was also mentioned that these technologies should be available to a larger proportion of the population, especially during health outbreaks when schools need to be closed.

**Table 11. Main challenges and suggestions for technologies in education.**

Activity	Challenges	Examples of specific technologies
Distance learning	Difficulties to provide education to rural students and during health outbreaks.	<ul style="list-style-type: none"> <li>Distance education with traditional methods (e.g. audio/video broadcasting, audio/video teleconferencing).</li> <li>Online education</li> <li>E-learning (online and offline teaching software)</li> <li>E-library technology</li> </ul>
Access to equipment	Limited access to global knowledge and more efficient educational processes	<ul style="list-style-type: none"> <li>Computer access</li> <li>Automatic CCTV cameras for exam writing and marking; automatic digital grading system</li> </ul>
Management	Educational planning and management are difficult with limited access to centralised information	<ul style="list-style-type: none"> <li>E-database techniques</li> <li>Software programs aimed at management/planning</li> <li>Monitoring of teacher and student absence</li> <li>Integrated financial management for the education sector</li> </ul>
Training	Limited ICT skills for digital technology users	<ul style="list-style-type: none"> <li>Compulsory computer training</li> <li>Introduction of ICT as a subject in high school curriculum</li> <li>The use of educational software in energy and other sectors</li> <li>Training of ICT teachers</li> </ul>
Higher education	To offer modernised higher education in the country there is a need to digitise higher education institutes to a larger extent and enhance their laboratories	<ul style="list-style-type: none"> <li>Compulsory computer training</li> <li>Introduction of ICT as a subject in high school curriculum</li> <li>The use of educational software in energy and other sectors</li> <li>Training of ICT teachers</li> </ul>
Access to network technologies	Limited access to reliable and affordable mobile technology and internet is challenging educational efforts in the country	<ul style="list-style-type: none"> <li>Digitalization of all components in universities/TVETs</li> <li>Laboratories equipped with the relevant materials, equipment</li> </ul>
Basic infrastructure	Weak basic infrastructure, such as electricity is limiting education in Sierra Leone	<ul style="list-style-type: none"> <li>Mobile technology</li> <li>Equitable internet access</li> <li>Internet for rural schools</li> </ul>

Source: Results from TNA Stakeholder Survey

Several of the stakeholders also indicated that training in the use of computers and in ICT subjects was important for development in the country. This is confirmed by the UNCTAD report discussed in Chapter 2 which evaluated Sierra Leone to lack ICT skills to take advantage of frontier technologies.<sup>2</sup> Considering that digital technologies are enabling technologies needed for development in so many different sectors of society, it is especially important for Sierra Leone to enhance ICT training of its population. Training teachers is a promising step to enhance digital training.

### 3.2.4 Health

In Table 12 the technologies that the survey respondents indicated would be needed to promote development of the health sector are presented.

There was a definite message amongst stakeholders that it was important to improve health services in the country by relying on digital technologies. Remote medicine options were

especially emphasised in order to provide populations in rural areas with quality health care. It is important to be inclusive and provide health services to women and low-income populations. The digital technologies that were mentioned included online health services, e-health, and drone technologies. As discussed in Chapter 2, some groups in the country have started to experiment using drones to deliver health services and this experience will be important in informing further plans in using the technology.

In general, there seems to be a demand for better diagnostics and treatment technologies in Sierra Leone. This can enhance diagnosis of diseases and make the treatment more effective for the benefits of populations in different parts of the country.

With expectations for evidence-based medicine and enhanced diagnosis comes a need for easy access to patients' health records. Many technology options can be pursued

**Table 12. Main challenges and suggestions for technologies in health.**

Activity	Challenges	Examples of specific technologies
Remote medicine	Difficulties to access health services, especially in rural places	<ul style="list-style-type: none"> <li>• Online health care services</li> <li>• Easy to use apps</li> <li>• E-health</li> <li>• Drone delivery of health supplies</li> </ul>
Diagnosis	Availability of accurate diagnosis of health problems is uneven	<ul style="list-style-type: none"> <li>• Accurate diagnostic technologies including advance scanning</li> <li>• Advanced lab equipment</li> </ul>
Treatment	Limited access to good quality treatment for all	<ul style="list-style-type: none"> <li>• Technologies for surgery</li> <li>• Equipment for treatments</li> <li>• Drug supply chain tech</li> <li>• Using quadcopter drone for medical distribution</li> </ul>
Data management	Cumbersome and insecure access to patient data	<ul style="list-style-type: none"> <li>• Have all health information digitalised</li> <li>• Health Management Information System</li> <li>• Use of Unstructured Supplementary Service Data (USSD) for health databases</li> </ul>
Management of health services	It can be challenging to plan and manage health services	<ul style="list-style-type: none"> <li>• ICT to improve health management processes</li> <li>• Health management information systems</li> <li>• E-monitoring of delivery of supplies</li> </ul>
Training	Inadequate training of users of health technologies	<ul style="list-style-type: none"> <li>• Training in the use of technology devices</li> </ul>
Providing network technologies	Uneven, expensive, and unreliable internet access, particularly in rural parts of the country can limit access to ICT intensive health services	<ul style="list-style-type: none"> <li>• Equitable internet access, with a strong focus on rural areas</li> </ul>

