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The state of science, technology and innovation in the least developed countries

Country Case Studies

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Acronyms and abbreviations

AFD	French Development Agency
AfDB	African Development Bank
AGOA	African Growth Opportunities Act
AI	Artificial intelligence
ANVAR	National Agency for the Valorization of Research Results and Innovation (Burkina Faso)
ASEAN	Association of Southeast Asian Nations
BCEAO	Central Bank of West African States
BERD	Businesses' expenditure on research and development
BPD	Barrels per day
BSL	Bank of Sierra Leone
CDAIS	Capacity Development for Agricultural Innovation Systems
CDC	Centers for Disease Control and Prevention
CEO	Chief executive officer
CIPMEN	*Centre Incubateur des Petites et Moyennes Entreprises* (SME Incubator Center)
CNPC	China National Petroleum Corporation
CNRA	National Council for Agronomic Research (Niger)
CNRST	National Centre of Scientific Research and Technology (Burkina Faso)
CROP	Council of Regional Organisations of the Pacific
CSA	Climate-smart agriculture
CSDG	Cambodia Sustainable Development Goals
CSR	Corporate social responsibility
DAS	Drone Africa Service
DHSE	Directorate of Health Security and Emergencies
DSTI	Directorate of Science, Technology and Innovation
EAC	East African Community
ECOSOC	Economic and Social Council
ECOWAS	Economic Community of West African States
ECTIM	Strategy for Science, Technology and Innovation of Mozambique
EEMS	Electronic Expenditure Management System
EVI	Economic and Environmental Vulnerability Index

FAO	Food and Agriculture Organization
FDI	Foreign direct investment
FNI	National Innovation Fund (France)
FONRID	National Fund for Research and Innovation for Development (Burkina Faso)
FRSIT	National Forum of Scientific Research and Technological Innovations (Burkina Faso)
FTE	Full-time equivalent
GBV	Gender-based violence
GDP	Gross domestic product
GII	Global Innovation Index
GIS	Geographic Information System
GNI	Gross national income
GNP	Gross national product
GOVERD	Government expenditure on research and development
HAI	Human Assets Index
HERD	Higher learning institutions' expenditure on research and development
HIC	High-income country
HIV	Human immunodeficiency virus
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and communications technology
IDEE	Initiatives for the Development of Enterprise
IEA	International Energy Agency
ILO	International Labour Organization
ILRI	International Livestock Research Institute
IMF	International Monetary Fund
INRAN	National Institute of Agricultural Research (Niger)
INRB	National Institute for Biomedical Research (Democratic Republic of the Congo)
IOM	International Organization for Migration
IoT	Internet of Things
IPOA	International Plan of Action
IT	Information technology
ITU	International Telecommunication Union
IVR	Interactive voice response
JAXA	Japan Aerospace Exploration Agency
LDC	Least developed countries
LNG	Liquid natural gas
LPDR	Lao People's Democratic Republic

M&E	Monitoring and evaluation
MGC	Matekane Group of Companies
MIC	Middle-income country
MICE	Meetings, Incentives, Conferences and Events
MISTI	Ministry of Industry, Science, Technology and Innovation (Cambodia)
MOST	Ministry of Science and Technology
MSME	Micro, small and medium-sized enterprises
MZN	Mozambican metical
NDP	National Development Plan
NDS	National Development Strategy (Solomon Islands)
NGO	Non-governmental organizations
NIDS	National Innovation and Digitization strategy
NSDP	National Strategic Development Plan (Lesotho)
NSEDP	National Socio-Economic Development Plan (Lao People's Democratic Republic)
NUL	National University of Lesotho
OACPS	Organisation of African, Caribbean and Pacific States
ODA	Official development assistance
OECD	Organisation for Economic Co-operation and Development
OLPC	One Laptop per Child
PAASEC	Climate-Sensitive Agriculture Support Program (Niger)
PCR	Polymerase chain reaction
PCT	Patent Cooperation Treaty
PETS	Public Expenditure Tracking System
PISCCA	Innovative Projects from Civil Societies and Coalition of Actors
PIURN	Pacific Islands Universities Research Network
PNDES	National Plan for Economic and Social Development (Burkina Faso)
PRACC	Competitiveness and Growth Support Project
PRODEC	Skills Development for Growth Project
PV	Photovoltaic
QNI	National Framework of Sustainable Development Goal Indicators (Mozambique)
QR	Quick response
R&D	Research and development
REC	Rwanda Education Commons
RSA	Rwanda Space Agency
RSSB	Rwanda Social Security Board
SACU	Southern African Customs Union

SADC	Southern Africa Development Community
SAMOA	States Accelerated Modalities of Action
SCAPP	National Strategy for Accelerated Growth and Shared Prosperity (Mauritania)
SDG	Sustainable Development Goal
SFM	Sustainable forest management
SID	Statistics and Informatics Division (Bangladesh)
SIDS	Small Island Developing States
SME	Small- and medium-sized enterprises
SMEDA	Small and Medium Enterprise Development Agency
SPCR	Strategic Program for Climate Resilience (Cambodia)
STEM	Science, technology, engineering and mathematics
STI	Science, technology and innovation
STIP	Science, Technology and Innovation Policy
SWOT	Strengths, weaknesses, opportunities and threats
TRIPS	Trade-Related Aspects of Intellectual Property
TVET	Technical and vocational education and training
UEMOA	States in the West African Economic and Monetary Union
UNCDP	United Nations Committee for Development Policy
UNCSTD	United Nations Commission on Science and Technology for Development
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNSD	United Nations Statistics Division
USAID	United States Agency for International Development
USSD	Unstructured Supplementary Service Data
WAAPP	West Africa Agricultural Productivity Programme
WHO	World Health Organization
WiCCS	Women in Climate Change Science
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
YAWWA	Youth, Advocacy, Women, Work and Alliances

Introduction

The following report contains detailed case studies describing the state of science, technology and innovation (STI) in 15 least developed countries (LDCs). Complementing the high-level chapter, this section provides a deep dive into each of the featured countries. Rather than representing a detailed mapping of the STI ecosystem in each country, however, the case studies describe the opportunities for growth and the extent to which they are currently being seized or missed.

All featured countries are designated as least developed countries at the time of writing. The identification of least developed countries is currently based on three criteria: income, human assets and economic and environmental vulnerability.[1] The latter two measures are assessed by two indices of structural impediments, namely the Human Assets Index and the Economic and Environmental Vulnerability Index. The least developed country category was established in 1971 by the United Nations, and since then, just six countries have graduated from the category. The category is revised every three years by the United Nations Committee for Development Policy (UNCDP), a subsidiary body of the United Nations Economic and Social Council (ECOSOC). The requirement for graduation from least developed country status is overseen by the UNCDP, and monitoring of the country's progress continues after graduation.

The featured countries were selected to provide as broad a range as possible of countries according to the following criteria:

- Eligibility for graduation from least developed country status
- Geographical location
- Size of population

Table 0.1. Selected countries featured in the report

	Eligibility for graduation from least developed country status	Geographical location	Size of population
Bangladesh	Scheduled for graduation in 2026	Asia	Very large
Burkina Faso	Not eligible	Africa	Medium
Cambodia	Met eligibility criteria for first time; will be considered for graduation in 2024	Asia	Medium
Democratic Republic of Congo	Not eligible	Africa	Very large
Kiribati	Recommended for graduation by the UNCDP, under consideration by ECOSOC	Pacific Island State	Small
Lao People's Democratic Republic	Scheduled for graduation in 2026	Asia	Medium
Lesotho	Not eligible	Africa	Medium
Mauritania	Not eligible	Africa	Very large
Mozambique	Not eligible	Africa	Medium
Myanmar	Met eligibility criteria but decision on recommendation for graduation deferred until 2024 due to political instability	Asia	Medium

1 "Income" is measured by gross national income per capita; "human assets" is measured through the Human Assets Index (which measures the level of human capital) and "economic and environmental vulnerability" is measured through the Economic and Environmental Vulnerability Index (which measures structural vulnerability to economic and environmental shocks).

	Eligibility for graduation from least developed country status	Geographical location	Size of population
Niger	Not eligible	Africa	Medium
Rwanda	Not eligible	Africa	Medium
Sierra Leone	Not eligible	Africa	Medium
Solomon Islands	Scheduled for graduation in 2024	Pacific Island State	Small
Tuvalu	Recommended for graduation by the UNCDP, under consideration by ECOSOC	Pacific Island State	Small

The data for case studies were obtained by an extensive desk review of relevant documentation (policy and strategic documents, academic articles, international organization reports, etc.) and stakeholder interviews. Interviewees from a broad range of stakeholder groups were sought out to provide as many different perspectives as possible (see Appendix A for interview guides). The consulted stakeholder groups included the following sectors:

- Governments
- Higher education
- Research centres
- Think tanks
- Supporting institutions such as incubators and accelerators
- Private sector
- Civil society
- Financers
- Grass-roots organizations

See Appendix B for a summary of stakeholder consultation by country.

Finally, each case study contains a series of infographics describing indicators relevant to STI. To achieve an overview of the level of activity of the least developed countries in the four chosen thematic areas, three highly innovative software programs were used:

- Scopus, a global database of scientific papers and books
- Meltwater, a firm that gathers social media posts and news articles with a global coverage
- Crunchbase, a firm that collects information about innovative companies worldwide

The data gathered by these programs have been used to construct innovative indicators on the state of STI in least developed countries, and four thematic areas have been chosen. See Appendix C for a detailed explanation of the way in which data were collected and used.

1. Bangladesh

Figure 1.1. Least developed country status indicators for Bangladesh

Asia
Bangladesh

Population
164 million (2020)

LDC status
Scheduled for graduation in 2026

Well-being		
Human Assets Index *(composed of six indicators)* 75 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 14% (2016) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 85 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 1,826 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 6% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 8% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 27 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 4% (2017) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 95% (2017) LDC median: 89% *Source: ILO*

1.1 Country profile

Bangladesh is a country in South Asia.[2]
Over the last two decades, Bangladesh has achieved remarkable economic progress: the country's gross domestic product (GDP) more than trebled in real terms between 2000 and 2019. The average GDP growth rate was 4.8 per cent, 5.8 per cent and 6.8 per cent in the 1990s, 2000s and 2010s respectively. In recent years, Bangladesh has featured among the fastest growing

2 Unless otherwise stated, all data in this paragraph come from United Nations Conference on Trade and Development "Vulnerability profile of Bangladesh" (2020). Available at https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/CDP-PL-2021-4A-VP.pdf. Accessed on 13 December 2021.

economies in the world, with GDP expanding at a rate of more than 7 per cent between 2016 and 2019,[3] until the COVID-19 pandemic struck in 2020 when GDP growth slowed to 2.4 per cent. The latest projections of the World Bank are 3.6 per cent for 2021, 5.1 per cent for 2022 and 6.2 per cent for 2023. A gradual decline in the rate of demographic expansion has gone hand in hand with economic buoyancy thanks to a successful population management policy, with the population growth rate falling steadily from 2.35 per cent in 1991 to 1.90 per cent in 2001, 1.15 per cent in 2011 and 1.03 per cent in 2019. This decline, and the associated demographic transition, have amplified the effect of the economic boom in terms of average income per capita. Further, economic growth appears to be inclusive, with the percentage of the population living in extreme poverty dropping from 44 per cent in 1991 to 14 per cent in 2016.[4]

> **This economic development is a remarkable transformation from the days when Bangladesh was an impoverished region of Pakistan.**

The country remained one of the world's least developed countries for decades, before it reached lower-middle-income country status in 2015. It now outperforms Pakistan on several economic indicators, its GDP per capita is expected to be higher than that of India in real terms by 2030,[5] and it is scheduled to graduate from the United Nations list of least developed countries. Indeed, at the 2018 triennial review of the list of least developed countries by the UNCDP, Bangladesh had fulfilled all three criteria for graduating to developing county from the bracket of least developed countries, and at the 2021 triennial review the UNCDP recommended Bangladesh for graduation, noting that it continues to meet all three criteria for graduation with comfortable margins, following years of steady development progress.[6] ECOSOC has endorsed the UNCDP's recommendation that Bangladesh should graduate from the list of least developed countries.[7] However, the UNCDP also recommended that various United Nations organizations monitor future development closely, out of concern that eligibility would not be reached at the 2024 triennial review, principally due to the slowing of development resulting from the COVID-19 pandemic.[8]

Economic growth during the last two decades has been driven by the expansion of manufacturing and services, alongside a significant rise in agricultural productivity. A policy of industrialization has gradually been deployed since the mid-twentieth century, and the clothing industry in particular expanded rapidly in the late twentieth century. A main driver of today's growth is the transformation of Bangladesh into a garment manufacturing hub on a global scale, with the country now the second-largest exporter of textiles in the world after China.[9] The ready-made garment and textile industry is the largest employment sector in Bangladesh: in 2018, out of the 69 million total workforce of the country, the ready-made garments and textile industry was thought to generate around 4.5 million jobs,[10] i.e. around 7 per cent of total employment. The ready-made garments industry accounted for about 5 per cent of GDP and 83 per cent of national exports in the 12 months to June 2020.[11] Moreover, between 2010 and 2015, the pharmaceutical industry almost doubled its earnings, and contributed

3 World Bank data: 7.1 per cent in 2016, 7.2 per cent in 2017, 7.9 per cent in 2018 and 8.2 per cent in 2019: World Bank Group, "GDP growth (annual % - Bangladesh)", World Bank database. Available at https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=BD. Accessed on 23 December 2021.

4 World Bank, "The World Bank in Bangladesh: overview–context", 3 October 2021. Available at https://www.worldbank.org/en/country/bangladesh/overview#1. Accessed on 13 December 2021.

5 Asia Unbound, "To reach its economic dreams, Bangladesh needs to rethink healthcare", Council on Foreign Relations, 17 June 2021. Available at https://www.cfr.org/blog/reach-its-economic-dreams-bangladesh-needs-rethink-healthcare. Accessed on 13 December 2021.

6 UNCTAD, "Vulnerability profile of Bangladesh". The country outperformed the average annual GDP growth rate of least developed countries since 2010, and that of South Asia in the years prior to the pandemic. Moreover, unlike the other least developed countries, Bangladesh has not suffered any contraction in real GDP per capita since 1989, notwithstanding instances of slowdowns and occasional political crises.

7 United Nations Economic and Social Council, *Resolution adopted by the Economic and Social Council on 8 June 2021,* E/RES/2021/11 (2021). Available at https://documents-dds-ny.un.org/doc/UNDOC/GEN/N21/149/60/PDF/N2114960.pdf?OpenElement. Accessed on 23 May 2022.

8 United Nations Committee for Development Policy, "The 2021 triennial review of the list of LDCs", 2021. Available at www.un.org/development/desa/dpad/wp-content/uploads/sites/45/CDP-excerpt-2021-3.pdf. Accessed on 13 December 2021.

9 Stefan Trines, "Education in Bangladesh", *World Education News + Reviews*, 1 August 2019. Available at https://wenr.wes.org/2019/08/education-in-bangladesh. Accessed on 13 December 2021.

10 Akhi Akter, "Employment trends in 2018 in Bangladesh textile and apparel industry", *Textile Today*, 2 January 2019. Available at https://www.textiletoday.com.bd/employment-trends-2018-bangladesh-textile-apparel-industry/. Accessed on 13 December 2021. However, no comprehensive study detailing the exact employment figures in the sector has been found.

11 United Nations Educational, Scientific and Cultural Organization, *UNESCO Science Report: The Race Against Time for Smarter Development* (Paris, 2021).

1.85 per cent of GDP in 2016–2017.[12] Bangladesh is today the largest exporter of pharmaceutical products among least developed countries. Software development and related services such as web design and maintenance are also currently booming in Bangladesh. Finally, the country's automobile industry is gradually migrating from the assembly of parts produced abroad towards value added manufacturing,[13] in line with the country's draft Automobile Development Policy, 2020. By 2019, value added manufacturing was contributing 19 per cent of GDP in Bangladesh, up from 16 per cent in 2012.[14]

Despite the positive development of Bangladesh, there are challenges to its sustained economic growth. Specifically, it has a high export concentration (overreliance on low-tech textile and clothing products) and heightened proneness to climate change and natural hazards.15 Indeed, Bangladesh and India are considered the two countries most vulnerable to the impacts of climate change over the next 30 years.16 Moreover, Bangladesh continues to provide refuge for Rohingya refugees from Myanmar in one of the world's largest refugee emergencies, putting pressure on the country's environment, infrastructure and social services. Finally, Bangladesh remains marred by significant social problems, such as rapid and uncontrolled urbanization, overcrowding, pollution, inadequate health care, high child mortality rates, land scarcity and severe urban/rural disparities.

1.2 Key development challenges

1.2.1 Priorities of the national development agenda

Regarding high-level policy documents, the Sustainable Development Goals (SDGs) are well aligned with the seventh Five Year Plan (2016–2020), the flagship strategic document of the Government of Bangladesh; in fact, the 2030 Agenda for Sustainable Development was a key guiding document in the selection of development priorities in the national context of Bangladesh. The Government has adopted "Vision 2041", a continuation of its "Vision 2021", that seeks for Bangladesh to eliminate extreme poverty and reach upper-middle-income country status by 2031, and high-income country status by 2041 with poverty approaching extinction. The Government has also prepared its eighth Five Year Plan (2021–2025) and approved its second Perspective Plan with the aim to fulfil Vision 2041. Following a reallocation of responsibilities from the Government to relevant ministries and divisions, designating them as leads, co-leads or associates for the implementation of the SDG targets, the ministries and divisions have prepared a SDGs National Action Plan highlighting new projects, programmes and policies to be implemented in the coming years to achieve the SDGs by 2030.

An SDG monitoring and evaluation framework was also set up by the Government of Bangladesh in 2018 to set targets for the indicators of the SDGs, with three milestone targets set for 2020, 2025 and 2030 (i.e. by the end of the seventh, eighth and ninth Five Year Plans respectively). Furthermore, Bangladesh has introduced the Annual Performance Agreement, a results-based performance management system, across the whole spectrum of the public sector with a view to improving efficiency and ensuring transparency and accountability. The Government has integrated the SDG targets into the Annual Performance Agreement system so they can be incorporated into the annual workplan of the ministries and divisions. An innovative online SDG tracker,[17] a web-based data repository system, has been launched to assist the monitoring of the implementation of the SDGs in the country, with all the data-generating ministries providing data on the platform.

Finally, the governance and institutional mechanisms created for the implementation of the SDGs in Bangladesh are worth noting,[18] as is the way the country has managed to involve the population in its development agenda and create a strong stakeholder ownership of the SDGs. The Prime Minister formed an interministerial SDGs Implementation and Review Committee, composed of secretaries from 20 ministries, and a high-level position of Principal Coordinator for SDG Affairs has been created in the Office of the Prime Minister. Moreover, a SDG Working Team has been formed, tasked with providing recommendations to the Committee,

12 UNESCO, *UNESCO Science Report*, based on data from the Bangladesh Association of Pharmaceutical Industries and the Bangladesh Bureau of Statistics.
13 Ibid. based on data from the Government of Bangladesh.
14 Ibid. based on data from the World Bank.
15 UNCTAD, "Vulnerability profile of Bangladesh".
16 David Maxwell Braun, "Bangladesh, India Most Threatened by Climate Change, Risk Study Finds", *National Geographic*, 20 October 2010. Available at https://web.archive.org/web/20160503045634/http:/voices.nationalgeographic.com/2010/10/20/bangladesh_india_at_risk_from_climate_change/. Accessed on 13 December 2021.
17 See https://sdg.gov.bd/.
18 Bangladesh, Ministry of Planning, *Bangladesh Voluntary National Reviews (VNR) 2020* (Dhaka: General Economics Division, Bangladesh Planning Commission, 2020).