Source: Results from TNA Stakeholder Survey

<sup>2</sup> UNCTAD (2021). Technology and Innovation Report 2021. Catching Technological Waves: Innovation with Equity. United Nations Conference on Trade and Development.

in developing this including using USSD (Unstructured Supplementary Service Data). Related to this, there is also a demand to strengthen the management of health services more generally. For example, providing options for making appointments online, can facilitate access. Also using technologies more for inventory assessments and planning can be beneficial.

As in other sectors, it is fundamental for the use of technologies in the health sector to have access to affordable and reliable internet. Unfortunately, this is not always available, especially in rural areas.

### 3.2.5 Infrastructure

The respondents made a few suggestions on how infrastructure can be strengthened in Sierra Leone and thereby enhance its contribution to development in the country (Table 13).

In the suggestion on technologies for infrastructure the stakeholders emphasised that the infrastructure must be well adjusted to the wider environment in Sierra Leone. It has to withstand changing climatic conditions but at the same time be environmentally friendly. There was discussion that there was a demand for more innovation and the development of technological solutions in this sector but also suggestions to use natural building material such as wood and bamboo.

### 3.2.6 Potential technologies in other sectors in Sierra Leone

Apart from these five priority sectors, there is also demand for technologies to contribute to other sectors in the country. Here some examples are presented of how technologies can spur development in sectors that were deemed to be of less priority importance by the stakeholders surveyed (Table 14).

**Table 13. Main challenges and suggestions for technologies in infrastructure.**

Activity	Challenges	Examples of specific technologies
Enhancing buildings	Limited availability of green buildings	<ul style="list-style-type: none"> <li>• Mass timber as building materials</li> <li>• Bamboo as a building material</li> <li>• 3-D printing</li> </ul>
Transportation	Limited transportation infrastructure thwarts efficient development	<ul style="list-style-type: none"> <li>• Improve road network</li> <li>• Build bridges</li> <li>• Lay plastic roads</li> </ul>
Management	It is challenging to ensure that infrastructure meets modern requirements, including being sustainable	<ul style="list-style-type: none"> <li>• Improve standardization regulations for infrastructure</li> <li>• Develop databases</li> </ul>
Access to energy	Lack of access to energy	<ul style="list-style-type: none"> <li>• Improve power generation infrastructure</li> </ul>

Source: Results from TNA Stakeholder Survey

**Table 14. Main challenges and suggestions for technologies in various sectors.**

Sector	Challenges	Examples of specific technologies
ICT	Need to modernise the financial system, and make it more secure and better connected	<ul style="list-style-type: none"> <li>• Introduce cashless payment system</li> <li>• E-banking</li> <li>• National financial switch</li> </ul>
Water	Limited supply of drinking water, especially in rural areas	<ul style="list-style-type: none"> <li>• Rainwater harvesting</li> <li>• Desalination plants</li> <li>• Boreholes</li> </ul>
Environmental monitoring	It is challenging to monitor vast environmental areas to establish if there is a problem that needs to be dealt with	<ul style="list-style-type: none"> <li>• Implementing sensors/monitoring equipment to monitor the groundwater, air, soil quality, sediment loads in streams/rivers, encroachments, deforestation etc</li> <li>• Drones for monitoring protected areas</li> <li>• High resolution satellite maps</li> <li>• LIDAR (Light Detection and Ranging) scanning</li> </ul>
Tourism	It can be challenging to market and manage tourism activities	<ul style="list-style-type: none"> <li>• Digital marketing</li> <li>• Management information systems for tourism</li> </ul>

Sector	Challenges	Examples of specific technologies
Fisheries	It is challenging to monitor vast ocean areas to prevent overfishing	<ul style="list-style-type: none"> <li>• Surveillance (incl online/ app) technologies to discourage illegal, unreported, and unregulated fishing</li> <li>• Drones</li> </ul>
Sanitation	There is a need to clean and recycle waste to improve sanitation	<ul style="list-style-type: none"> <li>• Recycling of wastes, including plastic waste</li> <li>• Hydraulic systems to ensure wastewater is channelled away to treatment plants</li> </ul>
Livestock	It is challenging to produce healthy livestock and increase meat production	<ul style="list-style-type: none"> <li>• Implement quality seed system and preservation for livestock feed</li> <li>• Use organic feeds and medications</li> <li>• E-farming</li> <li>• Breeding to increase meat production</li> </ul>
Mining	It can be challenging to keep up productivity of mines	<ul style="list-style-type: none"> <li>• Large scale mining and processing equipment</li> </ul>
Forestry	It can be challenging to monitor forestry distribution and logging efforts	<ul style="list-style-type: none"> <li>• Tracking logging</li> <li>• Surveillance systems to monitor the distribution of specific tree species and potential biodiversity loss</li> </ul>

Source: Results from TNA Stakeholder Survey

Again, a wide range of technologies can contribute towards development in various sectors. The stakeholders suggested a number of innovative technologies that seem well suited to the conditions in Sierra Leone. Even though these sectors were not considered among the top five priority sectors in the country, they still can contribute to development and are worth considering.

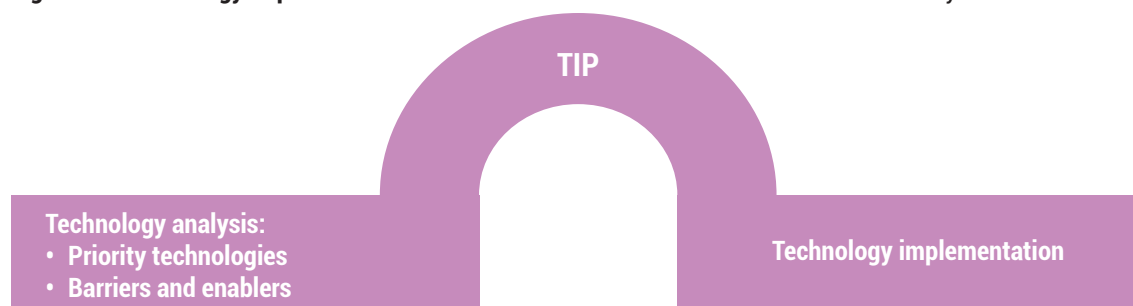
### 3.3 Implementation issues

From the discussion above it is evident that there are a lot of technology options Sierra Leone can pursue, both to address development challenges in the country and also to encourage growth of strategic sectors. Before looking at implementation in detail, it is important to go through a prioritization process and identify a manageable number of technologies that the authorities in Sierra Leone and other

stakeholders would like to pursue. This can be done in different ways, including through a process which examines how well the technologies are aligned with political priorities; through a systemic process of multi-criteria decision analysis involving experts; or a Delphi process involving various stakeholders. After the technologies have been prioritized, a detailed technology implementation plan (TIP) can be developed.

At this stage some implementation issues can be considered without going into the details that are required for a TIP. A TIP is basically a plan for the uptake and diffusion of prioritised technologies. The TIP can be seen as a bridge between the analysis of the prioritised technologies and their implementation (see Figure 12).<sup>3</sup> The TIP will present an overview on what capacity is needed in Sierra Leone to be able to implement the technologies in the

Figure 12. Technology Implementation Plan. Source: Results from TNA Stakeholder Survey



<sup>3</sup> Adjusted from UNEP DTU Partnership, Enhancing Implementation of Technology Needs Assessments Guidance for Preparing a Technology Action Plan.

country. The TIP will consider how particular challenges/barriers that prevent the use of the technology in the country can be addressed and what enabling environment is needed for the technologies to become a reality. The formulation of the TIP should be an iterative participatory process that turns the TNA into an actionable plan and should contribute to the country's social, environmental, and economic development.

The plan needs to include a consideration of various issues including:

- What capacity is needed for the implementation of the technologies?
- What are some of the main barriers/challenges that could prevent the implementation of the technologies?
- What enabling factors can be used to harness the technologies including are there some regulations in place for the deployment of the technologies?
- What is the potential of developing the technologies locally versus gaining access to

them through international procurement?