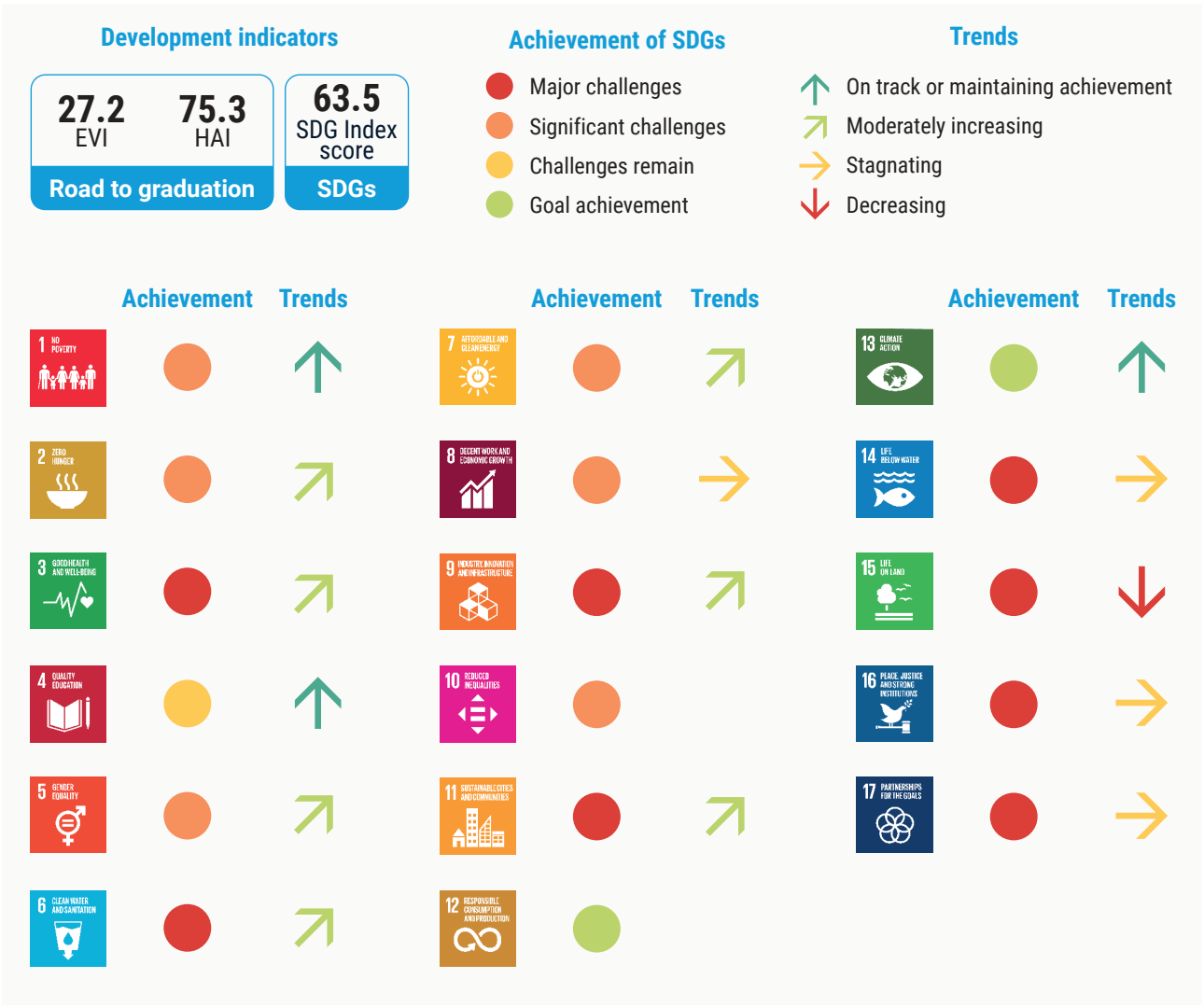
comprising 14 members including representatives of the Government, academia, civil society organizations (CSOs) and the private sector. In addition, three additional committees have been set up for better local implementation and coordination on the SDGs at the divisional, district and subdistrict levels.[19]

The Government of Bangladesh has also formed a National Data Coordination Committee composed of 50 members, tasked with identifying data gaps and ensuring the availability of quality data relating to the SDGs.[20] In 2018 the Government launched the National Conference on SDG Implementation Review, which gathered 2,000 participants from the Government, non-governmental organizations (NGOs), CSOs, the private sector and development partners, and which is intended to be held every two to three years (owing to the COVID-19 pandemic, the planned April 2020 meeting of the National Conference was postponed). Finally, all ministries and divisions coordinating on the SDGs must complete consultations twice in a year with all relevant stakeholders and submit reports to the Principal Coordinator for SDG Affairs.

1.2.2 Level of achievement of the SDGs

Bangladesh has already achieved its target for SDG 13 (climate action), as described in more detail in the subsections that follow.

Figure 1.2. Progress on the SDG index in Bangladesh



Source: Adapted from Sachs and others (2021).

19 These committees include representatives of non-governmental organizations, CSOs, business and professional bodies, and marginalized groups. Members of Parliament from specific constituencies have been appointed as advisers to the committees.
20 This Committee includes representatives from all data-producing government agencies and business associations, think tanks and academia.

Significant challenges remain in SDG 3 (good health and well-being; but modest progress is being made) and SDG 10 (reduced inequalities), also described below. In terms of SDG 2 (zero hunger) and SDG 7 (affordable and clean energy), significant challenges remain, but Bangladesh is making modest progress towards achieving its goals in these domains.

- **Agriculture, food and energy**

Bangladesh has achieved remarkable progress in the eradication of hunger and in food security, and it is now self-sufficient in major food production.[21] Agricultural production value has increased faster than in most of the country's regional peers at 3.54 per cent per year in the last two decades (1999–2019). However, food self-sufficiency is threatened by a decrease of arable land by 0.4 per cent per year, an increasing population, and declining output growth with the share of agriculture in GDP decreasing from 22.7 per cent in 1999 to just 12.7 per cent in 2019. Other major challenges regarding agricultural growth include the lack of agricultural diversification, rice-focused agricultural policies, poor logistics and transportation, limited processing and commercialization, weak food safety and quality regulations, recurrent natural disasters, and the negative effects of climate change.

> **Bangladesh has made considerable headway in increasing access to electricity and power generation capacity. The proportion of the population with access to electricity increased to 96 per cent in January 2020, from 76 per cent in 2015 and 31 per cent in 2000.[22]**

However, the sector faces challenges in ensuring reliable power supply mostly because of distribution breakdowns, inefficiency related to the aged grid, and inadequate transmission and distribution networks. The country's Power System Master Plan 2016 has been prepared for managing the electricity sector up to 2041, but adequate financing is a major challenge to the plan's implementation. Regarding renewable energy, the share in final energy consumption in 2019 was just one third (3.3 per cent) of the 10 per cent target for 2030,[23] which can be explained by several factors: scarcity of suitable land for solar parks, low solar radiation, low wind speeds, lack of local expertise and dependency on foreign experts.

- **Climate change and environment**

The geographical position of Bangladesh renders it especially vulnerable to the adverse impacts of climate change. The Global Climate Risk Index ranks Bangladesh as the world's seventh most affected country over the period 2000–2019,[24] with the estimated average annual cost of disaster to Bangladesh at around 1–2 per cent of GDP.[25] However, Bangladesh was hailed as a global leader in disaster risk reduction by former United Nations Secretary-General Ban Ki-moon. Indeed, the Government of Bangladesh has, over the years, adopted measures to establish an elaborate disaster management system involving the central and local governments, NGOs, and community-level organizations to mitigate impacts of disaster and disaster-related risks. The Government has formulated a long-term Bangladesh Delta Plan 2100 aiming to ensure water and food security, economic growth and environmental sustainability while effectively coping with natural disasters, climate change and other delta issues.

- **Health, inequalities and well-being**

In 2018, Bangladesh spent 2.3 per cent of its GDP on health – well below the average for all LDCs, which was 4.02 per cent.[26] However, although the public health investment of Bangladesh is comparatively lower with respect to GDP than comparable countries, its health outcomes appear to be better.[27] In 1990, the life

21 Data in this paragraph are drawn from World Bank, "The World Bank in Bangladesh: overview–results", 3 October 2021. Available at www.worldbank.org/en/country/bangladesh/overview#3. Accessed on 13 December 2021.
22 Bangladesh, Ministry of Planning, *VNR 2020*; UNESCO, *UNESCO Science Report*.
23 UNESCO, *UNESCO Science Report*.
24 David Eckstein, Vera Künzel and Laura Schäfer, Global Climate Risk Index 2021 (Bonn: Germanwatch e.V., 2021).
25 This includes losses in lives, livelihoods and health, and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. The five pillars of United Nations Office for Disaster Risk Reduction (UNISDR) data collection methodology are: a standard definition of hazards and their impacts; a standard set of common indicators, plus unlimited custom indicators; wide coverage of disasters, regardless of scale; disaggregation of data to subnational units (such as county or municipality); and the local collection and validation of data within the country. UNISDR, *UNISDR Annual Report 2014* (Geneva, 2015).
26 World Bank Group, "Current health expenditure (% of GDP) - Bangladesh, Least developed countries: UN classification", World Bank database. Available at https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS?locations=BD-XL (accessed on 13 December 2021).
27 Bangladesh, Ministry of Planning, *VNR 2020*.

expectancy at birth was 56.1 years; by 2018, it reached 72.3 years.[28] Progress on maternal and child health and nutrition, as well as fertility, has been better than would be expected given the low level of public expenditure on health in Bangladesh.[29] Credit might be given to low-cost interventions (such as the innovation of oral rehydration saline, a Bangladeshi invention that has drastically reduced diarrhoea-related mortality) and to the services provided by community clinics, one for every 6,000 rural people, which provide free medicines. Additionally, the Government approved the National Social Security Strategy in 2015 and its accompanying Action Plan (2018), with a view to addressing poverty, inequality, risk and vulnerability in the country; however, efforts in this regard are still hampered by fragmentation, poor targeting, inefficiency and leakage,[30] and existing programmes need to be better coordinated and integrated to ensure inclusive coverage of vulnerable populations.[31]

Regarding income inequalities,[32] Bangladesh has been experiencing an increasing trend in inequality: whereas the national Gini coefficient stood at 0.388 in 1991–1992, it hit 0.482 in 2016, showing increased income inequality. With the consistent economic expansion in Bangladesh, rising inequality indicates that the poor gain less in absolute terms from growth. However, the consumption-based Gini coefficient has barely changed over time (0.329 in 1995–1996 and 0.324 in 2016). Besides, the rural/urban gaps in inequality, as evidenced by both income and consumption Gini coefficients, have reduced over the years.

> **As far as gender equality is concerned, Bangladesh ranked fiftieth in the world in the Global Gender Gap Index in 2020.**

Bangladesh is the only one of the seven South Asian countries to feature in the top 100 of the Global Gender Gap Index.[33] However, despite having scored better than any of its South Asian neighbours, and even though the Government of Bangladesh has adopted several legal and policy measures to uphold the rights of women in the country, there is still scope for improvement in the empowerment of women.

1.2.3 Relevance of STI to solving these development challenges

Science and technology can play a decisive and pivotal role in achieving the national goals on poverty reduction and ensuring sustainable development through value addition to resources, job creation, reducing environmental pollution, the control and mitigation of natural hazards, increasing production and improving the living standards across different strata of the population. The National Science and Technology Policy of Bangladesh, adopted in 2011, identified several priority areas for science and technology research in Bangladesh: green technology, ecosystems as carbon sinks, information and communications technology (ICT), biotechnology and nanotechnology, and basic science. More specifically on STI, the current eighth Five Year Plan aims to ensure access to the Internet for all and the digitization of 90 per cent of government services by 2021. The plan prioritizes a number of issues relating to this goal: quality education, job creation, the creation of an environment for research and innovation, the increasing of information technology (IT)-based capabilities including in rural areas, the development of branding in the IT sector, the creation of information and communications technology infrastructure, and ensuring a conducive environment for investment. Finally, in the 2018 ICT Policy, specific objectives on education,

28 Bangladesh Bureau of Statistics, *Report on Bangladesh Sample Vital Statistics 2018* (Dhaka: Statistics and Informatics Division (SID), Ministry of Planning, 2019).
29 World Bank, "The World Bank in Bangladesh: overview–results".
30 According to the World Bank, "Allocation of resources across 140 programmes under 20 ministries reduces the impact of programmes and gives rise to duplication in programme objectives and beneficiaries. Poor targeting means only a third of eligible Bangladeshis participated in least one social assistance programme in 2010. Of those programme participants, almost 60 per cent recipients were non-poor. Also, a large share of resources allocated for SSN programmes – whether cash or food – do not reach beneficiaries, and programmes aimed at children under five years and at the elderly and people with disabilities in many cases are limited." World Bank, "Bangladesh: promoting more effective social protection and labour initiatives", 7 October 2016. Available at https://www.worldbank.org/en/results/2016/10/07/promoting-more-effective-social-protection-labor-initiatives. Accessed on 13 December 2021.
31 International Labor Organization, "Social protection in Bangladesh", n.d. Available at https://www.ilo.org/dhaka/Areasofwork/social-protection/lang--en/index.htm. Accessed on 13 December 2021.
32 Data in this paragraph are from Bangladesh, Ministry of Planning, *VNR 2020*.
33 World Economic Forum, *Global Gender Gap Report 2020* (Geneva, 2019). The Global Gender Gap Index measures the extent of gender gaps on four key dimensions (economic participation and opportunity, educational attainment, health and survival, and political empowerment), and tracks progress towards closing these gaps over time. The index measures the "distance completed to parity", meaning the higher the score, the lower the gender gap that remains to be closed.

research and innovation were set to promote research and development (R&D) in the sphere of information and communications technology.

- **Examples of how STI were applied to development challenges**

There are several concrete examples of the use of STI in Bangladesh, notably in the health sector.[34] Indeed, the success of Bangladesh in the use of information and communications technology for health has drawn global attention. In 2011, Bangladesh received the South-South Award, Digital Health for Digital Development, for its advances in digital health that have enabled the free treatment of malaria and tuberculosis patients, as well as AIDS screening up to district level. These developments represent significant progress towards achieving success on the attainment of Millennium Development Goals (MDGs) 4 and 5, reduce child mortality and improve maternal health. Further, not only have laptops and tablets been provided for community clinics and other field-level workers, but a Health Identifier Code has also been provided to every citizen, used in linking the health record software with the national ID card database. Also worth noting is the Intelligent Dengue Tracking and Management System, the first comprehensive disease management system in Bangladesh which monitors, tracks, visualizes and predicts the incidence of dengue, and in turn aids in the early public health mitigations to minimize morbidity and mortality related to the disease. Lastly, a paperless management information system has also been achieved in the health sector.

Bangladesh is very vulnerable to the adverse impacts of climate change, but has adapted well to the new challenges, and in 2005 made adaptation an organized national endeavour with the National Adaptation Programme of Action. One way Bangladesh has adapted to climate change is by harnessing nature-based adaptation technology. In order to combat the scarcity of fresh water, rainwater harvesting systems have been put in place on the southwest coast of Bangladesh. Drip irrigation technology is used to make sufficient water available for crop irrigation, and new rice and other crop varieties have been developed in the agricultural research institutes of Bangladesh that are tolerant of salinity, flooding and drought. Finally, to make use of waterlogging, a common effect of climate change, crops are cultivated and seedlings raised on floating gardens, rafts of rotten water hyacinth.

> **There is much potential for STI to tackle gender inequality (e.g. via increased financial independence via financial technology or fintech) but currently, technology inclusivity for women is low.**

Concerning mobile phone ownership, only 57 per cent of women in urban areas versus 82 per cent of men, and 42 per cent of women in rural areas versus 78 per cent of men, have a mobile phone.

Furthermore, only 23 per cent of urban-dwelling women and 13 per cent of rural-dwelling women have ever used the Internet. In addition, women make up most of the ready-made garment sector, where the use of automation and digital technology is increasing. Women are employed in largely routinized jobs that are at a high risk of automation, and there is an urgent need to create a skilled workforce of women to create new job opportunities and promote gender equality.

There are many opportunities for STI solutions to help Bangladesh meet its goals for SDG 14 and SDG 15 regarding life below water and life on land, where significant challenges remain. This could include producing and utilizing research to guarantee biodiversity protection and natural habitats, or the use of technologies to dynamize and protect biodiversity. Bangladesh still experiences challenges in terms of SDG 16 (peace, justice and strong institutions) and SDG 17 (partnerships for the goals), and progress on these goals is stagnating. E-government platforms and online administration can promote transparency via open data transparency, open participation and open collaboration,[35] thus contributing to SDG 16; it has already been noted how Bangladesh has prioritized the digitization of government services. Increased digital payments to combat corruption would also contribute to this same goal. In terms of partnerships, partnering with more developed countries would facilitate technology and knowledge transfer and help reduce the digital and technological gap between advanced and least developed countries.

1.2.4 Impact of COVID-19 in Bangladesh

The outbreak of the COVID-19 pandemic impacted Bangladesh profoundly, abruptly interrupting a prolonged period of sustained growth. To tackle the situation, the Bangladesh Government took rapid public health measures and announced a package of support

34 Examples are largely drawn from Bangladesh, Ministry of Planning, *VNR 2020*.
35 Emad A. Abu-Shanab, "The relationship between transparency and e-government: an empirical support", *Lecture Notes in Informatics*, vol. 221 (2013).

programmes to help poor and vulnerable households with cash transfer and food programmes and provided stimulus package to firms to sustain employment in key sectors. However, the sanitary situation in Bangladesh remains alarming: over the summer of 2021, the country was severely hit by a third wave due to the spread of the Delta variant of COVID-19, urging the Government to take additional emergency measure and impose new restrictions including lockdowns.

> **Although the outbreak of COVID-19 has triggered multiple shocks, hitting both aggregate demand and aggregate supply, existing forecasts suggest that Bangladesh may weather the storm much better than many other countries including its South Asian neighbours, maintaining a modest but still positive GDP growth (2.4 per cent in 2020[36]).**

Several factors can explain this performance, including the resilience of the agricultural sector, the adaptability of businesses, the increase in remittances and support by multilateral donors, and the stimulus package enacted by the Government.

Nevertheless, heightened uncertainty looms large in the future, and the COVID-19 shock may exert long-lasting effects in terms of poverty and employment.[37] Considering the significant prevalence of small companies and informal self-employed individuals in the Bangladeshi economy,[38] these are important concerns. Further, considering the overdependence of Bangladesh on exports, the disruption of supply chains and the resultant negative impact on exports is a concern. The contraction of employment opportunities disproportionately impacts youth, large numbers of whom are informal workers.[39] Several studies have also underscored the impact the downturn could have on global poverty and food insecurity if the pandemic were to disrupt agricultural activities,[40] which until now have remained resilient.

- **Examples of how STI have been successfully used to tackle COVID-19**

In the agriculture sector, a foodgrain procurement mobile application helped farming communities in rural Bangladesh sell produce and order supplies through mobile phones during the pandemic. This innovative programme was first launched by the Ministry of Food to ensure fair prices for the farmers and reduce foodgrain losses during harvesting seasons, and proved to be a crucial lifeline during the pandemic.

STI solutions were also used in the education sector, under the leadership of the Ministry of Education and with the technical support of the Government's Access to Information Programme (a2i) and the strategic support of other development partners. The Bangladesh Government immediately introduced alternative distance learning using different channels, through which students could continue studying at home during the pandemic. For secondary and higher education, lessons were broadcast on television and radio and live streamed on various social media platforms. In addition, the Konnect Kishore Batayon platform and Facebook page continuously worked with adolescent students of secondary and higher secondary levels on their mental well-being and soft skills development, with the support of the Directorate of Secondary and Higher Education. Finally, the government e-learning platform Muktopaath launched over 10 courses during the pandemic. Around 400,000 learners participated on these courses, including 50,000 doctors and 100,000 health workers.

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36 World Health Organization, "Bangladesh National Health Accounts, an overview on the public and private expenditures in health sector", 5 October 2017. Available at https://www.who.int/bangladesh/news/detail/05-10-2017-bangladesh-national-health-accounts-an-overview-on-the-public-and-private-expenditures-in-health-sector (accessed on 13 December 2021).

37 UNCTAD, "Vulnerability profile of Bangladesh".

38 World Bank Group, "Current health expenditure (% of GDP) - Bangladesh, Least developed countries: UN classification", World Bank database. Available at https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS?locations=BD-XL (accessed on 13 December 2021).

39 In the Bangladesh economy, 85.1 per cent of total employment is informal, including 82.1 per cent for men and 91.8 per cent for women. Bangladesh Bureau of Statistics, "Labour force survey 2017", 2017. Available at https://www.ilo.org/surveyLib/index.php/catalog/2214/data-dictionary/FA_BGD_LFS_2017_FULL?file_name=BGD_LFS_2017_FULL (accessed on 13 December 2021).

40 Daniel Gerszon Mahler and others, "Updated estimates of the impact of COVID-19 on global poverty", World Bank, 8 June 2020. Available at https://blogs.worldbank.org/opendata/updated-estimates-impact-covid-19-global-poverty (accessed on 13 December 2021); Andy Sumner, Chris Hoy and Eduardo Ortiz-Juarez, "Estimates of the impact of COVID-19 on global poverty", World Institute for Development Economics Research Working Paper 43 (2020); Giovanni Valensisi, "COVID-19 and global poverty: a preliminary assessment", in *COVID-19 in Developing Economies, Simeon Djankov and Ugo Panizza*, eds. (London, Centre for Economic Policy Research, 2020); David Laborde and Will Martin, "Impacts of COVID-19 on global poverty, food security, and diets: Insights from global model scenario analysis", *Agricultural Economics*, vol. 52, No. 4 (May 2021); Jonas de Vos, "The effect of COVID-19 and subsequent social distancing on travel behavior", *Transportation Research Interdisciplinary Perspectives*, vol. 5 (March 2021).

In the health sector, the Directorate General of Health Services, together with the a2i Programme and other stakeholders including government institutions, telecommunications companies, development partners, NGOs and academics, developed a data tracking and tracing platform to minimize the fatalities based on data-driven decision-making.[41] The analytics help to identify hotspots and high-risk cases, analyse and predict requirements for additional patient management, guide resource allocation, and guide the Government in making timely policy responses. Moreover, a full-fledged call centre has been launched, not to mention a Skype-based tele-consultation alongside the telemedicine service. Finally, a COVID-19 vaccine registration application called Surokkha—managed by the ICT Division of the Ministry of Posts, Telecommunications and Information Technology—was also launched in February 2021, and successfully helped millions of users with the administration process around receiving their vaccinations.

Regarding public procurement, during the pandemic the electronic Government Procurement System worked to continue day-to-day development operations in the country. It enabled around 1,300 public organizations to process all procurement activities online. Now, the Citizens' Portal can monitor public spending in Bangladesh through innovative digital dashboards and feedback loops to ensure transparency and accountability.

1.3 STI snapshot

1.3.1 STI system SWOT analysis

STI are clearly being utilized to positive effect in Bangladesh. Here, we take a deeper look at STI in Bangladesh in a strength, weakness, opportunity and threat (SWOT) analysis, specifically of the country's national innovation system.