- What type of technology transfer is needed for the technologies?
- Who should be responsible for implementing each measure and at what cost?
- What kind of support does Sierra Leone need for the successful implementation of the technologies?
- Who are potential funders of the technology?
- What risk factors that can limit the actions and approaches to deal with them?
- What are the environmental implications of these technologies?

In Table 15 a preliminary examination of some key implementation issues of select technologies identified in this TNA is presented. It is indicated in the table if the technology likely can be implemented in the short term (within the next five years); the medium term (between five to ten years); or long term (beyond ten years).

**Table 15. Preliminary Technology Implementation Plan for select technologies.**

Objective	Technology	Responsible organization	Expected users	Capacity/Resources needed
Increasing agricultural outputs	Technologies to improve seedlings (short term); Breeding to increase crop yields (short term); The use of organic fertilizers (short term); Technologies to improve crop varieties (short term); Genetic technology to increase yield of crops (medium term); GMO to make seeds more climate-resilient (medium to long term); Precision farming (medium term); Apps (short term); e-farming (medium term); Blockchain (medium to long term); Using advanced greenhouses (medium to long term)	Ministry of Agriculture and Forestry; Ministry of Planning and Economic Development; Ministry of Information and Communication; Directorate of Science, Technology, and Innovation; University of Sierra Leone; Njala University; Sierra Leone Agricultural Research Institute; Start-ups like Capitol Food; Association for Rural Development (ARD)	Farmers	Agricultural knowledge; expertise in plant biotechnology; Expertise in ICT for precision farming, developing apps and developing blockchains
To enhance access to environmentally friendly energy	Implement renewable energy e.g., microgrid or off grid powerplant (short term); Solar energy (short term); Battery storage for solar energy (short term); Hybrid solar technologies (medium term) Green hydro energy (medium term) Technologies to generate power from waste (medium term) Tri-generation systems (long term)	Ministry of Energy; Ministry of Planning and Economic Development; Ministry of Information and Communication; Directorate of Science, Technology, and Innovation; Sierra Leone Electricity and Water Regulatory Commission; University of Sierra Leone; Njala University; Start-ups such as Solar Era Holdings, Teleficient, Easy Solar and Energen WAP	Energy firms; consumers	Expertise in solar and hydro energy and in other energy options; engineering expertise in energy distribution

Objective	Technology	Responsible organization	Expected users	Capacity/Resources needed
Strengthen access to education in Sierra Leone by enhancing distance education opportunities Environmental monitoring	Distance education with traditional methods (e.g., audio/video broadcasting, audio/video teleconferencing) (short term); Online education (short term); E-learning (online and offline teaching software) (short to medium term); E-library technology (short to medium term)	Ministry of Basic and Senior Secondary Education; Ministry of Technical and Higher Education; Ministry of Information and Communication; Directorate of Science, Technology, and Innovation; University of Sierra Leone; Njala University; Milton Margai College of Education and Technology; Start-ups like Mosabi	Teachers, students	Understanding of teaching and distance and e-learning techniques. Availability of mobile and internet networks
Improve access to medical services in rural areas	Online health care services (short term); Easy to use apps (short term); E-health (short to medium term); Drone delivery (short to medium term)	Ministry of Health and Sanitation; Ministry of Information and Communication; Directorate of Science, Technology, and Innovation; University of Sierra Leone; Njala University; Hospitals/clinics; Start-ups	Health professionals, patients	Expertise in healthcare services; expertise in digital technologies
Design and build green buildings/infrastructure	Mass timber as building materials (short term); Bamboo as a building material (short term); 3-D printing (short term); Specialised technological equipment for building (medium term)	Ministry of Works, Housing, and Infrastructural Development; Ministry of Planning and Economic Development; Directorate of Science, Technology, and Innovation; University of Sierra Leone	Population at large	Expertise in buildings, and natural and innovative materials
To develop a secure and connected financial system	Introduce cashless payment system (short to medium term); E-banking (short to medium term); National financial switch (long term)	Ministry of Finance and Economic Development; Ministry of Information and Communication; Directorate of Science, Technology, and Innovation; University of Sierra Leone; Njala University; Central Bank of Sierra Leone; Start-ups such as MyPay, Noory and SaloneBuy	Banks and population at large	Expertise in financing; expertise in ICT; insight into databases and security issues
To monitor and evaluate the status of different environmental areas all over the country	Sensors/monitoring equipment to monitor the groundwater, air, soil quality, sediment loads in streams/rivers, encroachments, deforestation etc (short to medium term); Drones for monitoring protected areas (short to medium term); High resolution satellite maps (short term) LIDAR (long term)	Ministry of Lands, Country Planning and Environment; Ministry of Planning and Economic Development; Ministry of Information and Communication; Directorate of Science, Technology and Innovation; Environment Protection Agency; Sierra Leone Electricity and Water Regulatory Commission; University of Sierra Leone; Njala University.	Representatives at the Environment Protection Agency and other organisations protecting the environment	Expertise in environmental issues; expertise in monitoring technologies