Table 1.1. Strengths, weaknesses, opportunities and threats of the national STI system in Bangladesh

Strengths	Weaknesses
• Economic growth on track to graduate from the United Nations least developed countries list • Economic growth appears to be inclusive • Expansion of manufacturing and services • Increase in access to electricity and power generation • Infrastructural support for innovation development, with strong policy and governance framework for STI, and the creation of economic zones and technology parks • High political commitment, institutional framework and stakeholders' engagement for SDGs • Good progress in access to education	• Industrial base lacking in diversity (dominated by textiles, ready-made garments, jute) and labour-intensive • High export concentration with overreliance on low-tech textile and clothing products • High social problems: uncontrolled urbanization, overcrowding, pollution, inadequate health care, land scarcity, urban/rural disparities • Scores better than South Asian neighbours for gender equality, but there is still room for improvement • High skills mismatch and low university-industry linkages • Low R&D expenditures and patent applications

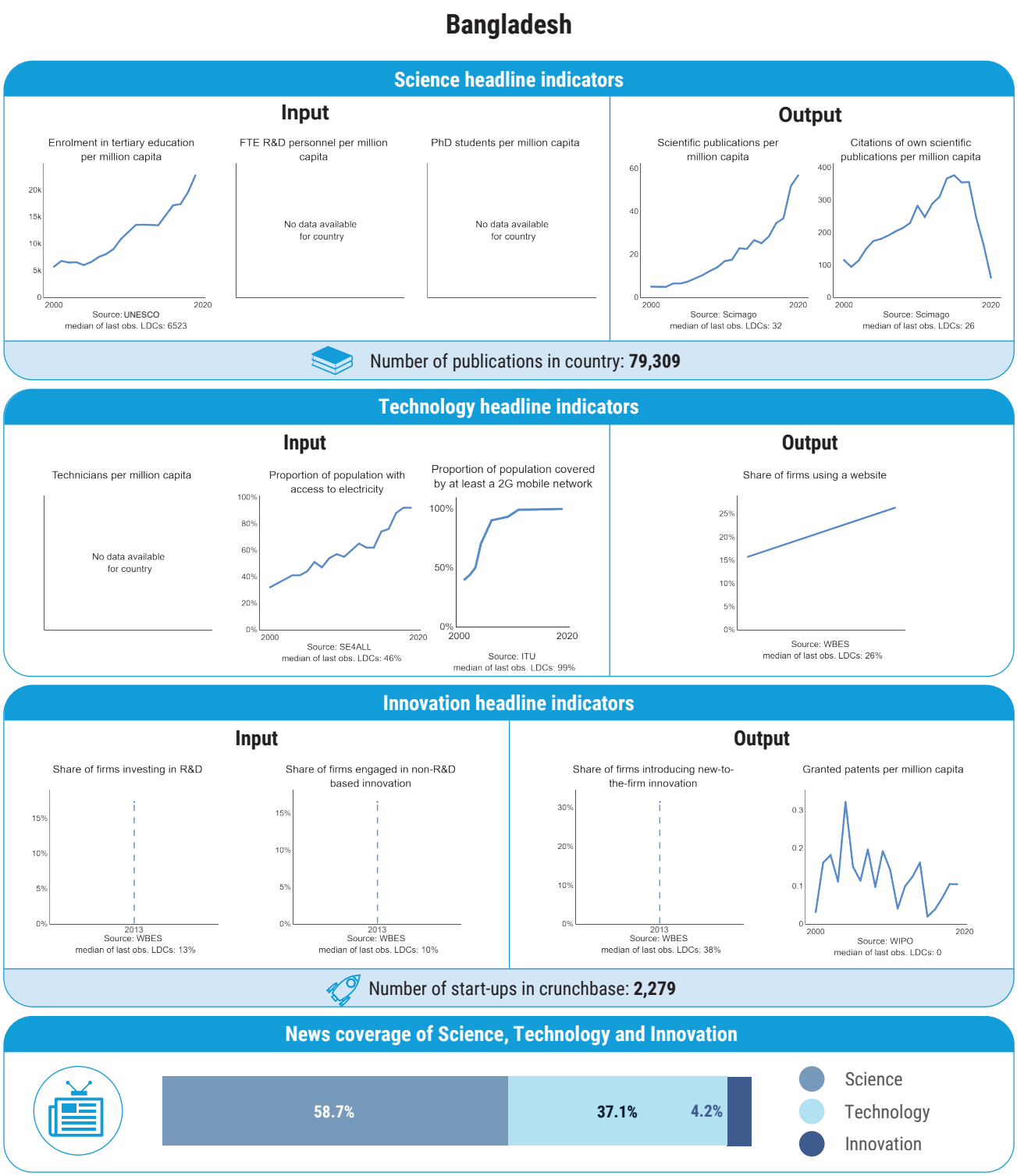
41 See http://www.corona.gov.bd.

• Good progress in expansion of financial services • Growth in e-commerce, e-banking, e-education, e-health, and e-government services, with an equalizing effect • Several financial and tax incentives	• Modest science and technology output, with very limited research in the industrial sector • Schools are overcrowded and teachers not sufficiently trained; dropout rates are high[42] • Majority of small enterprises and high number of informal employment/businesses • Lack of entrepreneurship culture • Difficulties in licensing and copyright barriers • Difficult and lengthy process to start a business • Corruption and bribery are an issue, but the Anti-Corruption Commission is addressing this • Insufficient accelerator/incubation programmes
Opportunities	**Threats**
• Government plan to increase R&D investments • Reforms in the running of businesses • Boom of software development and related services, such as web design and maintenance • Growing number of start-ups offering next-generation digital services (big data, Internet of Things, 3D imaging, robotics process automation) • Start-up ecosystem developing, with emergence of incubators and accelerators • Growing investment landscape with the emergence of specific venture capital funds and "business angels" • Boom of international trade and access to global markets • Productivity could be increased via skills development, training and vocational education • Government support to many organizations conducting entrepreneurship training programmes • Demographic dividend: Bangladesh has a large, globally connected young population that has the potential to drive the information and communications technology revolution in the country	• The COVID-19 shock may exert long-lasting effects in terms of poverty and employment destruction • Access to financial services still a challenge for much of the population • High demographic pressure: creating decent jobs for the growing labour force is a challenge • Major challenges facing agricultural growth • Challenges in ensuring reliable power supply: distribution breakdowns, inefficiency resulting from the aged grid, and inadequate transmission and distribution networks • Challenges in increasing the share of renewable energy: land suitable for solar parks is scarce and expensive; solar radiation levels are quite low, as are wind speeds; and there is a lack of local expertise and a high dependency on foreign experts • High vulnerability to climate change

42 Bangladesh, Ministry of Planning, *VNR 2020*

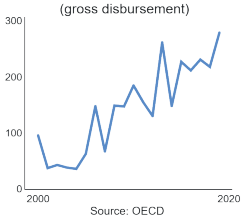
1.3.2 Key features of the STI system

Figure 1.3. Key features of the STI system in Bangladesh



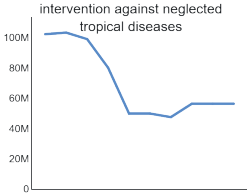
STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)



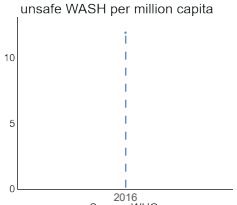
Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



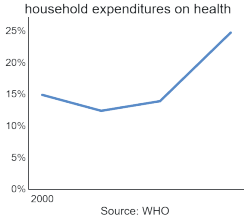
Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita



Source: WHO
median of last obs. LDCs: 34

SDG 3.8.2 Share of pop. with large household expenditures on health

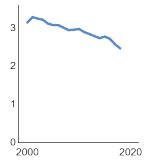


Source: WHO
median of last obs. LDCs: 9%

Publications 1,986: 2.5% of publications **Start-ups in crunchbase** 98: 4% of start-ups

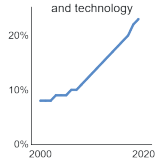
STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy



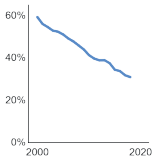
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



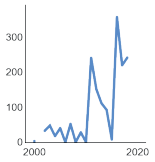
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development



Source: SDGs

Publications 637: 0.8% of publications **Start-ups in crunchbase** 11: 0.4% of start-ups

STI & Climate Adaptation

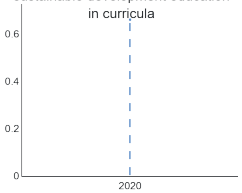
SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP

No data available for country

SDG 1.5.2 Direct agriculture loss attributed to disasters

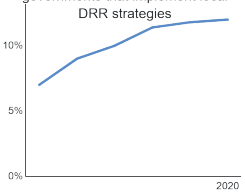
No data available for country

SDG 13.1.1 Mainstreaming of sustainable development education in curricula



Source: UNISDR
median of last obs. LDCs: 0

SDG 11.b.2 Share of local governments that implement local DRR strategies

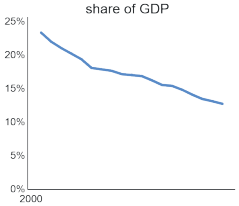


Source: UNISDR
median of last obs. LDCs: 44%

Publications 10: 0.01% of publications **Start-ups in crunchbase** 0: 0% of start-ups

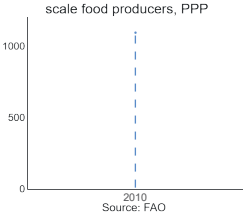
STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP



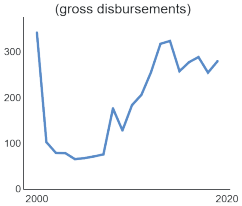
Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP



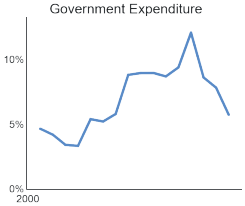
Source: FAO
median of last obs. LDCs: 714

SDG 2.a.2 Total ODA to agriculture (gross disbursements)



Source: OECD
median of last obs. LDCs: 63

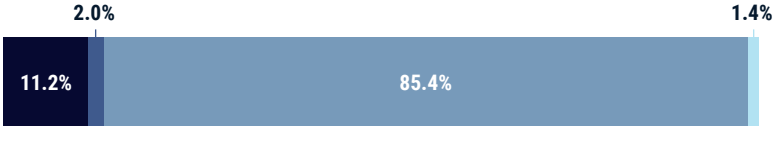
SDG 2.a.1 Agriculture share of Government Expenditure



Source: FAO
median of last obs. LDCs: 4%

Publications 26: 0.03% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas



The national innovation system of Bangladesh shows significant promise, beginning with its strong policy and governance framework for STI, as described below. However, the system is nascent, and innovation remains at a low level. Expenditure on R&D is low, patent applications are way below the average for least developed countries, and absorptive capacity could be higher. The expanding innovation infrastructure—in the form of emerging incubators, accelerators, venture capital funds and angel investors—will help this grow in the future. Knowledge development from research is also low, with the number scientific publications well below the average for least developed countries, despite increasing steadily. Technological infrastructure is strong, with high access to electricity and mobile phone coverage, preparing Bangladesh well for increased digitization and the Fourth Industrial Revolution, as described below.

- **Governance**

A distinctive feature of Bangladesh is its strong policy and governance framework for STI. In 1983, the National Committee on Science and Technology was created as the sole advisory body on science and technology in Bangladesh, within the Ministry of Science and Technology, with the President of the country as its Chair. Immediately after its creation, the National Committee worked for three years to draft a policy which was formally approved by the Government in 1986. More recently, the revised National Science and Technology Policy (2011) paved the way for the Engineering Research Council created in September 2020, and continues today to frame science and technology in Bangladesh.[43]

More specifically, achieving a "Digital Bangladesh" was one of the ambitions of Vision 2021.[44] The National ICT Policies (2015 and 2018) as well as the e-Government Master Plan for Digital Bangladesh (2018) and the Digital Security Act (2018), which led to the establishment of the Digital Security Agency, have all been means to this end. The Digital Security Act was enacted with the aim of limiting human rights violations and instances of defamation through electronic media. The key responsibilities of the Digital Security Agency are to ensure a safe cyberspace, analyse risks and detect cybersecurity threats, as well as to take measures to minimize threats and support law enforcement agencies in combating cybercrime.

> **In particular, the Ministry of Education plays a significant role in building a Digital Bangladesh. It formulated the Master Plan for ICT in Education 2012-2021, with support notably from the United Nations Educational, Scientific and Cultural Organization (UNESCO), aiming to reduce the digital divide between urban and rural areas in the education sector and to leverage information and communications technology as a cost-effective tool to enhance the quality of education.**

The 2019 progress report[45] of this Master Plan showed that real progress had been achieved, but notably recommended the extension of the Master Plan for ICT in Education to 2030. The Government has also been very active in promoting the development of information and communications technology solutions in the health sector, as already noted. However, according to the e-Government Master Plan,[46] each government ministry implements information and communications technology-related projects sporadically, thus leading to poor information-sharing and high delays in implementation.

The Government's a2i Programme,[47] initially designed to digitize government services and the main achievement of which is the opening of six thousand "digital centres" around the country, has proved very successful and significantly expanded its focus over the past decade. The programme objectives now include the promotion of social innovation, pro-poor fintech and youth skills. In 2017, it even set up an innovation lab.[48] Each digital centre is co-run by "citizen entrepreneurs" and local representatives, who reportedly serve 5 to 6 million clients.[49]

43 UNESCO, *UNESCO Science Report*.
44 UNESCO, *UNESCO Science Report*.
45 Bangladesh, Ministry of Education, *Master Plan for ICT in Education in Bangladesh (2012-2021) - Progress Review Report 2019* (Chaka, 2019). Available at https://planipolis.iiep.unesco.org/en/2019/master-plan-ict-education-bangladesh-2012-2021-progress-review-report-2019-6845 (accessed on 31 March 2022).
46 Bangladesh Computer Council, ICT Division, *e-Government Master Plan for Digital Bangladesh* (Dhaka, 2019). Available at https://bcc.portal.gov.bd/sites/default/files/files/bcc.portal.gov.bd/publications/3f9cd471_9905_4122_96ee_ced02b7598a9/2020-05-24-15-54-43f3d2b8b4523b5b62157b069302c4db.pdf (accessed on 31 March 2022).
47 This programme is run and implemented by the Information and Communications Technology Division.
48 UNESCO, *UNESCO Science Report*.
49 a2i Programme, Bangladesh Cabinet Division, Bangladesh ICT Division and United Nations Development Programme, "Access to Information (a2i-II) Programme final project review report" (2019).

- **Digitization and the Fourth Industrial Revolution**

The updated National ICT Policy (2018) accounts for the emergence of 5G technology and the challenges of the Fourth Industrial Revolution. Indeed, a notable fact is that software development and related services, such as web design and maintenance, are currently booming in Bangladesh:[50] a growing number of start-ups are offering next-generation digital services such as big data analytics, the Internet of Things, three-dimensional (3D) imaging and robotics process automation.

Bangladesh has also developed, with support from the United Nations Environment Programme (UNEP) and the United States Agency for International Development (USAID), a National Strategy for Artificial Intelligence, 2019–2024.[51] It aims to overcome data and talent shortages in the artificial intelligence (AI) sector by training 50,000 people in emerging technologies by 2024. Data accessibility is currently a major challenge for Bangladesh, as are the lack of technological infrastructure for AI (particularly for data handling and storage), and the insufficient pool of talents in that sector. Seven national priority areas for AI are identified: public service delivery, manufacturing, agriculture, smart mobility and transportation, skills and education, finance and trade, and health. The strategy notably plans to fund a thousand start-ups operating in AI-related areas over the 2019–2024 period.

It is also worth noting that the Federation of Bangladesh Chambers of Commerce and Industry Institute has been established to provide training in skills needed to better prepare students for innovation and the Fourth Industrial Revolution. A skills lab will also be set up in cooperation with renowned global knowledge partners. Diploma, bachelors and certificate programmes will be conducted in a wide range of areas, including AI, information and communications technology, robotics, cybersecurity, fintech, blockchain technology, mechatronics, biotech, light engineering, agro-processing, food processing, automotive manufacturing, leather footwear manufacturing, furniture making, ceramics, etc. to create a demand-driven future workforce. Partnership agreements with the University of Toronto and Seneca College of Canada have been signed to help implement the programmes.

- **Absorptive capacity**

Absorptive capacity in Bangladesh is somewhat low, but recent progress is worthy of note. There seems to be a mismatch between the labour-market demand for academic specialties, and the disciplines studied by many university students, leading to poor employment outcomes for university graduates.[52] Indeed, in 2017 16 per cent of university graduates were unemployed, compared with 7 per cent of secondary school graduates.[53] In this context, the ties between the labour market and the education system need to be strengthened. Linkages between universities and industry allow information to flow in both directions: universities can be better informed about market needs from industry, while industry can learn more about technological and scientific solutions to these needs. Establishing effective institution-industry linkages through partnership in R&D, experience sharing and internships would be highly beneficial.[54] Moreover, the education system needs to provide more non-cognitive skills and support graduates for job placement.

> **With very limited opportunities for science, technology, engineering and mathematics (STEM) graduates due to the absence of large-scale industrialization in the country except in the field of ready-made garments and textiles, graduates are looking into forming their own information and communications technology companies and start-ups.[55]**

Indeed, the start-up ecosystem in Bangladesh has had a late start compared to its regional peers, beginning its journey in the early 2010s. However, it has undergone a remarkable transformation and is finally "coming of age" with the successful implementation of several countrywide incubator and accelerator programmes.[56] For example, the Bangladesh Hi-Tech Park Authority under the ICT Division has established 27 specialized labs in 21 universities to bridge the gap between academia and industry. Moreover, the Government has created a company called Startup Bangladesh

50 UNESCO, *UNESCO Science Report*.
51 Ibid.
52 Bangladesh, Ministry of Planning, *VNR 2020* (2020).
53 Trines, "Education in Bangladesh".
54 Bangladesh, Ministry of Planning, *VNR 2020* (2020).
55 Mehad ul Haque, Ishtiak Mourshed and Md. Risalat Huda, "Bangladesh startup ecosystem – an untapped digital goldmine of Asia", Asia-Pacific Research Exchange, 11 August 2020. Available at https://www.arx.cfa/en/research/2020/08/soc170820-bangladesh-startup-ecosystem-the-untapped-digital-goldmine-of-asia (accessed on 13 December 2021).
56 DATABD.CO., "Bangladesh's startup ecosystem: gaming forward following on to bigger headlines", *LightCastle Analytics Wing*, 2 January 2020. Available at https://databd.co/bangladeshs-startup-ecosystem-coming-of-age/ (accessed on 13 December 2021).

Ltd, to provide support to STEM graduates and young entrepreneurs.

However, the existing accelerator and incubation programmes, mentorship and training still do not seem adequate for the next major changes within the ecosystem.[57] Bangladesh was ranked 116 out of 126 economies in the Global Innovation Index 2019. Bangladesh is still characterized by a lack of entrepreneurial culture and a risk-averse mindset: it ranked 94 out of 141 for its attitudes towards entrepreneurial risk, comparable to Cambodia (91) but lagging well behind India (43).[58]

Moreover, multiple difficulties are associated with setting up a business in Bangladesh. With one of the world's most inefficient regulatory structures, Bangladesh ranked 168 out of 190 countries in the Doing Business Index 2020. The legal system constrains start-up development with difficulties in licensing, copyright barriers, political instability, harassment, corruption and bribery. The country ranks 107 out of 141 in terms of cost of starting a business, only slightly worse than India (95) but far ahead of Cambodia (130), and 102 out of 141 regarding the timescale necessary to start a business (Cambodia 139, India 90).[59] Bangladesh also ranks poorly over the incidence of corruption (125/141, Cambodia 132, India 66), intellectual property protection (125/141, Cambodia 112, India 57) and property rights (100/141, Cambodia 82, India 65). Lastly, access to financial services remains a challenge:[60] there is still a large financing gap for all types of enterprises,[61] even though Bangladesh has made very impressive progress in expanding financial services across the country. On a more positive note, the private sector plays an increasing role in financing micro, small and medium-sized enterprises (MSMEs) and start-ups in Bangladesh,[62] with the emergence of venture capital firms and business angels.[63]

The Government is actively introducing reforms of the running of businesses and liberalizing trade so that private entrepreneurs can seize opportunities for establishing and running industrial enterprises, and also supports many organizations in conducting entrepreneurship training programmes.[64] A national task force led by the Principal Secretary to the Prime Minister has been formed so that proper policies and planning are followed in establishing MSMEs, and the Government has formulated a specific MSME policy to provide entrepreneurs with the necessary guidance and strategic support. Furthermore, the Government is setting up one hundred special economic zones (SEZs) for new industries and investment in both the public and private sectors. Twenty-four high-tech parks are ready for commercial operation:[65] in 2010, the Bangladesh Economic Zones Authority and Bangladesh High-Tech Park Authority were established by two separate acts of parliament to develop related infrastructure.[66]

- **Bridging the technology gap**

The Government of Bangladesh has taken many initiatives for fostering industrialization, and economic growth during the last decades has been driven by the expansion of manufacturing and services.[67] Manufacturing as a proportion of GDP has been rising steadily, standing at 20.16 per cent in 2014–15 and reaching 24.08 per cent in 2018–19.[68] However, the dominant areas of the sector such as textiles and ready-made garments are labour-intensive, and there needs to be more investment in R&D and high-tech products.

57 Ibid.
58 Klaus Schwab ed. *The Global Competitiveness Report 2019* (Geneva, World Economic Forum, 2019).
59 Ibid.
60 Bangladesh, Ministry of Planning, *VNR 2020*.
61 *The Global Competitiveness Report 2019* ranks Bangladesh 78/141 regarding domestic credit to private sector, only slightly behind India (70) but significantly behind Cambodia (38); 92 regarding financing to MSMEs, significantly behind India (23) but just slightly behind Cambodia (88); and 112 regarding venture capital availability, a very low score (India 22 and Cambodia 66).
62 DATABD.CO., "Bangladesh's startup ecosystem: gaming forward following on to bigger headlines", *LightCastle Analytics Wing*, 2 January 2020. Available at https://databd.co/bangladeshs-startup-ecosystem-coming-of-age/ (accessed on 13 December 2021).
63 Venture capital firms have played an integral role in building the start-up ecosystem in Bangladesh, with sector-specific venture capital firms helping start-ups targeted towards niche markets. Moreover, the angel market is growing rapidly: the Bangladesh Angels Network, a consortium of angel investors in the country, has been working to bring together promising early-stage start-ups and introduce them to serial entrepreneurs, tech executives and investors.
64 Organizations include the Bangladesh Small and Cottage Industries Corporation, the Bangladesh Rural Development Board, the Directorate of Women, Bangladesh Institutions of Management, Micro Industries Development Assistance and Service, the Youth Development Training Centre, the Bangladesh Industrial Technical Assistance Centre and the Bangladesh Rural Advance Committee.
65 Bangladesh, Ministry of Planning, *VNR 2020*.
66 UNESCO, *UNESCO Science Report*.
67 UNCTAD, "Vulnerability profile of Bangladesh".
68 Bangladesh, Ministry of Planning, *VNR 2020*.

However, even though R&D and knowledge development are prerequisites for innovation, Bangladesh currently has a low budget for R&D (0.3 per cent of GDP). The Government has a plan to increase its R&D investments: recognizing that the industrially advanced countries typically spend 2–3 per cent of their gross national product (GNP) on R&D, the National Science and Technology Policy, 2011 sets a target of 2 per cent of GNP for R&D. In terms of accomplishments, the science and technology output of Bangladesh has been modest except in the agricultural sector, and even there, R&D activities are essentially confined to developments in a few specific crops. The R&D research institutions in the scientific and industrial sectors, as opposed to those that carry out largely field-level studies in the agricultural and biomedical sectors, have been unable so far to deliver significant goods and services to the country. Research conducted in the industrial sector remains very limited and concerns only a handful of areas such as the fortification of edible oils and salt.[69]

1.3.3 Resilience of the national innovation system of Bangladesh

The innovation system approach is a widely used model that explains how innovations emerge through the joint actions of firms, research performers and government agencies. Knowledge development, in the form of systematic R&D, involves universities, public research organizations, private firms and civil society. The linkages among these actors lead to the identification of problems of mutual interest, their possible solution and deployment of solutions.

Although Bangladesh was severely impacted by COVID-19, the pandemic has also somewhat fostered STI development in the country. Indeed, STI have been successfully used to tackle the impacts of COVID-19, as already explained. Interestingly, the increased reliance on e-commerce, e-banking, e-education, e-health and e-government services had a very positive equalizing effect in Bangladesh. For instance, MSMEs which had not accessed e-commerce before the pandemic were urged to start using it, and populations who were previously unable to access e-financial services were able to do so for the first time, hence reducing inequalities.

In its response to the COVID-19 pandemic, the Government was exemplary in effectively listening to its citizens to better understand their needs; in working together with the private sector; and in repurposing existing foundations to create new solutions in a short time. These solutions did not always utilize advanced technology. At the beginning of the COVID-19 outbreak, the Government transformed the 333 national information hotline—a telephone number for citizens to receive critical information and report emergency situations to the Government, even in rural areas with low mobile phone coverage—into a platform for self-reporting COVID-19 symptoms, then quickly repurposed it again into a telemedicine portal. As the situation continued, it became a means of identifying those requiring emergency food relief, then a means of shaping p-commerce (commerce over the phone) and finally of delivering audio lessons to school pupils. At each stage a citizen-centric approach was taken, with each iteration of the hotline coming in response to changing citizen needs.

> **Key to the resilience of Bangladesh in the face of COVID-19 was also strong and agile collaboration, with alliances being formed even under extremely difficult circumstances.**

One collaboration involved the creation of a WhatsApp group to bring together the Minister of Telecommunications, chief executive officers (CEOs) of the four mobile phone networks in the country, and the Chair of the Bangladesh Telecommunication Regulatory Commission; this agile collaboration allowed discussion and decisions to occur at an unprecedented pace.[70] This constant innovation in search of better solutions to new problems puts Bangladesh in a strong position to remain resilient to other shocks in the future. Strengthening the structural elements of its innovation system in the meantime, such as developing innovation infrastructure, closing the skills gap and increasing expenditure on R&D, would increase resilience still further.

69 Bangladesh, Ministry of Planning, *VNR (2020)*.
70 Anir Chowdhury, "Repurposing innovations: learning from Bangladesh's rapid response to the pandemic", Observer Research Foundation, 9 October 2020. Available at https://www.orfonline.org/expert-speak/repurposing-innovations-learning-bangladesh-rapid-response-pandemic/ (accessed on 13 December 2021).

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Interviewees

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Amin, Khairul. Director-General at Digital Security Agency.

Bhuiyan, Mohammad Maksudur. Director at University Grants Commission.

Hossain, Anwar. Joint Secretary at Ministry of Finance, Economic Relations Division.

Hossain, Syed Mohammod. Director and Chief Scientific Officer at Bangladesh Atomic Energy Commission.

Latifee, Enamul Hafiz. Joint Secretary at Bangladesh Association of Software and Information Services.

Mahareen, Julfa. Executive Content and Research at Bangladesh Association of Software and Information Services.

Sarker, Abdus Sattar. Joint Secretary at Information and Communications Technology Division.

Sarker, Palash Kumar. Senior Scientific Officer at National Institute of Biotechnology.

Titas, Moinul Islam. Joint Secretary at Ministry of Science and Technology.

Uddin, Nobir. Senior System Analyst at Information and Communications Technology Division.

2. Burkina Faso

Figure 2.1. Least developed country status indicators for Burkina Faso

Africa
Burkina Faso

Population
20 million (2020)

LDC status
Member since 1971

Well-being		
Human Assets Index *(composed of six indicators)* 55 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 44% (2014) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 87 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 752 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 2% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 5% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 48 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 5% (2018) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 96% (2018) LDC median: 89% *Source: ILO*

2.1 Country profile

Burkina Faso occupies an area of 274,200 km² and has a population of 20 million inhabitants. The official language is French, but it is not widely spoken; most people speak the Mooré language in daily life, and Dyula for commerce.

The country has a history of political instability since its independence from France in 1960.[71] Successive coups have brought about frequent abrupt changes in administrations.

Agriculture is the main economic activity in the country, employing 80 per cent of the workforce and representing 20 per cent of GDP. The country depends

71 Jean Dresch, "Burkina Faso", *Encyclopedia Britannica*, 10 March 2021. Available at https://www.britannica.com/place/Burkina-Faso/additional-info#history (accessed on 13 December 2021).

heavily on agricultural exports, especially of cotton.[72] Official development assistance (ODA) to agriculture is increasing; however, the Government's share of expenditure on agriculture has been declining.

Today the mining sector is vibrant and growing, with 17 active industrial mines. The gold sector has contributed 13 per cent of the country's GDP, an increase from 10 per cent in 2018.[73] The country has benefited from this recent increase in gold exports.[74] It is now one of the main export products, along with cotton.

> **Though the agricultural and mining sectors are the key industries in Burkina Faso, there is a growth potential in the agro-silvo-pastoral, wildlife, fisheries, industrial and artisanal, service industries, infrastructure and environmental sectors.[75]**

Burkina Faso entered the least developed countries group in 1971. It displays a low gross national income (GNI) per capita (US$752, while the threshold for graduation from least developed country status is US$1,222 or above). The country also rates low on its human assets and high on its economic and environmental vulnerability. Burkina Faso is not expected to graduate from this category in 2024.[76]

Education (indicated by gross secondary school enrolment ratio and adult literacy rate), stability of exports of goods and services, and stability of agricultural production are the key drivers of the country's development towards graduation.[77] However, while secondary education is experiencing a positive trend, tertiary education remains a challenge because universities are overpopulated. Current national policies are in place which aim to decentralize higher education from the capital Ouagadougou by creating universities in other regions. "Brain drain" has been also a key economic issue in the country, though it is occurring less.

State legitimacy and the situation regarding human rights in the country have been declining, a problem emphasized by the current security threats due to terrorism. Islamist militants have carried out attacks in many regions of the country, mainly in the north but also in Ouagadougou, in an attempt to impose radical Islamic beliefs, a trend seen in many countries of the Sahel region including Chad, Mali, Mauritania and Niger.[78] The number of refugees and internally displaced persons has been increasing due to terrorism.

The country is ranked among the most economically fragile States when it comes to aid dependency. The country received 7.5 per cent of its gross national income (GNI) in the form of ODA.[79] The difficulties in Burkina Faso lie in its economic, political and social conditions.

2.2 Key development challenges

2.2.1 Priorities of the national development agenda

The National Plan for Economic and Social Development (PNDES 2016–2020) aims to address the country's development challenges, to develop human capital and to place research and innovation at the forefront of the country's development agenda.[80] The three main priorities are to reform the institutions and modernize its administration, to develop human capital, and to stimulate sectors potential economic and employment growth. The country's vision is to create a "democratic, united and cohesive nation, transforming the structure of its economy to achieve a strong and inclusive growth, through sustainable consumption and production".

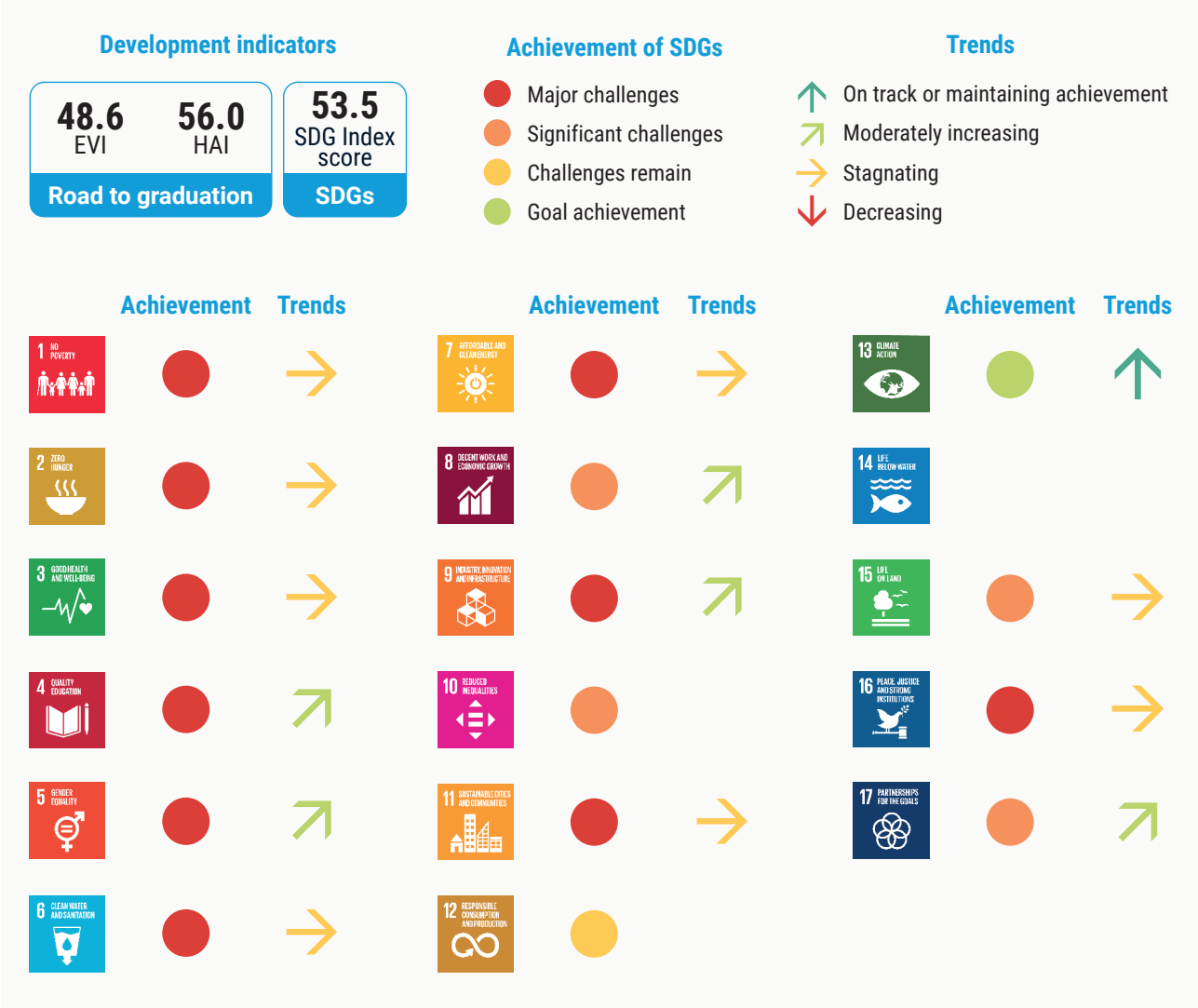
72 World Bank, "The World Bank in Burkina Faso: overview–results", 26 October 2021. Available at https://www.worldbank.org/en/country/burkinafaso/overview#1 (accessed on 13 December 2021).
73 Rédaction Africanews, "Burkina Faso: Gold mine vandalized after the death of seven illegal diggers", *Africanews*, 3 September 2021. Available at https://www.africanews.com/2021/09/03/burkina-faso-gold-mine-vandalized-after-the-death-of-at-least-seven-diggers/ (accessed on 13 December 2021).
74 African Development Bank Group, *African Economic Outlook 2021: From Debt Resolution to Growth—The Road Ahead for Africa* (Abidjan, African Development Bank Group, 2021).
75 International Monetary Fund African Department, "Burkina Faso", 23 March 2018. Available at https://www.elibrary.imf.org/view/journals/002/2018/085/article-A001-en.xml (accessed on 13 December 2021).
76 United Nations Department of Economic and Social Affairs (UNDESA), "Graduation from the LDC category", n.d. Available at https://www.un.org/development/desa/dpad/least-developed-country-category/ldc-graduation.html (accessed on 13 December 2021).
77 Ibid.
78 Dresch, "Burkina Faso".
79 Organisation for Economic Co-operation and Development, "OECD DAC aid data at a glance by recipient", OECD database. Available at https://public.tableau.com/views/OECDDACAidataglancebyrecipient_new/Recipients?:embed=y&:display_count=yes&:showTabs=y&:toolbar=no?&:showVizHome=no (accessed on 23 December 2021).
80 Burkina Faso, *Plan National de Développement Économique et Social (PNDES) 2016–2020* (2015).

This goal is to be attained through leadership, equity, subsidiarity and partnership, results-based management, and proactivity in the creation of a favourable environment for competitive and sustainable industrial development. In addition, the structural transformation of the country is intended to be achieved through a strengthened productive sector and developmental investment.

2.2.2 Level of achievement of the SDGs

The country is progressing slowly towards attaining its development goals. Indeed, 14 out of the 17 SDGs present significant to major challenges. Nevertheless, Burkina Faso is moderately increasing its performance on quality of education, gender equality, decent work opportunities, economic growth, industry, innovation and infrastructure.

Figure 2.2. Progress on the SDG index in Burkina Faso



Source: Adapted from Sachs and others (2021).

Three challenges remain particularly critical hurdles that may impede the country's efforts: the terrorist threat, the structural energy deficit and low infrastructural development.

- **The fight against growing insecurity**

Burkina Faso is facing a sharp security crisis. The situation has considerably deteriorated since 2015, with the spread of the Sahel political crisis from Mali to Burkina Faso. Since 2016, Ouagadougou has faced three

terrorist attacks, and the country has had to deal with repeated attacks in the north, east and west of Burkina Faso. The security threats have exacerbated the country's other socioeconomic development challenges.

The most immediate consequence of the growing insecurity is internal displacement from the north of the country. As a result, the population density has increased in certain regions, especially Ouagadougou. In addition, over 2,500 schools have closed, and 350,000 children have lost access to education.

Moreover, the increased insecurity has created a less attractive business climate that has witnessed a decrease in foreign investment. It also puts pressure on the national budget through increasing military expenditure for a country that struggles to mobilize sufficient internal resources and is endeavouring to curb indebtedness.

- **The increase in energy supply**

Burkina Faso also faces a structural energy deficit that has led to frequent power outages. The rate of access to electricity in the country remains one of the lowest in sub-Saharan Africa, a situation that strongly affects the country's industrialization. To date, manufacturing industries contribute only 4 per cent of its GDP.

The energy sector of Burkina Faso is characterized by the dominance of thermal electricity in a country that has enormous solar potential, but also by the significant intervention of external actors to finance the sector.[81] Burkina Faso imports 30 to 35 per cent of the energy it consumes from Côte d'Ivoire.

> **The predominance of the thermal sector in the energy mix has greatly increased the cost of energy.**

This has created a financial imbalance in the sector, forcing the government to grant fuel subsidies, affecting the public finances and hindering the involvement of the private sector. Among the social implications, difficulties in accessing energy are forcing millions of people, especially women, to use traditional cooking fires, causing major health problems and high levels of deaths resulting from pneumonia.[82] The improvement of the institutional and regulatory framework should encourage increased private investment in energy production and distribution in the future.

- **The development of socioeconomic infrastructure**

Burkina Faso is also confronted with a severe infrastructure deficit that is increasing its isolation and reducing the competitiveness of its economy.

As a landlocked country, more than 80 per cent of imports to and exports from Burkina Faso are carried out by land. The transport sector is characterized by insufficient road coverage, relatively inefficient road maintenance and weak connectedness of rural areas to the road network.

Furthermore, the limited resources mobilized to finance public infrastructure projects are difficult to absorb due to institutional dysfunction. Burkina Faso suffers from shortcomings in terms of planning, prioritization in the allocation of resources, implementation of infrastructure projects and coordination between central Government and local authorities. In general, the economic infrastructure is insufficiently open to competition.

Burkina Faso has made infrastructure development a strategic objective for the structural transformation of the economy in the PNDES 2016–2020. Specifically, the "identified essential sectors" for increased investment are transportation, energy, telecommunications, housing and urban planning, industry and crafts, water and sanitation, and education. The intensification of public investment in infrastructure has already contributed to strengthening the dynamism of the construction industry in particular. However, it should be noted that over the period 2016–2020, financing needs for infrastructure development were estimated at US$2.2 billion per year, or 15 per cent of GDP; only 10 per cent of GDP was spent on infrastructure development in the period.

2.2.3 Relevance of STI to solving these development challenges

The PNDES also identifies research and innovation as a pillar for structurally transforming the economy of Burkina Faso and addressing development challenges, namely those related to agriculture and agro-transformation, health, climate change and the environment. The National Policy for Scientific and Technological Research (2015–2025) has the objective to create conducive conditions to produce the knowledge and technology necessary for the sustainable socioeconomic development of Burkina Faso. The

81 African Development Bank Group, "Réforme dans le secteur de l'énergie au Burkina Faso : Un prêt de 18 millions d'euros de la Banque africaine de développement" [Energy sector reform in Burkina Faso: 18 million euro loan from the African Development Bank], 18 July 2018.
82 Ibid.

main priorities of this policy are to increase agricultural productivity, enhance the processing of natural resources, improve the population's health and contribute to the qualitative transformation of society.

Burkina Faso has achieved significant innovation in the agricultural sector, mainly in the transformation of raw products, the production of improved seeds, the development of sustainable cultivation and irrigation methods, among others. Entrepreneurs increasingly engage in agro-transformation and export products at a high cost on the international market. Examples include the transformation and trademarking of shea butter and cottonseed oil.

Burkina Faso also has the ambition to become an innovator in the development of microirrigation, since a vast area of the country is arid.

> **The country launched a programme to promote microirrigation, with 2,000 ha already developed with this cultivation technique. Burkina Faso has gone from 20 pilot farms in 2019 to implementing this method in nearly 500 farms in 2021.**

In the health sector, innovative initiatives include M@SAN and IEDA. M@SAN is an e-health project that aims to improve health-care coverage of mothers, children and people living with the human immunodeficiency virus (HIV) in rural areas using mobile phones. The results following the first 24 months of operation are encouraging, with an increase in vaccination coverage and screenings. IEDA is a digital tool co-created by the Swiss aid organization Terre des Hommes and the Burkina Faso Ministry of Health. It digitized the medical protocol of the World Health Organization's (WHO) Integrated Management of Childhood Illness programme. Data collected through IEDA are analysed to improve the quality of care and inform decision makers.

In recent years, the ODA received for R&D in clean energy has increased, as has the proportion of the population with access to electricity. To compensate for its energy gap, the Government of Burkina Faso has embarked on a new sectoral policy, adopted in December 2017. The objective is to promote an energy mix, with an emphasis on solar energy, helping to reduce Burkina's dependence on neighbouring countries. The government initiated the construction of a solar energy plant, 55 ha in size, in Zagtouli on the outskirts of Ouagadougou in March 2021; construction is expected to last 18 months. This plant is expected to be able to power tens of thousands of homes and will allow the government to reach its goal of 200 MW solar capacity by the end of 2021,[83] from the 62 MW capacity at the end of 2020.[84]

Other development goals present major challenges in Burkina Faso but can also be achieved in part through STI solutions. For example:

SDG 1 (no poverty) may be addressed by creating e-governance platforms to increase transparency, decrease pollution and improve wealth distribution

SDG 5 (gender equality) may be addressed through increased access to digital skills education for all and access to media platforms to guarantee equal representation

SDG 6 (clean water and sanitation) may be addressed through infrastructural adaptation to the local environment

SDG 11 (sustainable cities and communities) may be addressed through the use of AI technologies in cities to regulate traffic, as has been achieved in the Democratic Republic of the Congo, for example.

2.2.4 Impact of COVID-19 in Burkina Faso

Despite the disruptions which accompanied the pandemic, the impact of COVID-19 in Burkina Faso has been limited. The health crisis did not have a significant impact in terms of mortality, as Burkina Faso has remained one of the least affected countries in the world at the time of writing in November 2021.[85]

83 Amadjiguéne Ndoye, "Le Burkina Faso lance un nouveau projet d'énergie solaire de 30 MW", *Financial Afrik*, 15 March 2021. Available at https://www.financialafrik.com/2021/03/15/le-burkina-faso-lance-un-nouveau-projet-denergie-solaire-de-30-mw/ (accessed on 13 December 2021).
84 Gwladys Johnson Akinocho, "Burkina Faso: GreenYellow reçoit 21 millions € pour la centrale solaire de Nagréongo (30 MW)" [Burkina Faso: GreenYellow receives €21 million for the Nagréongo solar power plant], *Agence Ecofin*, 7 June 2021. Available at https://www.agenceecofin.com/investissement/0706-88944-burkina-faso-greenyellow-recoit-21-millions-pour-la-centrale-solaire-de-nagreongo-30-mw (accessed on 13 December 2021).
85 See https://covid19.who.int/region/afro/country/bf.