Source: Results from TNA Stakeholder Survey

### 3.4 Conclusions

It is clear from the discussion in this chapter that the stakeholders surveyed in Sierra Leone, think that technologies can play important roles in promoting development in the country. There seems to be a consensus on a few priority sectors to focus on, which align well with the strategic focus in the Government of Sierra Leone's Medium-Term National Development Plan, 2019-2023. The stakeholders identified a wide range of challenges in the country to which technologies could be applied. They also suggested numerous technologies that could address these challenges.

Some of the suggestions are quite knowledge intensive and perhaps it is not realistic that they will be widely used in the country within the next five to ten years. It may, for example, take some time for farmers in rural areas of the country to gain access to the more technology intensive solutions, whereas others are likely to be more easily available.

Many of the technologies can enhance the lives of women and youth and contribute to more inclusive society in Sierra Leone. They can also have beneficial environmental impact and play a role in reducing the effects of climate change.

Digital technologies feature centrally in the survey respondents' suggestions. This aligns well with the government's emphasis on digital development and its National Innovation and Digital Strategy and the National Digital Development Policy. Many of these technologies are feasible and in use in other countries. It is, however, important for Sierra Leone to strengthen its mobile communication and internet networks in order to be able to harness digital technologies all over the country.



# CHAPTER 04

## Recommendations and conclusions

This STI and TNA in Sierra Leone shows that there are important steps being taken towards strengthening STI in the country and an interest in harnessing STI to a larger extent to address development needs. While the government has not prepared a specific science and technology policy, its Medium-Term National Development Plan, 2019-2023 incorporates some focus on STI themes. The government also has established the DSTI to support its STI mandate across the ministries. DSTI has started to contribute to promoting STI in the country, for example, by developing a National Innovation and Digitalisation Strategy and the National Digital Development Policy which have the ambition to turn Sierra Leone into a digital economy. As digital technologies can enable development of diverse sectors in the country, if successful, they could make a substantial contribution to Sierra Leone's ability to address its development needs and reach the SDGs.

Considering the current status of STI activities in the country, Sierra Leone needs to enhance its standing on several different fronts to be able to reap benefits of STI development. UNESCO has, in a recent report, shown that Sierra Leone's research output is small. It does not seem to be engaging in research on cross-cutting strategic technologies or ICT issues, which is likely to reflect poor capacity for knowledge production in these fields. UNCTAD showed that Sierra Leone is among the least prepared countries in the world to take advantage of frontier technologies. Its ICT and skills ranking are particularly low, which doesn't reflect good opportunities for the country to harness these technologies. The World Economic Forum has shown that Sierra Leone ranks low in terms of its innovation ranking, which will be an obstacle to harnessing knowledge and technologies.

## 4.1 Recommendations to strengthen the STI system

In light of this STI performance, the Government of Sierra Leone needs to strengthen its support for STI development in the country. Starting with the Medium-Term National Development Plan as a blueprint, the government needs to look systematically at each sector and analyse

how furthering STI development could meet the challenges in each. This needs to be based on a systematic examination and grounded in the reality of the country. It should also be based on extensive input from public and private sector organisations and informed by user needs and preferences. The strategy needs to focus on building and connecting components of an innovation ecosystem in the country so the system can work in a coherent manner. The strategy should include a focus to support women and youth entrepreneurs.

**Recommendation A1.** The Government of Sierra Leone is to develop an overarching evidence-based STI strategy for the country, anchored on the Medium-Term National Development Plan, to systematically support research and innovation activities in priority areas. A fund tied to the strategy should be set up that provides competitive grants aimed at solving targeted development needs in the country. The strategy should focus on breaking down silos and encourage domestic collaboration to address development challenges.

The stakeholders who responded to the TNA survey underscored the importance of the country enhancing its network infrastructure. Better internet coverage appears to be instrumental to see the technologies suggested in the different sectors taken into action. For instance, to enhance education and health, particularly in rural areas, it is deemed essential to set up affordable and reliable internet. The stakeholders also discussed that limited internet access was holding back STI development in general.