Measures initially put in place by the government included a nationwide curfew, a ban on travel between cities and the closure of land and air borders to all. The lockdown measures particularly negatively impacted the informal sector that employs the largest portion of the population, mainly women who represent 60 per cent of the workers in this sector. Many saw their source of income disappear or significantly decrease. The closing of borders also affected trade, transport and tourism, and caused inflation (from -3.2 per cent in 2019 to 3.2 per cent in 2020).[86]

The negative impact of the crisis on the economy was kept under control. Year-on-year real GDP fell by over 5 per cent in the first half of 2020, but the government's emergency plan generated an 8-per cent turnaround in the third quarter. Real GDP grew at about 0.6 per cent in 2020. The temporary cancellation of taxes, and the additional COVID-19 related expenditure, kept the fiscal deficit at 5.5 per cent, with a 4.9-per cent increase in public debt from 2019 to 2020. The economy is expected to recover gradually, but with inflation and the deficit remaining high in 2021.[87]

2.3 STI snapshot

2.3.1 STI system SWOT analysis

STI are contributing to transform the economic and social landscape of Burkina Faso. The strengths, weaknesses, opportunities, and threats of the national STI system are summarized in the SWOT table below.

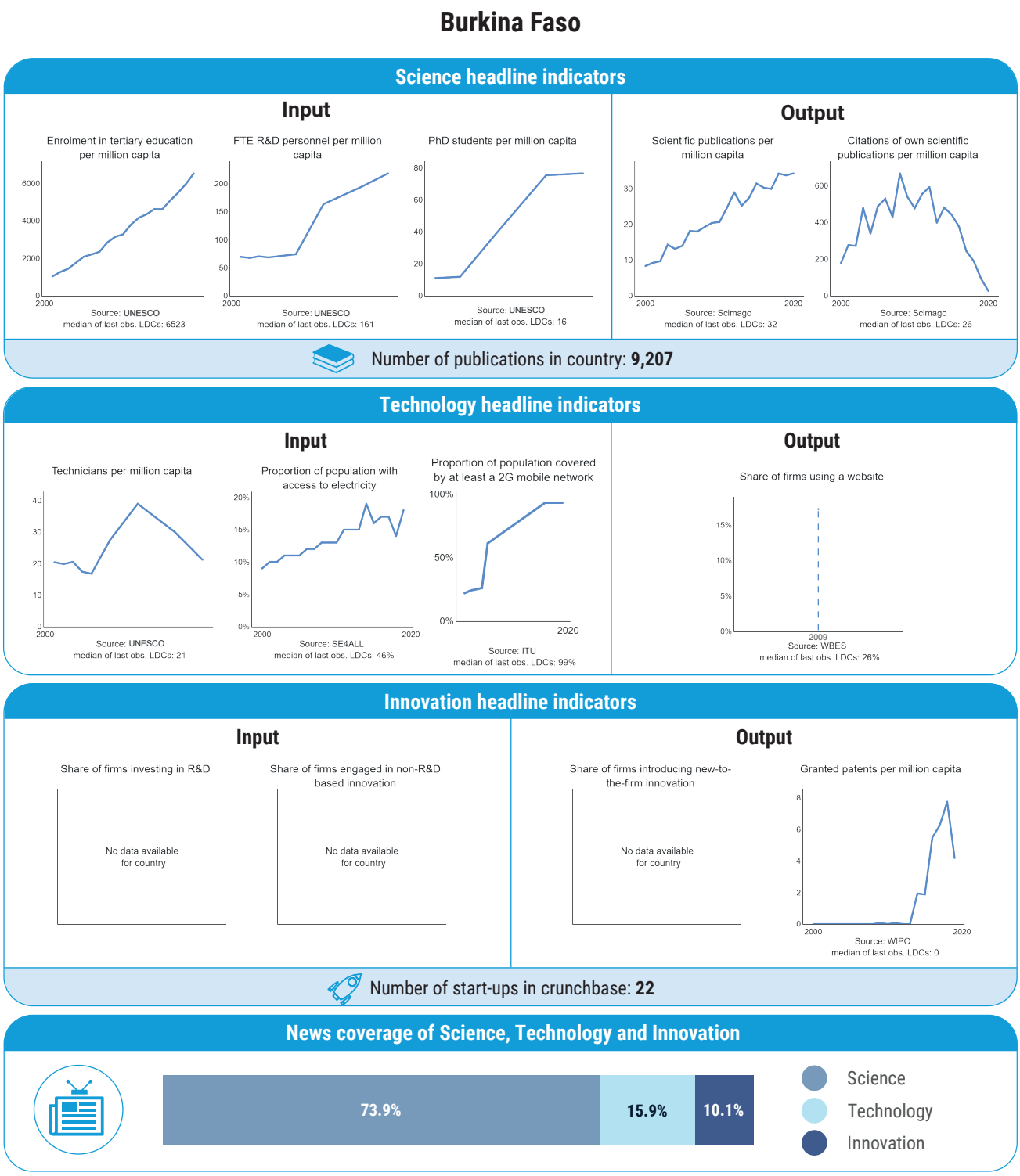
Table 2.1. Strengths, weaknesses, opportunities and threats of the national STI system in Burkina Faso

Strengths	Weaknesses
• Political and governmental incline towards STI • Existence of an institutional framework that supports R&D through national policy, a dedicated ministry and public bodies, and the National Fund for Research and Innovation for Development (FONRID) • Availability of infrastructure for research such as laboratories, incubators, universities and the National Center for Scientific and Technological Research (CNRST) • An increasingly globally connected youth that relies on digital solutions to address development challenges • Innovation forums that publicize research findings such as the National Forum of Scientific Research and Technological Innovation (FRSIT) which has existed since 1994, and the International Science and Technology Symposium • Increased resources invested in R&D, from 0.2 per cent of GDP in 2014 to 0.7 per cent, placing Burkina Faso as the least developed country that invests the most in R&D • Fast-growing innovation ecosystem: as at 2021, the country has 18 support structures (incubators and accelerators) for innovative entrepreneurship, gathered into a federation (SAEI-Burkina) – no incubators existed in the country prior to 2016	• Lack of financial resources to support all R&D needs, only 10 per cent of the Ministry for Higher Education, Research and Innovation budget is allocated to research • Lack of valorization of research findings, causing brain drain and reduced incentives to conduct research • Research valorization receives only 0.6 per cent of the budget of the Ministry for Higher Education, Research and Innovation • Many laboratories in need of equipment for higher quality research • Low absorption capacity of the private sector • Inadequate numbers of laboratories and research centres; universities are overpopulated • Lack of training for researchers in how to access available funding • High cost of intellectual protection, leaving research findings unprotected/unpatented
Opportunities	**Threats**
• Existence of regional and international funding opportunities, and the FONRID disbursement of US$26,930,310 for research in infectious diseases since COVID-19	• Political instability causing frequent changes in agenda • Security threats create the urgency for the government to invest in security and deter investment in other sectors

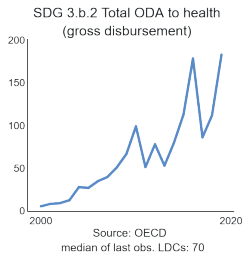
86 World Bank, "The World Bank in Burkina Faso: overview–results", 26 October 2021. Available at https://www.worldbank.org/en/country/burkinafaso/overview#1 (accessed on 13 December 2021).
87 Ibid.

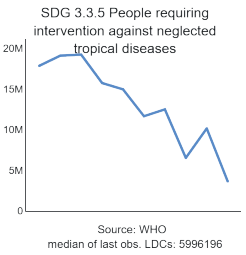
2.3.2 Key features of the STI system

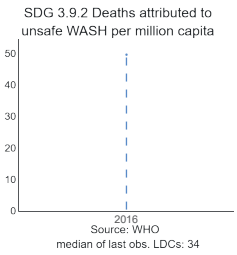
Figure 2.3. Key features of the STI system in Burkina Faso

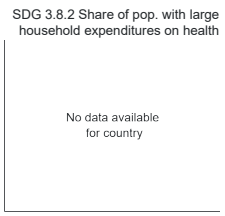


STI & COVID-19 & Health



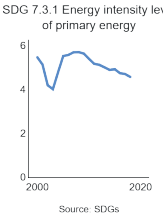


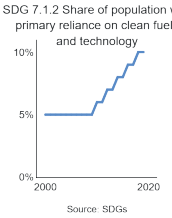


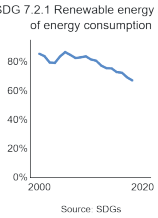


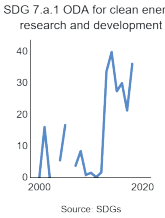
Publications **417: 4% of publications** **Start-ups in crunchbase** **1: 4% of start-ups**

STI & Clean Energy



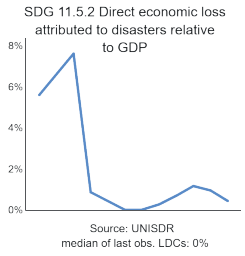


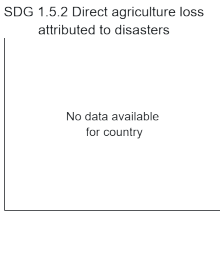


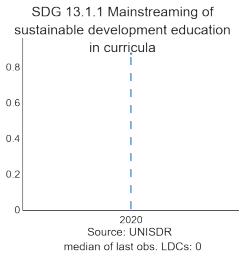


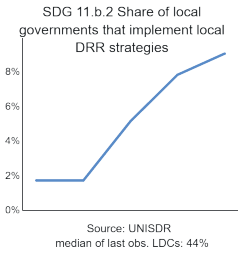
Publications **48: 0.5% of publications** **Start-ups in crunchbase** **0: 0% of start-ups**

STI & Climate Adaptation



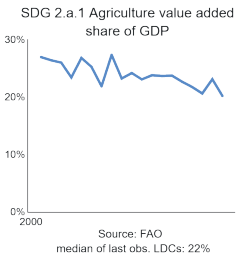


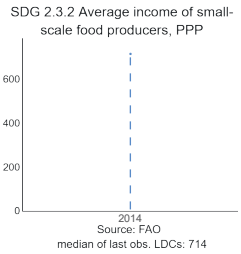


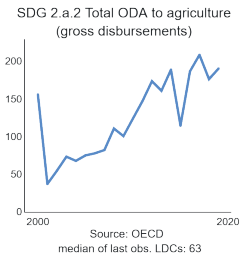


Publications **0: 0% of publications** **Start-ups in crunchbase** **0: 0% of start-ups**

STI & Agriculture

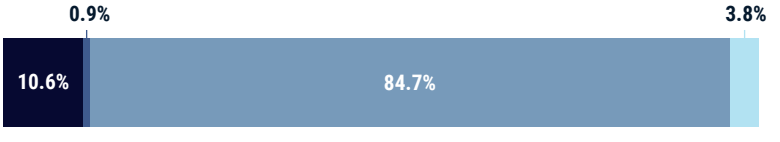






Publications **32: 0.3% of publications** **Start-ups in crunchbase** **0: 0% of start-ups**

News coverage of thematic areas



The STI system in Burkina Faso is one of the fastest growing in the West Africa region. The number of full-time personnel in R&D is steadily increasing, along with the enrolment in tertiary education and the number of PhD students. The technological readiness of the country is also improving, with better coverage of electricity and broadband, among other developments. However, the number of technicians has declined over the past five years.

Burkina Faso is making noticeable progress towards developing the STI landscape, through the institutional framework, policies and instruments the government is putting in place. In the future, the government sees Burkina Faso evolving in the digital sector, as well as the agricultural, health and mining sectors. There is strong potential for lasting promotion and development of STI through the willingness and the dynamism of the researchers on the ground in these sectors. Nevertheless, the absorption capacity of research results is still low.

Private innovators have an increasingly important role in the local STI sector through their involvement in FONRID and FRSIT. They are also taking the initiative in agricultural mechanization and transformation, for instance in the local development of their own adapted and patented incinerator and multipurpose shredders.

- **A clear political commitment and structured governance**

Burkina Faso can be considered an example of best practice for the development of STI in West Africa. The agenda for research and innovation is straightforward and supported by policies and organizations that create coherence among all actors in the national innovation system. As mentioned, Burkina Faso outperforms its regional peers (Côte d'Ivoire, Ghana, Mali, Senegal and Togo) in terms of gross expenditure on R&D (GERD).[88]

Burkina Faso has created a ministry specifically dedicated to higher education, research and innovation. This ministry ensures that research and innovation is a part of the agenda of other ministries in the country, such as the ministries of agriculture, health, and education.

Burkina Faso has also developed the Strategic Plan for Scientific Research and Technology, 2015–2024. This plan was elaborated as a response to the following identified needs: i) strengthened coordination, synergy and coherence of research within the different institutes of the CNRST; ii) greater linkage between the CNRST's research programmes and major national development programmes; and iii) mainstreaming emerging themes through collaborative research programmes. The objective of this strategic plan is to create favourable conditions to produce knowledge and technologies necessary for the sustainable socioeconomic development of Burkina Faso. The expected outcomes are: i) the growth of agricultural productivity and the transformation of agrifood products and natural resources; ii) the improvement of the population's health; and iii) the strengthening of the country's human resources through technology, innovation and knowledge diffusion. This plan is to be achieved through a resource mobilization strategy between the government and national, regional and international financial actors.[89]

Burkina Faso established national unified research programmes in multiple sectors, including agriculture, education, sustainable energy, health and climate change, in 2019.[90] The programmes aim to unify the efforts of researchers in these fields. The implementation of these programmes will be achieved by pooling skills and resources.

Furthermore, the National Agency for the Valorization of Research Results and Innovation (ANVAR) was created in 2013 to ensure that local innovation is developed and reaches the market. The agency facilitates the largest forum for innovation in Burkina Faso, the FRSIT, and today has an innovation park dedicated to scientific research and agriculture.[91] ANVAR developed and currently implements the National Strategy for the Valorization of Technologies, Inventions and Innovation.

- **A vibrant knowledge-generation system**

Moreover, although the pool of researchers is smaller than those of other countries in the region (Côte d'Ivoire, Senegal and Togo) at 107 researchers per million

88 UNESCO, *UNESCO Science Report*.
89 Centre National de la Recherche Scientifique et Technologique, "Plan Stratégique de La Recherche Scientifique et Technologique 2015–2024" (2015).
90 National Fund for Research and Innovation for Development, "Avis d'appel à proposition de notes conceptuelles de projets 2021", 24 August 2021. Available at https://fonrid.com/avis-dappel-a-proposition-de-notes-conceptuelles-de-projets-2021-2/ (accessed on 13 December 2021).
91 Dembele, "Parc d'innovation de l'ANVAR 'une initiative louable' selon la ministre déléguée à la Recherche Scientifique et l'Innovation", National Agency for the Valorization of Research Results (ANVAR), 2021. Available at https://anvar.bf/parc-dinnovation-de-lanvar-une-initiative-louable-selon-la-ministre-deleguee-a-la-recherche-scientifique-et-linnovation/ (accessed on 13 December 2021).

inhabitants, the research community in Burkina Faso appears to be more productive. On average, the country produces 39.4 research papers per researcher per million inhabitants, while the ratio in Côte d'Ivoire, Senegal and Togo is 19.6, 5.9 and 9.8 respectively. Researchers in Burkina Faso are mainly active in the medical sciences (26.5 per cent), followed by natural sciences (25.8 per cent), social sciences (16.6 per cent) and agriculture and veterinary sciences (10.1 per cent).[92] The CNRST comprises more than 900 researchers spread across its four institutes, the Environment and Agricultural Research Institute, the National Institute for Social Sciences, the Applied Sciences and Technological Research Institute and the Health Sciences Research Institute.

The vibrancy observed in the research field is also paralleled in the institutions. The stakeholders of the national innovation system endeavour to create links and synergies; for example, the Ministry of Agriculture works closely with the Environment and Agricultural Research Institute. ePrivate companies and private research institutes also collaborate with public research centres formally and informally, even if this collaboration remains limited to a small number of private actors.

A low absorption capacity

Another feature of the STI system in Burkina Faso is the low absorption capacity of the results of research by the market. The country faces a real challenge in valorizing the findings of local researchers; this is the rationale behind the creation of the ANVAR, which is working to curb this trend. The private sector primarily relies on importation for its needs, rather than investing in indigenous innovation. The ongoing effort to promote and publicize local knowledge and innovation, complemented by the development of links through effective instruments, will strengthen technology transfer and the commercialization of research results. The ANVAR is striving to increase the valorization and absorption of local innovation through capacity-building support, organization of forums, and other initiatives such as its innovation park.

- **Indigenous innovation**

Despite the challenges it faces, the STI system of Burkina Faso, develops innovative solutions that are aligned with the needs of the country's population and with its traditional culture. The country even created the international science and technology symposium, a regional initiative in which researchers from other countries come and present their innovations.

The dedication to advancing indigenous innovation shows in the efforts of the government to incorporate traditional medicine practitioners in the CNRST. A Directory for the Promotion of Traditional Medicine and Pharmacopoeia has even been created within the Ministry of Health. Burkina Faso presents a success story in using local existing knowledge and resources to find innovative solutions to health and agricultural problems.

FACA syrup, for example, is a medicinal solution produced since 2010 to treat sickle cell anaemia. Sickle cell anaemia is the most widespread genetic disease in the world, and Africa is the continent most affected by it, having the highest concentration of births with sickle cell anaemia. FACA syrup is mainly made of medicinal plants, a solution that arose from a visit that pharmacy students paid to a local traditional healer in 1990. The healer shared the plants he used to manage the symptoms of his sickle cell patients. The students then began an R&D process based on this traditional knowledge, and went on to develop FACA syrup with the support of the government and international donors.[93]

Another successful indigenous innovation in the agricultural sector is the farmer-to-farmer extension technique. In the 1980s, farmers developed a technique for the rehabilitation of degraded land. It consists of developing traditional planting pits into small pits, by depositing small matter to attract termites. This creates an ecosystem through which water can infiltrate the soil and retrieve nutrients. This local innovation is still used by farmers today.

2.3.3 Resilience of the national innovation system of Burkina Faso

The innovation system of Burkina Faso has proven its adaptability and capacity to absorb negative shocks throughout the COVID-19 pandemic. The government allocated US$27 million for research and innovation as a response to the pandemic. Entrepreneurs and researchers had access to this fund and were active in researching a vaccine against the virus. COVID-19 highlighted the need to consolidate and pursue the country's efforts to develop its innovation and use STI to unlock its development potential.

92 UNESCO, *UNESCO Science Report*.
93 Valérie Sabatier and Ignace Medah, *Le FACA: tradimedecine et developpement d'un medicament 'made in Burkina'* [FACA: Traditional Medicine and the Development of a Drug "Made in Burkina Faso"] (UNESCO, 2014). Available at http://www.unesco.org/new/fileadmin/MULTIMEDIA/FIELD/Dakar/pdf/FACA.pdf (accessed on 13 December 2021).

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Konkobo, Soulamane. Chief Executive Officer at Burkina Business Incubator.

Lassina, Nebié. President at Burkina Association of Inventors and Innovators.

Sawadogo, Abdoulaye. Founder and CEO at Nafaso.

Sawadogo, Louis. Director-General at ANVAR.

Sirima, Sodiomo. CEO at Groupe de Recherche Action en Santé (GRAS).

Yameogo, George. Research Leader at CNRST.

Zangre, Ibrahim. Director of Studies at Ouaga 3S University.

3. Cambodia

Figure 3.1. Least developed country status indicators for Cambodia

Asia
Cambodia

Population
16 million (2020)

LDC status
Met eligibility criteria for the first time; will be considered for graduation in 2024

Well-being		
Human Assets Index *(composed of six indicators)* 74 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* No data	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 80 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 1,376 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 6% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 6% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 30 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 0% (2017) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 94% (2012) LDC median: 89% *Source: ILO*

3.1 Country profile

Cambodia is located in the south of the Indochinese Peninsula, bordering with Thailand, the Lao People's Democratic Republic and Viet Nam. It gained independence in 1953 after 90 years as a French colony. However, it faced three decades of political and economic turmoil from the 1960s to the 1990s, suffering extensive bombing during the Viet Nam war from 1969 to 1973, Khmer Rouge rule and the Cambodian genocide from 1975 to 1979, and the Cambodia-Viet Nam war of 1978 to 1989. Following the 1991 Paris Peace Accords, Cambodia was briefly governed by a United Nations Mission and joined the group of least developed countries. After a coup d'état in 1997, power was consolidated under the Cambodian People's Party, who remains in power to this day in a constitutional monarchy operated as a parliamentary representative democracy. Since then, Cambodia has been making significant socioeconomic progress, making strides towards sustained, rapid and broad-based economic development.

The economy of Cambodia grew by 19.6 per cent per year between 1994 and 2015.[94] This growth has been principally driven by exports of goods and services, mainly garments and tourism, the latter centred on well-known cultural sites such as Angkor Wat and Siem Reap. Growth has also been driven by the country's rich natural capital—agriculture remains an important source of wealth, contributing 30 per cent of GDP in 2015, and oil was discovered in 2005 off the Cambodian coast and was first exploited in early 2021. Cambodia has maintained an average GDP growth rate of over 7 per cent per year in the past two decades, supported by policies that ensure strong macroeconomic stability and an open economy. This has resulted in high levels of employment, higher average incomes and a dramatic reduction in poverty and inequality. Domestic revenue is estimated to have reached a record high of 22.3 per cent of GDP in 2018, thanks to improved tax administration.

Cambodia joined the Association of Southeast Asian Nations (ASEAN) in 1999 and has reaped benefits from its membership with a common trading block enlarging its economic prospects, a security shield in a region with rising tensions, and an opportunity to promote Cambodian culture.

At the 2021 triennial review of the list of least developed countries by the UNCDP, Cambodia met the graduation eligibility criteria for the first time. However, the Committee recommended that various United Nations organizations monitor development closely, out of a concern that eligibility would not be reached again at the 2024 triennial review, principally due to the slowing of development resulting from the COVID-19 pandemic.[95] However, it is anticipated that growth in Cambodia will have been renewed in 2021, with the World Bank giving an estimated figure of 4 per cent.