**Recommendation A2.** The Government of Sierra Leone should, together with multilateral organisations/donors explore options to strengthen internet access in the country. This is particularly needed in rural areas.

A related theme is the need to strengthen skills development in the country to take advantage of frontier technologies. This was emphasised in the recent Technology and Innovation report by UNCTAD but also echoed by the stakeholders who stated that limited skills were a weakness in the STI system. Sierra Leone has a lot of young people, but they need better preparation to be able to harness the power of STI.

This needs to start at schools and teachers must be better prepared in applying and teaching STEM skills. At the higher education level an emphasis should be to include both universities and TVET institutions. Considering the expectation of the country towards digital technologies, this skills development needs to be infused throughout the education sector.

**Recommendation A3.** Substantially strengthen STEM skills development throughout the education system through a special skills development program supported by multi-laterals and other donors. With better skills development the pipeline for start-up development can be strengthened.

To further strengthen youth entrepreneurship and provide opportunities for young people with good ideas, there is scope for the government and others to step up and establish a specific initiative to support youth entrepreneurship. The traditional banking system often lacks understanding of technology intensive enterprises and is unlikely to take on the risk of supporting young people, who often have low credit rating but may have good business ideas. There is, therefore, a need to set up a specific competitive funding mechanism to support young people. Allocating some of the funding to women entrepreneurship would also promote more gender equity in the country. Supporting the private sector in nurturing youth entrepreneurship can also be a part of this initiative as hubs often lack financial means to provide sustained support.

**Recommendation A4.** The Government of Sierra Leone should work with the banking system and multilaterals/donors to support youth entrepreneurship by establishing a funding mechanism aimed at start-up development and to strengthen intermediaries (e.g., hubs, accelerators, and incubators) in Sierra Leone.

Limited funding is just one of the challenges for start-up development and the demanding features of the wider business environment can pose hindrances for technology-based firms. It is important for Sierra Leone to wholistically look at the challenges for start-up development and develop a start-up act that addresses them. The development of the act should

include extensive input from private sector organizations and its development can include the use of innovative tools such as hackathon events with the start-up community and others.

**Recommendation A5.** The start-up community in Sierra Leone should spearhead the development of a start-up act that wholistically addresses challenges for the development of technology-based start-ups.

## 4.2 Recommendations for next steps for the TNA

There are a number of steps that need to be done to follow up on this TNA process. This exercise provides suggestions of technologies to pursue to address development needs in Sierra Leone. As discussed in Chapter 3, a variety of technologies were suggested by the stakeholders which address a range of development needs. In general, there was a relatively strong focus on development needs in rural areas. It is, however, important to prioritize and identify a manageable number of technologies for the UN Technology Bank for the Least Developed Countries to support Sierra Leone to pursue together with other stakeholders. These should be specific technologies and initially not be more than three to five technologies in total. Later, when the implementation for these technologies has started, there is the scope to identify more technologies the Tech Bank can support Sierra Leone pursuing.

**Recommendation B1.** The UN Technology Bank for the Least Developed Countries is to support government representatives and other stakeholders in Sierra Leone to prioritize no more than three to five technologies to implement.

There are different ways to conduct this prioritization. One way is in face-to-face settings when this report is launched. There can be discussion firstly on which sector(s) to focus on and then specifically which technologies to choose. One criterion for the choice of technology is to choose ones those other multilaterals are not working on in Sierra Leone on. Another criterion is to choose a technology that is likely to be implemented in the short to medium term. A third criterion is for the technology to be relevant across sectors.

**Recommendation B2.** The UN Technology Bank is to support Sierra Leone to develop detailed TIPs for the prioritised technologies, which are customized to the features of the technologies and the wider context in Sierra Leone.

After choosing the technologies to focus on the Tech Bank should commission a group to develop an implementation plan for them.

**Recommendation B3.** The UN Technology Bank is to support the authorities to start implementing the prioritised technologies together with stakeholders in Sierra Leone.

The implementation process can start by focusing only on one technology in the beginning or start with two or three technologies. After half to one year of implementation a formative evaluation can be performed to identify lessons learned that can be applied in subsequent implementation of technologies.

As the Tech Bank will be working with a number of LDCs in implementing their prioritised technologies, it is quite likely that more than one country will be pursuing the same technologies. In those cases, the Tech Bank can organize events where representatives from the different countries can meet and exchange lessons on what approaches have worked to promote the technologies. They can even explore if they want to establish some alliances to formally collaborate in promoting the technologies. That will give options to share their strengths with other LDCs and learn from each other's challenges.

**Recommendation B4.** The UN Technology Bank is to encourage South-South collaboration in implementation of the technologies.

Starting to implement these technologies in Sierra Leone can significantly contribute to the country's ability to address its development needs. The TNA also indicates that many technologies can contribute to enhance the quality of life and economic gains of women and youth in Sierra Leone. It can, therefore, make the society more inclusive. In addition, a number of the technologies can lessen environmental deterioration and thereby reduce the detrimental effects of climate change. Harnessing

technologies to a larger extent to solve development problems can help Sierra Leone meet its SDGs and contribute to improve the quality of life, economic growth, and environmental conditions in the country.

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## Appendix - Suggested Technologies

Agriculture	Technologies
General	Technologies that allow agribusinesses to be more profitable, efficient, safer, and more environmentally friendly.
	Automated system for agriculture
Mechanisation	Simple and efficient farm machines and equipment for land preparation
	Tractors equipped with GPS, seed, fertilizer, and pesticide application equipment
	Modern technologies for large scale farming
Crop control	Technologies for improve seedlings
	Breeding to increase crop yields
	Technologies to improve crop varieties
	The use of organic fertilizers
	Integrated and organic farming systems
	Genetic technology to increase yield of crops
	GMO to make seeds more climate-resilient
	Precision farming
	Apps
	E-farming
	Blockchain
	Using advanced greenhouse
Pest control	Pesticide, herbicide
	The use of organic herbicides
	Biological pest control
	Breeding to increase disease resistance
Irrigation	Sub-soil and surface irrigation
Crop management	Technologies for more efficient use of farmland
	Technologies to address which particular crop to use which particular farming method and fertilizer
	Using AI to help the crop rotation
	E-monitoring of delivery of supplies to farming
Environment	Waste management and use
	Bioremediation
	GMO to make seeds more climate-resilient
	Climate smart technologies
Preserving & Processing	Food preservation technologies
	Harvesting and post-harvest operations
	Any investment in storage and process to avoid waste
	Value addition

Marketing	Market access and information
	Mobile money
	E-commerce for farmers
	E-banking
	E-vouchers
	Apps to link farmers to markets
	Fintech
	USSD solutions to give farmers access to market information
Information	Access to farming information through an app or a website - weather, how to plant, what to plant, soil
Training	Training on use of technology gadgets
Communication network	Access to affordable and reliable Internet

Energy	Technologies
General	Technologies to improve general supply of electricity to households and business, as well as ensure sustained revenue generation for the service provider and government
	Increased energy generation and improved transmission
	Use different technologies for energy production, distribution, and transmission
Renewable energy sources	Renewable energy
	Climate smart
	Alternative green energy coverage especially for rural Areas;
	Implementing renewable energy e.g., microgrid or off grid powerplant
	Solar energy
	Battery storage in solar energy
	Hybrid solar technologies
	Green hydro energy
	Technologies to generate power from waste
	tri-generation systems
Energy distribution	Improve electricity distribution network
	Efficient transmission to reduce costs
	Pre-paid energy meters
	Artificial intelligence to energy access and distribution
	E-erergy
Energy conservation	Energy efficiency technologies
	Improve and efficient cooking stoves
	Technologies for monitoring energy management and use
Energy management	Technologies for billing to minimise theft and increase sustainability
Other	Software Application

Education	Technologies
General	Access to global knowledge base
	Creating solutions
	Empowering innovations
	ICT
	Innovative mindset for teaching
	Access to learning materials for example and other 4IR tools
Distance learning	Delivery of the education material
	online education
	E-learning (online and offline teaching software)
	E-library technology
Equipment	Computer access
	Automatic CCTV cameras for exams writing and marking
	Automatic digital grading system
Management	E- database techniques and software programs
	Monitoring of teacher and student absence
Training	Compulsory computer illiteracy
	Basics of internet to enable you use the internet efficiently
	Introduction of ICT as a subject in High school curriculum
	The use of energy software or other educational software
	Training ICT teachers for Schools
Higher education	Digitalization of all components in the university
	Laboratories equipped with the relevant materials, equipment, etc.
	All departments should perform research based on their domain
Management	Payments
	Integrated Financial Management for education sector
Network technologies access	Internet Access
	Internet for rural schools
	mobile technology
Electricity	Reliable energy
	Energy related technologies
	Solar/gravity powered water supply system for rural schools