Despite this positive development, there are threats to the sustained economic growth of Cambodia. Firstly, risk associated with rapid credit growth (credit to the private sector jumped from 2 per cent of GDP in 1993 to 63 per cent in 2015, in the form of increased credit given from microfinance institutions) could cause problems in the longer term.[96]

Secondly, natural disasters have already caused significant economic damage in Cambodia, with the country's high level of exposure to climatic factors making it vulnerable to frequent floods, storms and droughts. For example, in October 2020 Cambodia was hit by flash floods that killed at least 44 people and displaced around 50,000, costing the Government US$91 million for infrastructural repairs.[97] This will likely only worsen with climate change: it is predicted that temperatures in the country will increase by 0.7°C to 2.7°C by 2060, causing increased intensity and frequency of extreme precipitation and flooding in the monsoon season.[98] Indeed, the Organisation for Economic Co-operation and Development (OECD) argues that Cambodia faces significant fragilities in terms of both climate and social factors.[99] The United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) points out that these risk factors can combine multiplicatively: the intersection of weak institutions and social fragility with climate change vulnerability is referred to as the climate-conflict nexus. Rather than being seen as a singular driver of conflict, climate change should be seen as a stressor that may lead to heightened risk of violence and conflict in an already fragile setting. Cambodia was one of 20 countries (all of which are low- or middle-income countries) designated in this report as at risk from the climate-conflict nexus.[100]

3.2 Key development challenges

3.2.1 Priorities of the national development agenda

In its long-term strategic document, Vision 2050, Cambodia outlines its aim to become an upper-middle-income country by 2030 and a high-income country in 30 years. To achieve these goals, Cambodia has two main development plans. Firstly, Rectangular Strategy

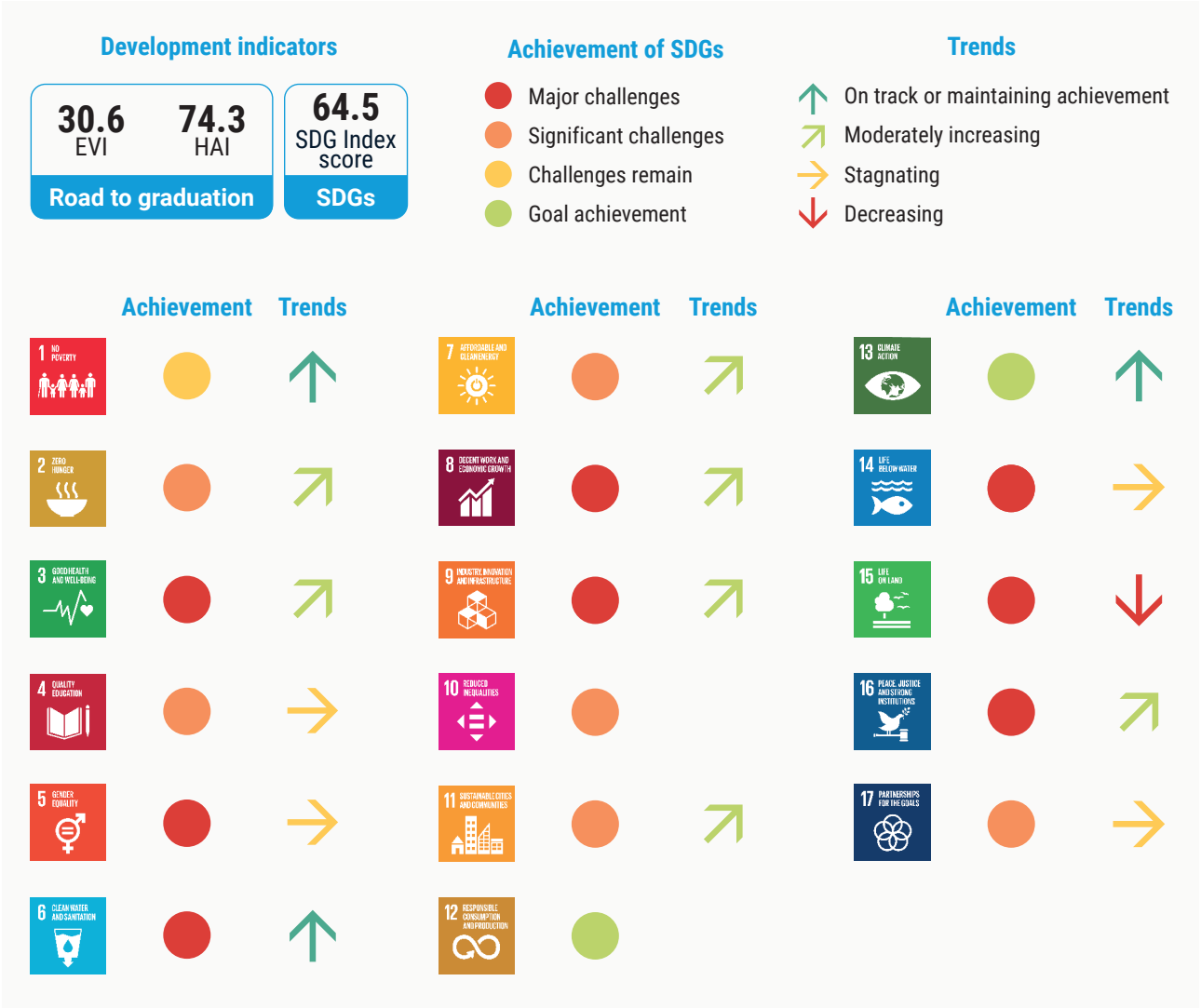
94 Information in this paragraph is taken from World Bank Group, *Cambodia: Sustaining Strong Growth for the Benefit of All—A Systematic Country Diagnostic* (Washington, D.C. World Bank Group, 2017).
95 UNCDP, "The 2021 triennial review of the list of LDCs".
96 World Bank Group, *Cambodia*.
97 Phoung Vantha, "Cambodia counting the cost of recovery from flooding", *Cambodianess*, 25 November 2020. Available at https://cambodianess.com/article/cambodia-counting-the-cost-of-recovery-from-flooding (accessed on 13 December 2021).
98 Xavier Espinet Alegre and others, "Analyzing flooding impacts on rural access to hospitals and other critical services in rural Cambodia using geo-spatial information and network analysis", Policy Research Working Paper, No. 9262 (Washington, D.C. World Bank, 2020).
99 OECD, *States of Fragility 2016: Understanding Violence* (OECD Publishing, Paris, 2016).
100 Nicholas Bodanac, Daniel Hyslop and Rodolpho Valente, "Understanding the climate-conflict nexus from a humanitarian perspective: a new quantitative approach", OCHA Policy and Study Series, No. 17 (New York, UNOCHA, 2016).

Phase IV (RS-IV) identifies four "strategic rectangles" for development, including human resource development, economic diversification, private sector and employment development, and inclusive and sustainable development. These axes are accompanied by four priority areas (roads, water, electricity and people), and aim to reach four strategic goals: i) an annual growth of 7 per cent and enhancing competitiveness; ii) improving the quality and quantity of jobs in particular for young people; iii) reducing poverty below the 10 per cent threshold; and iv) strengthening public institutions' governance and capacity. This policy instrument aims to contribute to reaching the goals set in Vison 2030 and 2050.

This strategy then feeds into the National Strategic Development Plan 2019–2024 (NSDP). The NSDP has been formulated to detail the implementation of the RS-IV, identifying the priorities, indicators and time frame for implementation, and the mechanisms for the monitoring and evaluation of the results framework. Importantly, the NSDP outlines the roles and responsibilities of line ministries and agencies which are divided according to the four rectangles.

These plans are accompanied by the Cambodian SDG Framework which adds to the 17 initial goals an additional eighteenth goal aiming at ending the negative impact of landmines in the country. In 2019, Cambodia conducted a voluntary national review of the implementation of the 2030 Agenda for Sustainable Development, showcasing its progress in the different SDGs. Six goals were prioritized: education, decent work and growth, reduced inequalities, climate action, peace and institutions, and SDG partnership, each being integrated into the RS-IV and the NSDP.

Figure 3.2. Progress on the SDG index in Cambodia



Source: Adapted from Sachs and others (2021).

3.2.2 Level of achievement of the SDGs

This section focuses on SDG 2 (zero hunger), SDG 6 (clean water and sanitation) and SDG 7 (affordable and clean energy) in "agriculture, food, water and energy"; SDG 13 (climate action) in "climate change and the environment"; and SDG 1 (no poverty) and SDG 8 (decent work and economic growth) in "economy and jobs". These areas are explored in-depth because of the distinctly positive trend observed in Cambodia around them.

- **Agriculture, food, water and energy**

Although malnutrition prevalence has declined over the past two decades, about one third of children under the age of five were stunted in 2016. Access to improved water and sanitation facilities (at 75 and 42 per cent of total population, respectively) both remain significantly below the average for lower-middle-income economies (90 and 52 per cent, respectively) and is a major contributor to stunting, along with suboptimal infant feeding practices and low dietary diversity.[101] While the diets of mothers and children under five remain poor, obesity is increasing in certain subgroups of the population.[102] One of the major challenges faced by Cambodia in meeting SDGs related to adequate food and water is its own rapidly changing development status, resulting in population growth, urbanization and migration. These changes demand increased public budgets and private investments for sustainability.

More than 75 per cent of Cambodians live in rural areas, and agriculture accounts for about a quarter of GDP. Historically, Cambodian farming has mainly focused on rice, and the country imports more vegetables than it harvests. Converting rice fields into vegetable fields could allow farmers to diversify their operations with high-value crops—studies have shown that profits from vegetables can be 3 to 14 times higher per hectare than from rice. At the same time, consumption of locally grown fruit and vegetables has economic and environmental benefits, and their nutrient content is higher than that of imported fresh produce.

Photo credit: Paul Szewczyk, Unsplash

101 World Bank Group, *Cambodia*.
102 Cambodia, *Cambodia's Voluntary National Review 2019 on the Implementation of the 2030 Agenda for Sustainable Development* (Phnom Penh, Kingdom of Cambodia, 2019).

- **Climate change and the environment**

Cambodia is one of the most vulnerable countries to climate change in the region, and is among the top 10 most vulnerable countries globally.[103] Cambodia has already seen temperature rises, the arrival of the monsoon is becoming less predictable, and floods and droughts are increasing in frequency and severity. In these changing conditions, agricultural methods need to adapt.[104] Climate change has been integrated in the RS-IV and the NSDP. In 2017, Cambodia reached its target of spending 1 per cent of public expenditure on addressing climate change, in line with the Cambodia Climate Change Strategic Plan 2014–2023, and initial progress has been made on the reduction of greenhouse gas emissions. Progress is being hampered, however, by a lack of data and technologies, and limited access to finance for firms wishing to make climate-smart investments.[105]

- **Economy and jobs**

As already described, Cambodia has enjoyed strong economic growth in recent decades, leading to its achieving lower-middle-income status in 2015 based on its GDP per capita. Strong sectors include the garment trade, tourism, and in recent years, construction and real estate. Financial services and the banking sector have also enjoyed strong growth. However, Cambodia still faces a number of important challenges holding back further growth. First, the country must move away from labour-intensive industries to those that require a more skilled workforce and advanced technologies, and are higher value added.

Second, many businesses in Cambodia are still reluctant to formalize their status (it has been reported that, out of all enterprises in Cambodia, only 3.5 per cent have registered with the Ministry of Commerce),[106] resulting in a lack of data about them and their needs, hampering public-sector interventions. This is particularly important in light of the COVID-19 crisis, as it will be more difficult to address economic recovery in the informal sector.

Third, infrastructural limitations (in electricity, skills and logistics, among other areas) are holding back business growth.[107] Upskilling the workforce will be particularly important in preparing for the Fourth Industrial Revolution. Cambodia has a workforce that is ample but currently characterized by low levels of education and skills—the average educational attainment level of the current workforce is primary school completion.[108] As such, they are not only lacking in technical skills, but also the soft skills required in the workplace. It should be noted that the Cambodian Government has put in place a Technical and Vocational Education and Training Policy (2017–2025) with the goal of transforming and modernizing the skills development system to better serve new labour force entrants, existing workers and the future development of Cambodia.

3.2.3 Relevance of STI to solving these development challenges

For these three overarching themes (agriculture, climate change and jobs and productivity), STI are being mobilized and are a key part of the noted upward trend in achieving the SDGs. Below are examples of how STI have been put into practice in Cambodia to solve development challenges.

Agricultural innovation: The Ministry of Agriculture, Forestry and Fisheries is promoting the use of an IT and digital suite in order to establish the country's Agricultural Big Data Platform. The Ministry is also examining opportunities for the establishment of agricultural product monitoring and traceability systems through IT. It is hoped this will promote the importance and benefits of IT systems in agriculture in Cambodia through mobile applications, the Ministry's website, and social networks.

Amru Rice, a leading exporter of rice in Cambodia, has since 2018 been developing a project called BlocRice, which utilizes blockchain technology to empower Cambodian rice farmers. BlocRice lays out the entire supply chain for farmers, agricultural cooperatives, exporters, importers and consumers. Farmers confirm if they are paid for their rice, if the agreed price is paid, if they are paid on time, how much they are able to supply, and whether other contract conditions are met. This same process takes place at each stage of the supply chain. As such, all stakeholders can track the origin of

103 Cambodia, *Cambodia's Voluntary National Review 2019*.
104 UNDP, "Cambodia adapts to climate change", *Medium*, 1 July 2019. Available at https://undp.medium.com/cambodia-adapts-to-climate-change-653538af50ca. Accessed on 13 December 2021.
105 UNESCO, *UNESCO Science Report*.
106 Nuppun Institute for Economic Research, "Supporting micro-, small and medium-sized enterprises (MSMEs) to achieve the SDGs in Cambodia through streamlining business registration policies" (New York, UNDESA, 2020).
107 Cambodia, *Cambodia's Voluntary National Review 2019*.
108 Asian Development Bank, "Toward adopting a skills development fund for Cambodia", *ADB Briefs*, No. 90 (February 2018).

the rice which they buy, sell or process and can check whether other stakeholders were paid correctly according to the contract. If the project proves successful, it can be scaled up to other farmer cooperatives in the rice chain and other commodity value chains in Cambodia and elsewhere.

The Feed the Future Innovation Lab for Horticulture is a global network focused on fruit and vegetable research that is led by the University of California, Davis (UC Davis) and funded by USAID. In conjunction, researchers from the Royal University of Agriculture in Cambodia have been working with small-scale farmers to test new methods for growing and selling produce locally. For example, researchers from UC Davis worked with local farmers to design "net houses", which allow farmers to cultivate the land within the structure as they normally would, but with protection from insects. The net houses obviate the need for pesticides, saving farmers money while producing higher quality crops that attract better prices at markets. Additionally, in order to help farmers aggregate their produce, researchers developed a packing house in collaboration with local farmers. Here they can wash, prepare and pack produce for market, and use a cool room (utilizing a "CoolBot" that tricks an air conditioner into achieving colder temperatures at a lower cost than refrigeration) to store produce, extending the shelf life of products. The Government has plans to extend the use of packing houses across Cambodia, with one available for use in each farming community. The impacts of this initiative have been positive and widespread: farmers have increased their income and local nutritional standards have been raised. The partnership has also advanced R&D at both UC Davis and the Royal University of Agriculture, with over 300 students working on the projects over several years.[109]

Climate change-proofing and early warning systems: As described, Cambodia is among the countries in the world most vulnerable to the impacts of climate change. As part of its response to climate change, the Government, in collaboration with its development partners, is implementing the Strategic Program for Climate Resilience (SPCR). The SPCR emphasizes two streams to promote climate resilience. The first stream aims to build knowledge about the impacts of climate change on Cambodia and how climate resilience can be mainstreamed into agriculture, water resources and transport and urban infrastructure. The second stream invests in new skills, techniques, technology and engineering practices for climate resilience. For example, the SPCR is climate-proofing infrastructure in towns in the portion of the South-East Asia region's Southern Economic Corridor in Cambodia, by conducting vulnerability mapping and adjustments and implementation of adaptation measures; constructing and rehabilitating safe access roads, wastewater systems and flood control systems; and building facility maintenance and asset management capacity for climate-resilient infrastructure. This six-year-long project, with a budget of US$55.4 million, impacted a total of 185,820 beneficiaries, of whom 92,910 were women and girls. The SPCR has also implemented projects to develop flood-resistant infrastructure, develop sustainable farming practices with spice farmers and promote climate-resistant agricultural practices.

The United Nations Development Programme (UNDP) has been working with Cambodia to build climate forecasting and early warning equipment for those working in agriculture and water management. For example, the National Committee for Disaster Management worked with the NGO People in Need to set up the EWS1294 early warning system, using solar-powered and mobile data enabled water gauges to detect rising water levels, and which provides voice-based alerts (therefore suitable for populations with low literacy levels) to locals' mobile phones.

Innovative approaches to preparing for the Fourth Industrial Revolution: The Bluetribe incubation programme, supported by UNDP, was launched in 2020. It uses a technology acceleration framework to incubate tech start-ups, create high-skilled employment among Cambodian youth and create future jobs for other youth by upskilling high potential talents through world-class entrepreneurship programmes.[110] Among the projects incubated at Bluetribe are Homeapp, a business that targets and upskills informal workers in the construction sector; WheelCiti, a start-up that onboards Cambodian MSMEs onto digital platforms and helps potential customers find them; and KlemBox, a start-up that has created an offline and online learning platform, combined with experiential learning kits, to increase digital learning and promote STEM and entrepreneurship in public schools.

109 Ann Filmer, "Agricultural innovations help Cambodian farmers thrive", UC Davis, 8 October 2019. Available at https://www.plantsciences.ucdavis.edu/news/agricultural-innovations-help-cambodian-farmers-thrive. Accessed on 13 December 2021.
110 UNDP Cambodia, "Bridging the gap: reshaping tomorrow for the young Cambodian workforce", 13 November 2020. Available at https://www.kh.undp.org/content/cambodia/en/home/presscenter/articles/2020/bridging-the-gap--reshaping-tomorrow-for-the-young-cambodian-wor.html (accessed on 13 December 2021).

STI have been applied to other development goals to a lesser extent in Cambodia, but can also be achieved in part through STI solutions. For example:

SDG 10 (reduced inequalities) can be addressed through access to education through e-learning

SDG 12 (responsible consumption and production) can be addressed through research on the sustainable production of information-sharing on nutritional components

SDG 16 (peace, justice and strong institutions) can be addressed through the monitoring of illicit online activities, or through e-payments to reduce corruption

There is still potential for the development of STI in the pursuit of the SDGs.

3.2.4 Impact of COVID-19 in Cambodia

In comparison to other ASEAN countries, Cambodia is more dependent on its tourism sector, and earnings from tourist arrivals decreased by more than 70 per cent after the COVID-19 pandemic hit in 2020, with drastically reduced mobility between cities, airports, tourist landmarks and SEZs. Cambodians lost on average 4.8 per cent of their working hours in 2020, and growing unemployment particularly in the informal sector hit border provinces and tourism hotspots hard. Data show that women and people with disabilities in informal work were hit hardest by the crisis, 18 per cent of them reporting being unemployed in 2020. Overall, the country's economic growth rate went into negative values (-1.4 per cent) for the first time, and the stimulus package, with a value of 4.9 per cent of the GDP of Cambodia, may leave a durable impact on the public deficit. However, according to different scenarios of the impact of the COVID-19 crisis on the country's road to graduation from least developed countries status, Cambodia should not see its HAI decrease sharply, with some moderate instability to be observed in terms of GNI per capita and the Economic and Environmental Vulnerability Index.

To fight the crisis, the Government has launched specific policies to protect vulnerable people and productive capacities. Vulnerable people have included furloughed, informal or returned migrant workers, for whom social assistance, skills training and cash transfer programmes were upscaled. Support to the private sector was provided with tax exemptions for the hospitality industry and subsidized interest payments on loans provided by banks to affected businesses. In addition, the COVID-19 vaccination programme in Cambodia has been an enormous success—at time of writing more than 98 per cent of Cambodian adults have been vaccinated at least once, and 65 per cent are fully vaccinated.

- **Example of how STI have been successfully used to tackle COVID-19**

In March 2021 the Ministry of Health launched KhmerVacc, a mobile application for COVID-19 vaccination registration, helping to reach the Government's target of vaccinating 90 per cent of the population. The application allows people to register to receive the vaccine and subsequently receive a notification from the health authorities of the date, time and location of their appointment.

The UNDP-funded Accelerator Labs Cambodia supported a project to create dashboards bringing together visualizations of and insights on the COVID-19 pandemic in Cambodia. Grouped according to different themes (impacts of COVID-19 on mobility, informal workers and MSMEs), the dashboards showcase trending survey data and geolocation data, collected before and throughout the pandemic. The insights drawn from these dashboards can help citizens, policymakers, decision makers, NGOs and CSOs understand the varied and far-reaching effects of the pandemic on women, business owners, MSMEs, the population in general and any intersections between those groups.[111]

111 See https://www.dataforcambodia.org.

3.3 STI snapshot

STI are helping to transform Cambodia. This section takes a deeper look at the STI system in a SWOT analysis, using the national innovation system as a framework.

3.3.1 STI system SWOT analysis

Table 3.1. Strengths, weaknesses, opportunities and threats of the national STI system in Cambodia

Strengths	Weaknesses
• Rapid economic growth—an average of 7 per cent GDP growth over the last 20 years • Large working-age population • 31 SEZs provide economic incentives for foreign direct investment (FDI) • Growing knowledge diffusion through university-industry linkages • Strong Government and governance for STI development, with a dedicated Ministry for STI, allowing for an integrated approach with less risk of siloing • Growing innovation infrastructure including co-working spaces and incubators and accelerators • Advanced intellectual property laws • Tax breaks for MSMEs: all newly registered small- and medium-sized enterprises (SMEs) are eligible for the three-year tax break. To be eligible for the five-year break, newly registered MSMEs must use at least 60 per cent local raw material, increase the number of employees by 20 per cent, or be located in the small and medium enterprise cluster zone	• Industrial base lacking in diversity—most activities are concentrated in garment production and food processing • Majority of small enterprises less inclined to innovation than medium-sized enterprises (product innovation) and large firms (process innovation) • High number of informal businesses with little regulation or oversight are unfair competition for formal businesses • Difficulty of setting up a business—only 99 days to legally register a new business • Low entrepreneurial activity: annual business entry density rate of 0.23, less than one third of the average for low- to middle-income countries • Only a small percentage of university students studying STEM subjects • Low knowledge development: low Government spending on R&D and very few patent applications • Limited scientific culture and skills
Opportunities	**Threats**

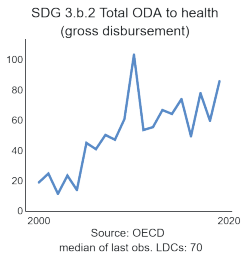
• Universities are succeeding in making more links with industry and offering incubation and start-up centres and industry linkage offices on campuses
• Growing investment landscape:
  • Skills Development Fund
  • Entrepreneurship Development Fund
  • Capacity Building, Research and Development Fund
• Although Government spending on R&D is low, the Government aims to increase this to 1 per cent of GDP by 2030 as outlined in its STI Roadmap
	• Most support for entrepreneurial activities is based in urban locations with little provision for innovation activities in rural settings; this means innovation will disproportionately address urban needs
	• Gender bias in Cambodian start-up culture—very few women-led start-ups[112]

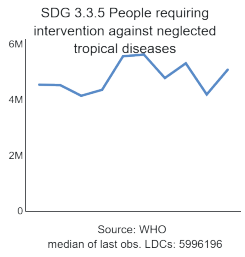
112 Bora Kem and others, "'Startup Kingdom': Cambodia's vibrant tech startup ecosystem" (Phnom Penh, Mekong Strategic Partners and Raintree, 2019).

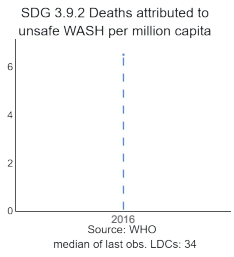
3.3.2 Key features of the STI system

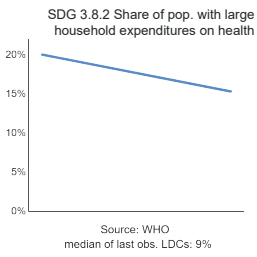
Figure 3.3. Key features of the STI system in Cambodia

STI & COVID-19 & Health



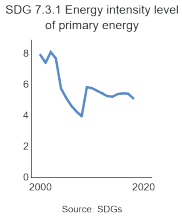


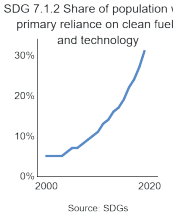


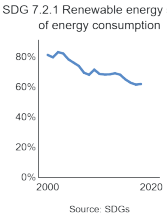


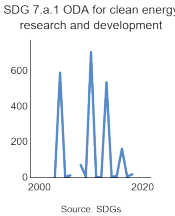
Publications 254: 4% of publications **Start-ups in crunchbase** 8: 4% of start-ups

STI & Clean Energy



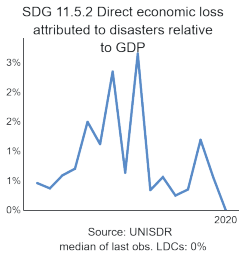


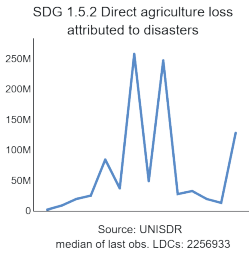


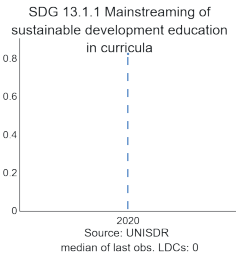


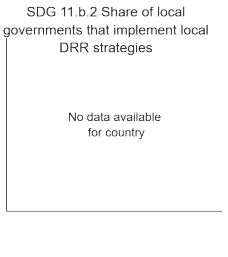
Publications 32: 0.5% of publications **Start-ups in crunchbase** 4: 2% of start-ups

STI & Climate Adaptation



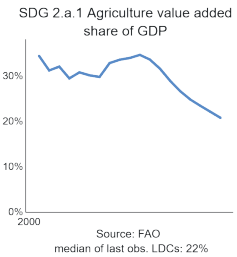


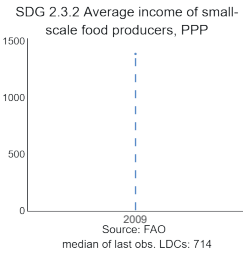


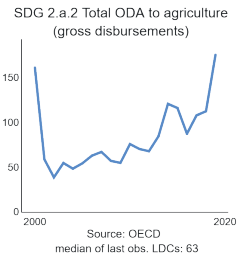


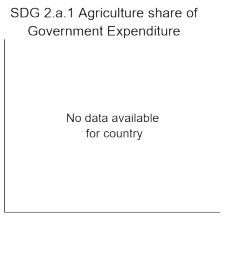
Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Agriculture









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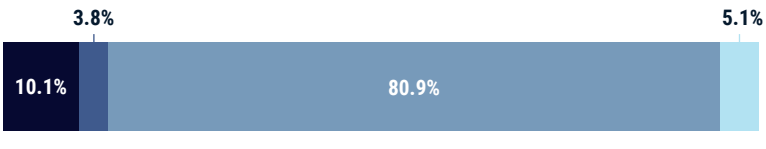
News coverage of thematic areas



Regarding innovation in Cambodia, science headline indicators are on a positive trend, with more R&D personnel, PhD students and scientific publications per capita over time. This is also true of technology headline indicators, with more technicians per capita, access to electricity and/or mobile networks and people using the Internet. However, while patents per capita are rising, firms' investment in R&D is on a downward trend.

The indicators related to STI and their impact on efforts towards achieving the SDGs are also positive:

- More ODA is directed towards health, and fewer people are requiring intervention against tropical diseases
- The energy intensity level of primary energy is decreasing, while the share of the population with primary reliance on clean fuels is rising
- Relative to GDP, the economic loss attributed to disasters is volatile, but on a downward trend

To better explore the STI system of Cambodia which has led to such achievements, this section focuses on its absorptive capacity, regional and subregional cooperation on STI, and key features such as social innovation and the governance of the system.

- **Absorptive capacity**

Absorptive capacity refers to the ability of firms to recognize, assimilate, transform and apply new knowledge for the benefit of their business performance. Many factors feed into the capacity to recognize and assimilate new knowledge. Knowledge spillover is one potential route, which often occurs through FDI: Cambodia scores well compared to its ASEAN competitors on net FDI inflows, and this could be expected to result in knowledge and technology absorption. Knowledge can also be assimilated via collaborations between firms and research institutions, and Cambodian universities have been successful in this respect. A number of universities have established industry linkage offices on campuses to help bridge communication gaps and forge partnerships between education and business institutions. On the other hand, there is not much indication that this knowledge is being transformed and applied to benefit business performance. Cambodia ranks low on the R&D subscale (publications, patent applications, R&D expenditure and research institution prominence) of the Global Competitiveness Index, at 121 out of 141.[113] A differentiation can be made between potential absorptive capacity (the acquiring and assimilation of knowledge) and realized absorptive capacity (the transforming and exploitation of knowledge),[114] and it seems that Cambodia has potential absorptive capacity but less realized absorptive capacity. Knowledge-sharing between firms may be highlighted as being key to closing the gap between potential and realized absorptive capacity.

- **Regional and subregional cooperation**

Cambodia joined ASEAN in 1999. Smaller and less technologically advanced than some of the other member countries, it is still catching up in terms of institutional reforms and human resources. However, since then, Cambodia has reaped benefits from its membership through the common trading block and security shield in a region where tensions are rising. Cambodia participates in the ASEAN Committee on Science, Technology and Innovation which supports ASEAN cooperation in STI and promotes the implementation of programmes and activities in the areas defined in the ASEAN Plan of Action on Science, Technology and Innovation 2016–2025. In Cambodia, the Committee is under the supervision of the Ministry of Industry, Science, Technology and Innovation (MISTI).

- **Social innovation**

The social innovation ecosystem in Cambodia is nascent, small, dynamic and accessible. Government initiatives have paved the way for the social innovation ecosystem to develop rapidly in recent years; the Government has launched a private entity called Khmer Enterprise that is leading on the development of the start-up and MSME ecosystem through support for accelerators and ecosystem builders, as well through the Small and Medium Enterprise Bank and Fund.[115] Cambodia Sustainable Development Goals (CSDGs) "superheroes", an initiative of UNDP Cambodia Accelerator Labs, the Ministry of Planning and Impact Hub Phnom Penh, showcases Cambodian social innovators and changemakers through the lens of the SDGs. The

113 Schwab ed. *The Global Competitiveness Report 2019*.
114 Shaker A. Zahra and Gerard George, "Absorptive capacity: a review, reconceptualization, and extension", *The Academy of Management Review*, vol. 27, No. 2 (April 2002).
115 Richard Hazenberg and Abigail Perriman, "Cambodia social innovation ecosystem: infographic report" (Northampton and Phnom Penh, University of Northampton and Impact Hub Phnom Penh, 2020).

initiative aims in particular to support grass-roots innovation projects that contribute to CSDG achievement. For example, one project working towards SDG 1 (no poverty) addresses the difficulties faced by migrant workers in Thailand who have been forced to return home due to COVID-19 but find themselves out of work in Cambodia. The project trains these returning migrant workers in poultry farming and provides them with chickens to start their businesses, thereby supporting livelihoods and reducing migration.

- **Governance**

Following the signature of the Law on the Establishment of the MISTI in March 2020, the MISTI replaced the previous Ministry of Industry and Handicraft. This Government infrastructure, interministerial and overarching, provides a strong basis for the development of the national innovation system, although this still requires increased coordination and effective action.

Vision 2050 will be supported by the implementation of the National STI Policy 2020–2030, approved in 2019. The STI policy strengthens the foundations of STI in the country, and builds national STI capability to: i) create potential technologies for development; ii) strengthen innovation capacity in response to the fundamental needs of the nation; iii) improve the quality of people's lives; iv) increase national wealth; v) develop competitive national industries; and vi) improve STI governance.

Three additional instruments have recently been created. The Skills Development Fund, financed by formal enterprises and managed by the Ministry of Labour and Vocational Training, is intended to bridge the mismatch between university curricula, existing entrepreneur capabilities and market needs. The Entrepreneurship Development Fund, a government trust fund managed by the Ministry of Economy and Finance, will contribute to engendering a mindset that encourages innovation and careers beyond more traditional professional pathways, thereby increasing entrepreneurial activity. The Capacity Building, Research and Development Fund, managed by the Ministry of Post and Telecommunications, promotes start-ups and technology entrepreneurship in the country.

In addition, the National STI Policy 2020–2030 was approved by the Prime Minister in December 2019 and focuses on five scientific and technological domains:

- Agricultural yield increase, produce diversification, and agro-processing
- Modern production and engineering
- Health and biomedical sciences
- Material science and engineering
- Services and the digital economy including AI, space and spatial technology

These five domains are aligned with the key targeted economic sectors prioritized in the Industrial Development Plan, and are complemented by the STI Roadmap 2030, created in collaboration with the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). A national research agenda will be developed in the near future.

3.3.3 Resilience of the national innovation system of Cambodia

One of the most important parts of an STI system is its resistance to external shocks, with COVID-19 having been a prime illustration of this globally in 2020–2021. The strong response to the pandemic in Cambodia, in which effective use of STI played an important part, may indicate the potential impact of future shocks.

COVID-19 has accelerated digitization trends. Cambodia, like other least developed countries, has seen an important development towards digital financing, through quick response (QR) code-based payments. These technologies are particularly relevant for avoiding potential viral contamination via cash-based payments, and may further spur technological developments. This has led Cambodia to increase measures favouring interoperability of digital payment options, by scaling up investments in national payment infrastructures.

It has been observed in Cambodia that STI can be particularly relevant in fighting the crisis, through the development of online services that can support social distancing measures. STI can also boost the diversification of the country's economy beyond the garment, food processing and tourism sectors that have faced both supply and demand disruptions.

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4. Democratic Republic of the Congo

Figure 4.1. Least developed country status indicators for the Democratic Republic of the Congo

Africa
Democratic Republic of the Congo

Population
89 million (2020)

LDC status
Member since 1991

Well-being		
Human Assets Index *(composed of six indicators)* 47 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* No data	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 108 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 505 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 90% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 5% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 28 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 4% (2012) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 97% (2012) LDC median: 89% *Source: ILO*

4.1 Country profile

The Democratic Republic of the Congo is the largest country in sub-Saharan Africa, with a surface equivalent to that of Western Europe, divided into 10 provinces. It hosts a population of 89 million inhabitants. The official language is French, but Kikongo, Lingala, Swahili and Tshiluba are national languages.[116] One of the poorest countries in the world, one out of six people in extreme poverty conditions in sub-Saharan Africa live in the Democratic Republic of the Congo. Despite the conditions of poverty, the Democratic Republic of the

116 France, Ministry for Europe and Foreign Affairs, "Présentation de la République démocratique du Congo", 27 April 2021. Available at https://www.diplomatie.gouv.fr/fr/dossiers-pays/republique-democratique-du-congo/presentation-de-la-republique-democratique-du-congo/ (accessed on 13 December 2021).

Congo is exceptionally rich in natural resources such as copper, hydropower potential and arable land, and also contains immense biodiversity and the world's second-largest rainforest.[117]

Politically, the Democratic Republic of the Congo experienced its first peaceful democratic transition since its independence in 2018 following the presidential election. However, the country has been unstable, especially in the Eastern region due to the actions of armed groups. These groups, involved in the illegal exploitation of natural resources, are the origin of a humanitarian crisis in the Democratic Republic of the Congo, creating 5 million internally displaced persons and 20 million people living in chronic food insecurity.[118]

The industrial sector (manufacturing and construction) in the country is very embryonic.[119] The principal motor of growth in the country has been the mining industry, which grew by 7 per cent in 2020 against 1 per cent in 2019, mainly due to the high demand from China.[120] The economy is thus highly dependent on world mineral prices, and is directly affected by the security situation in the eastern part of the country where the mines are located. However, the mining sector employs 11 per cent of the population.[121]

The current business climate is not attractive to investors. Agricultural jobs account for more than 60 per cent of the national labour market. Agriculture is the main source of employment for the poorest portion of the rural population. However, the sector has not been able to generate sufficient income, sustainable employment or food to meet the country's needs. Production, including food crops, will have to increase by 60 per cent over the next years to keep pace with population growth. While up to 72 per cent of farmers and small-scale agricultural entrepreneurs are women, women owned less than 10 per cent of the land, and only 2 per cent of women have access to credit services offered by financial institutions.

> **Overall, 70 per cent of the economy is informal, and the economy is dominated by women.**

Human development indicators are extremely low: in 2020, the Democratic Republic of the Congo was ranked 175 out of 189 countries on the Human Development Index and 152 out of 160 countries on the Gender Inequality Index.[122] The education system is facing great challenges: the country has not yet reached universal and equal education at primary level (completion rate was 67 per cent in 2018), with significant regional and gender disparities. Other challenges include vulnerability in water resources, land use and forestry, health and sanitation, and energy.[123] The Democratic Republic of the Congo has been a least developed country since 1991, and is not expected to graduate from this category in the timeline up to 2024.[124]

117 Ibid.
118 Ibid.
119 UNDP, "Climate change adaptation: DR Congo", n.d. Available at https://www.adaptation-undp.org/explore/middle-africa/democratic-republic-congo. Accessed on 13 December 2021.
120 World Bank, "The World Bank in DRC: overview–context", 3 April 2021. Available at https://www.worldbank.org/en/country/drc/overview#1. Accessed on 13 December 2021.
121 Extractive Industries Transparency Initiative, "Democratic Republic of Congo" (2021). Available at https://eiti.org/democratic-republic-of-congo (accessed on 13 December 2021).
122 World Food Programme, "Democratic Republic of the Congo country strategic plan (2021–2024)" (2020).
123 World Bank, "The World Bank in DRC: overview–context".
124 UNDESA, "Graduation from the LDC category".

4.2 Key development challenges

4.2.1 Priorities of the national development agenda

The National Strategic Development Plan 2019–2023 of the Democratic Republic of the Congo intends to tackle the challenges keeping the country from graduating from least developed country status. It is centred around five pillars: i) valorization of human capital and social and cultural development; ii) strengthening of good governance, restoration of State authority and consolidation of peace; iii) consolidation of economic growth and diversification and transformation of the economy; iv) spatial planning, reconstruction and modernization of infrastructure; and v) protection of the environment and fight against climate change, through sustainable and balanced development.[125]

The country's goal was to first attain middle-income status by 2021, and a GDP of US$1,050 per capita.[126] This goal has not yet been achieved: GDP per capita reached US$556.81 in 2020, a decline from 2019 (US$580.72, the highest in the Democratic Republic of the Congo since 1978) due to the COVID-19 pandemic.[127] The Democratic Republic of the Congo strives to achieve GDP per capita of US$4,000 and emerging market status by 2030, and developed country status by 2050, bringing GDP per capita to US$12,000.[128]

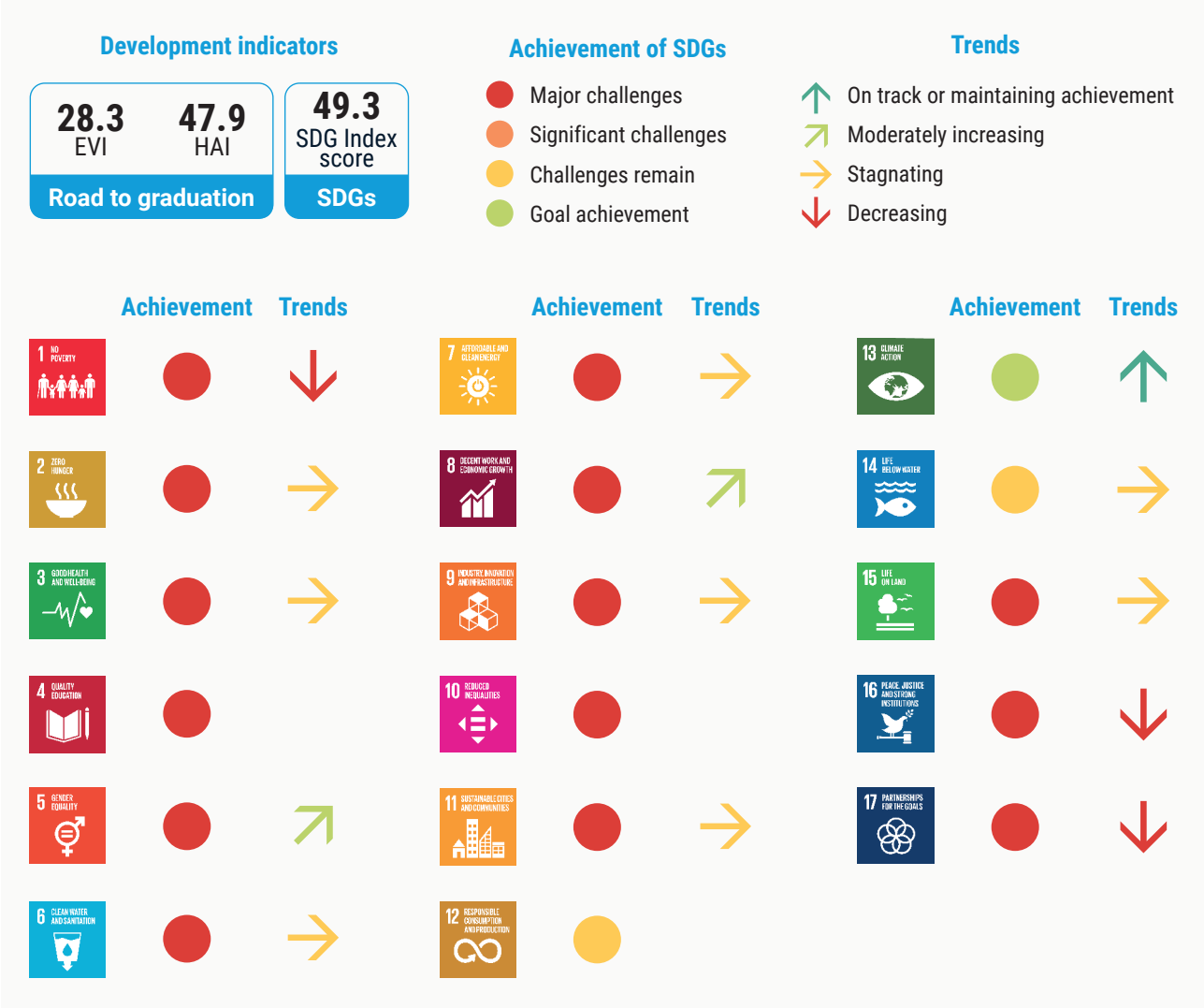
4.2.2 Level of achievement of the SDGs

The country is moving slowly in pursuing the aforementioned goals, and shows very modest signs of progress towards achieving the SDGs. The only SDG attained is SDG 13 (climate action). All the other SDGs present major challenges, except for SDG 12 (responsible consumption and production) and SDG 14 (life below water). SDG 12 has received particular attention recently due to the Conflict-free Technology campaign to force manufacturers who receive the raw material (minerals and gold) necessary for their appliances from the Democratic Republic of the Congo to ensure due diligence of their supply chains. The campaign has had a positive impact in terms of child labour reduction and improved occupational safety. SDG 14 presents minimal challenges because the Democratic Republic of the Congo has a very small coastline and thus does not invest significantly in activities impacting life below water such as fishing; the carbon footprint of the country, which could also impact the ocean, is also very low.

Even if still presenting major challenges, progress on SDG 5 (gender equality) and SDG 8 (decent work and economic growth) is moderately improving, while there is regression on SDG 1 (no poverty), SDG 16 (peace, justice and strong institutions) and SDG 17 (partnerships for the goals). Movement on all other SDGs (SDGs 2, 3, 6, 7, 9, 11, 14 and 15) is stagnating.