Health	Technologies
Remote medicine	Online health care services
	Easy to use applications
	E-health
	Drone delivery
Diagnosis	Accurate diagnostics technologies including advance scanning
	Advanced lab equipment
Treatment	Technologies for surgery
	Equipment for treatments
	Drug supply chain tech
	Using quadcopter drone for medical distribution
Data management	Have all health information digitalised
	Health Management Information System
	Use of USSD for health databases
Management	ICT to improve health management processes
	Health management information systems
	Medical schemes
	E-monitoring of delivery of supplies
Training	Training in use of technology gadgets
Network technologies	Internet access, especially in rural areas
Other	Software Application
	Facilities

Infrastructure	Technologies
General	Green infrastructure solutions
	Use emerging technologies
Diagnosis	BIM systems in all government offices
	Mass timber as building materials
	Bamboo as a building material
Equipment	Need technological equipment
	3-d printing
	Machines
Transportation	Improve road network
	Bridge and roads building
	Plastic roads
Management	Improving the standardization regulations for infrastructure
	Develop databases
Energy	Improve power generation
Other	Highly skilled manpower with technological skills to supervise and manage infrastructure development
	Innovative planning and development solutions

ICT	Technologies
General	Improve ICT infrastructure nationwide
	Technologies that make ICT more affordable and accessible
Network technologies	Mobile phone coverage
	Technologies for increased internet in rural communities
	Faster broadband
	Fibre broadband
	Internet exchange points
Education system	Introduction of ICT into schools and tertiary institution
	Digital literacy
	E-learning
	Virtual Classroom
Finance	Introduce cashless payment system
	E-banking
	National financial switch
Governance	E-parliament
	Digitizing records and registration of instruments such as land documents
Multi sector ICTs	Appropriate ICT solutions in all sectors to promote processes
	Blockchain
	Artificial intelligence and machine learning
	Quantum computing
	Edge computing
	Robotic Process Automation
Information	E-information dissemination

Water	Technologies
General	Production of improved drinking water
	Water sufficiency
Water purification	Technologies for effective water treatments and purification test
	organic water cleaning substances
	Solar powered water filtration
	Treat water well
Water sources	Rainwater harvesting.
	Desalination plants
	Boreholes
Water management	Water management and irrigation to support all-star round production
	Safe and stainless water channel pipes
	Geolocation and planning
	Gravity systems
	Real time monitoring and supervision in management of infrastructure and payment system and enforcement
	USSD and other tech solutions

Environment	Technologies
Environmental treatment	Wastewater treatment plant
	Technologies to convert harmful pollutants to less harmful ones
	Prevent plastic waste entering drainage systems,
	Recycle plastic at source
Environmental conservation	Technologies for conservation
	Technologies for afforestation
Environmental monitoring	Implementing sensors/monitoring equipment to monitor the groundwater, air, soil quality, sediment loads in stream/river, encroachments, Deforestation
	Drones for monitoring protected areas
	High resolution satellite maps
	LIDAR
Environment management	Water catchment and harvesting
	Weather forecasting technologies
	GIS
	Real data analyses
	Efficient means to address environmental disaster
Outreach	There is the need to sensitize the public using technologies

Tourism	Technologies
Marketing	Digital marketing
Management	Management information systems for tourism

Fisheries/marine	Technologies
Monitoring technology	Surveillance (incl online/ app) tech to discourage illegal, unreported and unregulated fishing
Processing	Fish processing technology
	Any technology that will increase shelf life of fisheries products
Productivity	Technologies to improve fish farming such as fishponds, processing and storage facilities
	New Intensive Pond Technologies for aquaculture
Disease prevention	National database on fish diseases

Sanitation	Technologies
Treatment technologies	Recycling of wastes, including plastic waste
	Hydraulic systems to ensure wastewater is channelled away to treatment plants
Monitoring technologies	Monitor the level of waste being generated at the landfill site
	Monitoring the level of cleanliness of areas around the city

Livestock	Technologies
Livestock handling	Implement quality seed system and preservation for livestock feed
	Use organic feeds and medications
	E-farming
	Breeding to increase meat production
Management	E-financing
	National database on animal diseases
	Simple and efficient livestock management equipment
Processing	Technologies to improve meat processing, packaging, and storage

Mining	Technologies
Productivity	Large scale mining and processing equipment

Forestry	Technologies
Marketing	Logging tracking
	Surveillance systems
	Identify which family or specific tree, native to the original rains forest is planted where
Yield	Technologies to encourage sustainable regrowth