125 Democratic Republic of the Congo, Ministry of Planning, *Plan National Strategique de Développement 2019-2023* [National Strategic Development Plan 2019-2023] (2019). Available at https://www.cd.undp.org/content/rdc/fr/home/library/plan-national-strategique-de-developpement.html.
126 Democratic Republic of the Congo (2019).
127 World Bank, "Interview with Professor Muyembe, the Ebola and COVID-19 response coordinator in the DRC: "Community engagement and awareness-raising campaigns are key to winning the battle", 19 May 2020. Available at https://www.worldbank.org/en/news/feature/2020/05/19/interview-with-professor-muyembe-the-ebola-and-covid-19-response-coordinator-in-the-drc-community-engagement-and-awareness-raising-campaigns-are-key-to-winning-the-battle (accessed on 13 December 2021).
128 Democratic Republic of the Congo (2019).

Figure 4.2. Progress on the SDG index in the Democratic Republic of the Congo



Source: Adapted from Sachs and others (2021).

In the light of the priorities expressed in the National Strategic Development Plan 2019–2023, the challenges related to agriculture, industry and education draw particular attention, as do those related to governance, due to its structural and transverse nature.

- **Agriculture, industry and education**

The value added of agriculture as a share of GDP has been decreasing in relevant terms, in line with development assistance to and government expenditure on agriculture. The Government seeks to transform agriculture and attract investment to the sector by increasing agricultural productivity and developing agro-industrial parks and integrated development centres.

The Democratic Republic of the Congo also faces the challenge of raising the level of education of the society by investing in the accumulation of human capital and R&D. The number of full-time personnel in R&D has been decreasing along with the number of PhD students. The number of technicians available in the country has also fallen sharply. The Human Capital Index of the Democratic Republic of the Congo stands at 0.37, below the average for sub-Saharan African countries of 0.40. This means that a child born in the Democratic Republic of the Congo today will achieve in adulthood only 37 per cent of the productive potential they could have reached if they had benefited from full schooling and optimal health conditions during their first years of life. On average, a child from the Democratic Republic of the Congo has 9.1 years of schooling, corresponding to only 4.5 years of schooling when adjusted for prior learning.[129]

129 World Bank, "The World Bank in DRC: overview–context".

- **Good governance, rule of law and protection of civilians**

Good governance remains a concern in the Democratic Republic of the Congo due to the conflicts and wars that have afflicted the country. Since 1990, the Democratic Republic of the Congo has faced social, economic, and political crises that have had broad-ranging negative impacts on the administrative apparatus, economy and rule of law in the country.[130] Fortunately, the economy stabilized and began to grow from 2010 onwards, although the COVID-19 pandemic has impacted this somewhat.[131] At the institutional level, the institutions provided for in the Constitution were gradually built from 2007 on, while the public administration was reorganized. Protection of civilians, particularly children, is a priority for the Democratic Republic of the Congo, since the impacts of the armed conflicts have fallen upon them. Children continue to pay the heaviest price, and have been victims of over 11,500 grave violations committed by more than 40 parties to the conflict, as verified by the United Nations.[132]

4.2.3 Relevance of STI to solving these development challenges

STI are relevant in addressing the main development challenges the Democratic Republic of the Congo faces, thus playing a major role in attaining the national development goals. The country already showcases multiple examples of the use of STI to address challenges in agriculture, human capital development (education and health) and rule of law, as described below.

Agro-industrial parks have helped address the challenges related to agricultural development. In 2014, the Democratic Republic of the Congo launched its first agro-industrial parks to attract investment in agricultural production, agro-processing and trade. The aim is to open sites across the country on which to build or improve the physical infrastructure necessary to increase productivity in the field crops consumed in the Democratic Republic of the Congo, process these crops and channel both public and private investment to the agrifood industry.[133] The first park of Bukanga Lonzo was a pilot which failed three years later in 2017 due to the mismanagement of financial resources.[134]

Agritech solutions include ManiTech,[135] a homegrown innovation providing technology for the extraction of fruit syrup for the production of jam and paste, using local resources, infrastructure and labour. ManiTech has now formed a local agronomy research team with its own private laboratory. One agricultural product with high consumption in the Democratic Republic of the Congo is cassava; however, unless properly processed it contains a high density of cyanide, which causes a disease called konzo leading to the paralysis of the lower limbs. A specialist in molecular biology at the University of Kinshasa has developed an innovative method to process cassava to extract the cyanide before consumption, responding to a national health problem.

The **National Institute for Biomedical Research (INRB)** in Kinshasa is a centre of excellence for R&D in the health sector. The INRB was founded in 1984 by the renowned Congolese virologist Professor Jean-Jacques Muyembe—who co-discovered the Ebola disease—to enhance R&D in biomedicine with the support of the Government. Equipped with high-quality equipment and active research teams, the INRB is internationally recognized for its research results. For example, the INRB identified the first effective treatment for Ebola, curing 70 per cent of Ebola patients in the Democratic Republic of the Congo.[136] The INRB is also the prime research centre in the fight against COVID-19 in the Democratic Republic of the Congo.

The N**ational Agency of Clinical Information and Health Informatics Engineering** is a digital health agency. The

130 Leila Zerrougui, "Strengthening the rule of law and protection of civilians in the Democratic Republic of the Congo", *UN Chronicle*, 1 April 2018.
131 Augustin Matata Ponyo Mapon, "Good governance: a key issue for DRC's Development?" *ID4D Sustainable Development News*, 4 October 2016. Available at https://ideas4development.org/en/governance-key-issue-drc/ (accessed on 13 December 2021).
132 United Nations Organization Stabilization Mission in the Democratic Republic of the Congo, *Echos de la MONUSCO: La Force de la MONUSCO. Pour la Protection des Civils* (May–August 2019). Available at https://monusco.unmissions.org/sites/default/files/echos_88_special_force_fr_0.pdf (accessed on 13 December 2021).
133 Democratic Republic of the Congo, Ministry of Planning, *Plan National Strategique de Développement 2019-2023* [National Strategic Development Plan 2019-2023] (2019). Available at https://www.cd.undp.org/content/rdc/fr/home/library/plan-national-strategique-de-developpement.html.
134 Oakland Institute, "Parcs agro-industriels en RDC: tirer les leçons de la débâcle de Bukanga Lonzo", 2019. Available at https://www.oaklandinstitute.org/parcs-agro-industriels-en-rdc-bukanga-lonzo (accessed on 13 December 2021).
135 See https://manitechcongo.com/category/qui-sommes-nous/.
136 World Bank, "Interview with Professor Muyembe, the Ebola and COVID-19 response coordinator in the DRC: 'Community engagement and awareness-raising campaigns are key to winning the battle', 19 May.

Democratic Republic of the Congo has been affected by successive health crises, with Ebola and the COVID-19 pandemic being the latest. The digital health agency was created following the Ebola outbreak in 2018, and today provides regular updates on COVID-19 in the country. It has also been responsible for the acceleration of the use of telemedicine. The Agency also organized a hackathon competition, with the first prize going to Lokole, an application designed to support the Ebola Response Coordination Team and community workers through real-time data exchange without a smartphone or Internet access.[137]

Schoolap responds to education challenges. A platform for administering lessons and courses in the national education system online at a very low cost, Schoolap was created well before the COVID-19 outbreak, but has undergone innovations to meet a wider audience during the pandemic. For example, the application includes modules of lessons for persons with hearing and speaking impairments, and a free basic version has been launched that allows access without Internet through several mobile network operators, reaching populations in remote areas with no Internet access.[138]

Traffic-regulating robots were created by the Congolese inventor Thérèse Kirongozi and first deployed in Kinshasa in 2013 to allow more rigorous monitoring and regulation of road traffic, thus reducing accidents.[139] These robots are still in use today, and the success of Kirongozi's invention generated interest in other African countries, such as Côte d'Ivoire.

Other development goals face major challenges in the Democratic Republic of the Congo, but STI solutions can contribute to progress towards these goals. For example:

SDG 5 (gender equality) can be addressed through increased access to digital skills education for all and access to media platforms to guarantee equal representation

SDG 6 (clean water and sanitation) can be addressed through adapted infrastructural solutions to the local environment

SDG 7 (affordable and clean energy) can be addressed through the use of renewable energies

SDG 8 (decent work and economic growth) can be addressed through investment in more skilled jobs for all

SDG 15 (life on land) can be addressed through increasing R&D to guarantee the protection of biodiversity and natural habitat, especially in areas with mining activities

SDG 17 (partnerships for the goals) can be addressed by creating partnerships with developed countries to reduce the digital and technological gap between the least developed countries and developed countries.

137 UNESCO, *UNESCO Science Report*.
138 See www.schoolap.com/about.
139 News from Elsewhere. "DR Congo: traffic cop robot installed in 'second capital'", *BBC News*, 31 March 2014. Available at https://www.bbc.com/news/blogs-news-from-elsewhere-26820565 (accessed on 13 December 2021).

4.2.4 Impact of COVID-19 in the Democratic Republic of the Congo

COVID-19 brought additional challenges to the Democratic Republic of the Congo. The pandemic had an overall negative impact on the country's economy. Restrictions on trade operations, disruptions at international borders and declining demand for key exports during 2020 all had a negative impact on growth, employment and debt levels. While growth reached 4.4 per cent in 2019, it dropped to 0.8 per cent in 2020.

Collectively, all economic sectors other than mining contracted by 1.6 per cent in 2020, with 71 per cent of companies experiencing a sharp drop in revenue compared to the same period the previous year. As a result, two thirds of business leaders in 2021 reported employing fewer people on open-ended contracts than at the same time in 2020.[140] At the time of writing, 55 per cent of companies in the Democratic Republic of the Congo are experiencing delays or disruptions in their supply chains. The budget deficit reached 1.9 per cent in 2020.[141] Despite these negative economic impacts, the health impact of the pandemic has remained relatively low in the Democratic Republic of the Congo.[142]

- **Examples of how STI have been successfully used to tackle COVID-19**

The Democratic Republic of the Congo harnessed the potential of STI to mitigate the disruptive impact of COVID-19 and the risks of contamination for its population. One example is the "safe gates", automatic disinfection tunnels that offer effective protection for public spaces such as government buildings, supermarkets, museums, offices and hospitals among others. The safe gates are among the most prominent COVID-19 safety measures adopted in the Democratic Republic of the Congo. The National Institute of Professional Preparation also developed *maboko peto* (Lingala words for "clean hands"), sensor-automated hybrid solar-powered handwashers that automatically provide soap and water, dry hands, and are equipped with a thermometer to detect temperatures.[143]

4.3 STI snapshot

4.3.1 STI system SWOT analysis

STI are clearly contributing to alleviating the development challenges faced by the Democratic Republic of the Congo. The following SWOT analysis takes a closer look at the features of the country's national innovation system.

Table 4.1. Strengths, weaknesses, opportunities and threats of the national STI system in the Democratic Republic of the Congo

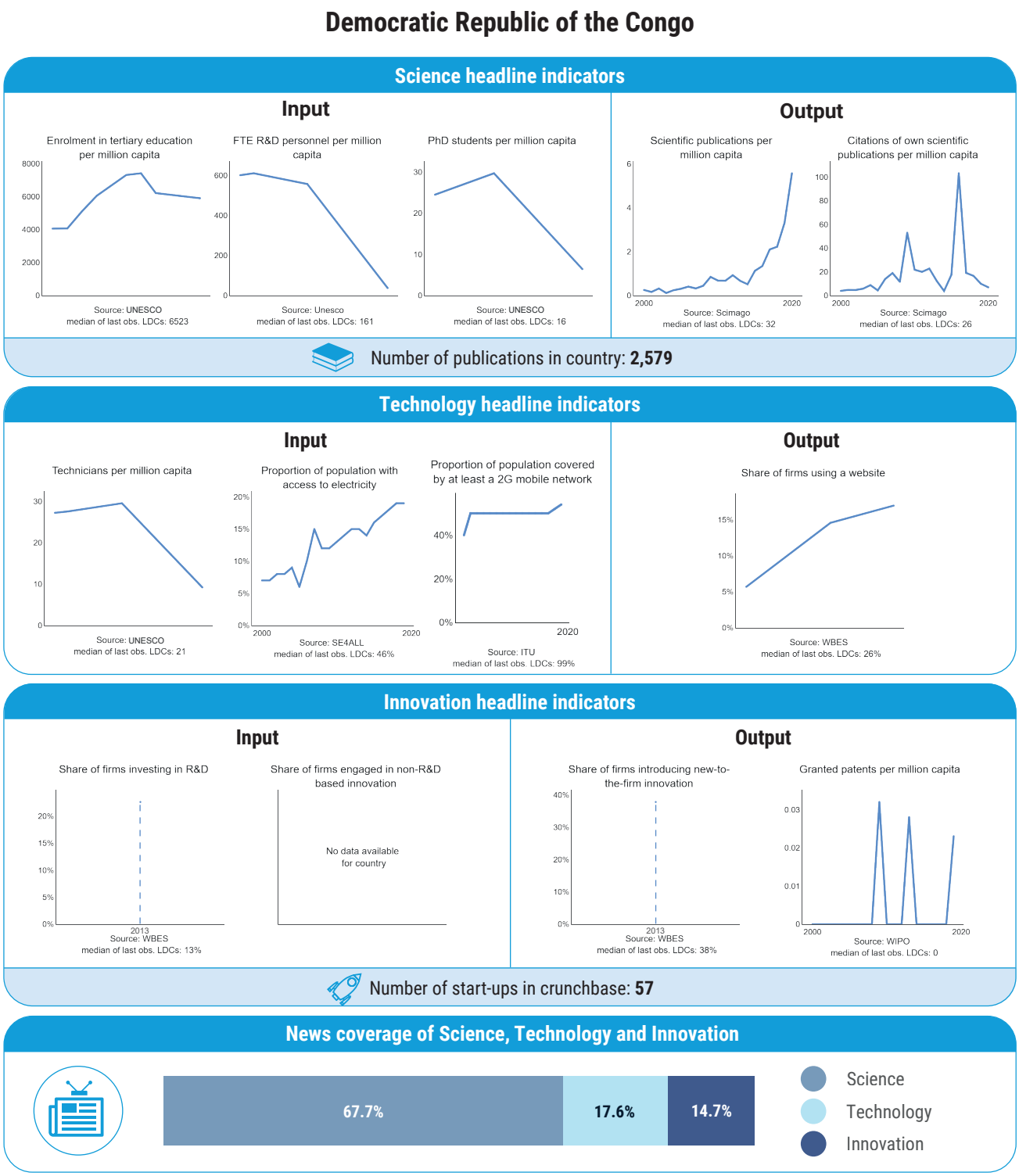
Strengths	Weaknesses
• The existence of research infrastructure • Events and competitions, such as the Week of Science and Technology and the Kinshasa Innovation Forum (Kininnov) are showcasing researchers' findings and ensuring knowledge and innovation diffusion • A tradition of innovation and a heritage of infrastructure: the Democratic Republic of the Congo was a research hub with well-equipped scientific centres during pre-independence period	• Insufficient STI policy to structure and support the STI initiatives of private and public actors • Human resources for research lacking due to the weak education system • Low public spending on education (1.5 per cent of GDP in 2017)[144] • Low financing of research (0.16 per cent of GDP spent on R&D)[145]

140 Federation of Enterprises of Congo and Economist Intelligence Unit, "République Démocratique du Congo, Enquête EIU auprès des entreprises : Impact de la COVID-19—itération de l'enquête 9", August 2021. Available at https://fpm.cd/wp-content/uploads/2021/08/Impact-Covid19_Rdc_Entreprises_v1.pdf (accessed on 13 December 2021).
141 World Bank, "The World Bank in DRC: overview–context".
142 See https://covid19.who.int/region/afro/country/cd.
143 United Nations Development Programme. "Africa innovates: 50 homegrown African innovations tackling COVID-19", 2020. Available at https://reliefweb.int/sites/reliefweb.int/files/resources/Africa%20innovates%20-%2050%20homegrown%20African%20innovations%20tackling%20COVID-19%20%28Compressed%29.pdf (accessed on 13 December 2021).
144 UNESCO, *UNESCO Science Report*.
145 Global Economy, "Democratic Republic of the Congo: research and development expenditure", 2021. Available at https://www.theglobaleconomy.com/Democratic-Republic-of-the-Congo/Research_and_development/ (accessed on 13 December 2021).

• Highly motivated researchers who innovate and valorize local products and expertise • A relatively active diaspora of researchers and scientists who are increasingly contributing to the country's development, especially in the field of R&D • The adoption of a scientific policy focusing on five priority areas, including improving business productivity, promoting green industries and building a knowledge society through education and training	• Ageing existing research infrastructure (buildings and laboratory equipment) that requires maintenance • Lack of statistical data for information and evidence-based policymaking • Entrepreneurial projects financed and supported by donors, especially in agriculture, have not included the building of ties with the research sector • Low volume and quality of research • Low private investment in STI • Low collaboration among stakeholders in the STI system • Absence of a strategic action plan for the implementation of the recently validated science policy • National development needs do not prioritize research • Weak promotion of research culture • High mobility of researchers and brain drain: the country's talents (scientists and researchers) have tended to leave the Democratic Republic of the Congo to continue their careers elsewhere
Opportunities	**Threats**
• Increasing availability of facilities supporting innovation (the Democratic Republic of the Congo currently has 22 active technology hubs) • Increased interest in and initiatives supporting women in STEM, for instance a scholarship programme for women scientists • Growing interest of entrepreneurs in developing high-quality products valorizing local resources • Ongoing country reforms and donor-supported programmes in the education sector, such as the Education Project for the Quality and Relevance of Secondary and University Education, supported by the World Bank • Existence of national, regional and international research networks • Presence of technical and financial partners working in the sector • Availability of a large amount of expertise in the diaspora	• Fragile sociopolitical context: the Democratic Republic of the Congo is a young democracy which still bears the scars of long armed conflicts and crises • Brain drain • Ageing and ever-decreasing researcher population—research is less appealing to younger generation due to insufficient incentives (remuneration, research conditions) • De-professionalization of research, with researchers becoming increasingly less skilled

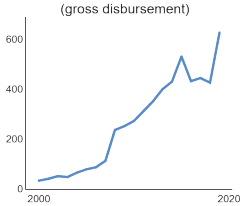
4.3.2 Key features of the STI system

Figure 4.3. Key features of the STI system in the Democratic Republic of the Congo



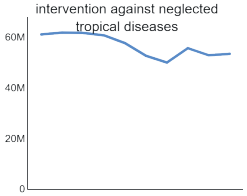
STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)



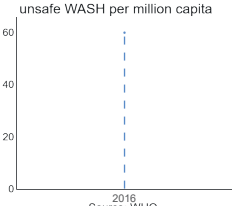
Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



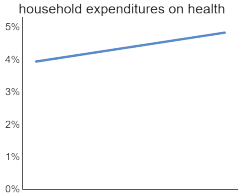
Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita



Source: WHO
median of last obs. LDCs: 34

SDG 3.8.2 Share of pop. with large household expenditures on health

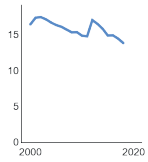


Source: WHO
median of last obs. LDCs: 9%

Publications 152: 5% of publications **Start-ups in crunchbase** 4: 7% of start-ups

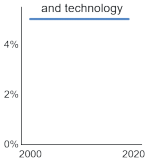
STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy



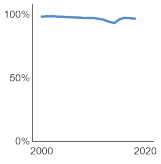
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



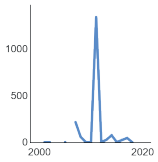
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development



Source: SDGs

Publications 7: 0.2% of publications **Start-ups in crunchbase** 1: 1% of start-ups

STI & Climate Adaptation

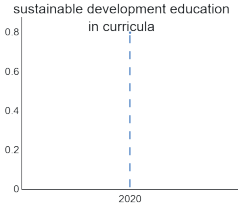
SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP

No data available for country

SDG 1.5.2 Direct agriculture loss attributed to disasters

No data available for country

SDG 13.1.1 Mainstreaming of sustainable development education in curricula



Source: UNISDR
median of last obs. LDCs: 0

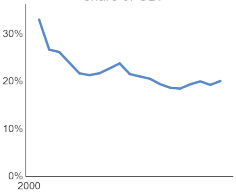
SDG 11.b.2 Share of local governments that implement local DRR strategies

No data available for country

Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP

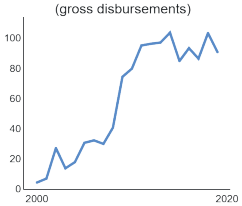


Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP

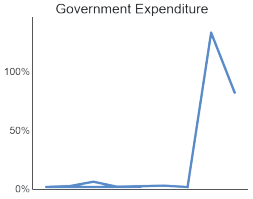
No data available for country

SDG 2.a.2 Total ODA to agriculture (gross disbursements)



Source: OECD
median of last obs. LDCs: 63

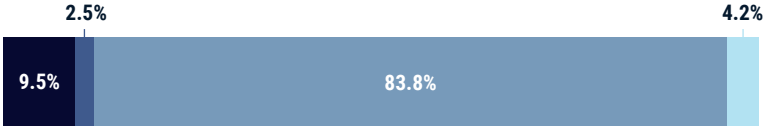
SDG 2.a.1 Agriculture share of Government Expenditure



Source: FAO
median of last obs. LDCs: 4%

Publications 7: 0.2% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas



- Agriculture
- Climate adaptation
- Health
- Renewable energy

Overall, the STI system in the Democratic Republic of the Congo is still underdeveloped, but there are signs of renewed interest from key stakeholders (the Government, private sector, civil society and development partners) and promising prospects for development. While sharing many of the features of the national innovation systems across African countries, the system in Democratic Republic of the Congo is particularly characterized by an ageing population of researchers and research infrastructure, an institutional STI framework which is still maturing, a relatively active research community in the health sector, a motivated diaspora disposed to contribute to the development of their country, and the existence of indigenous knowledge systems.

- **A declining yet relatively active researcher population**

As highlighted in the SWOT analysis, one important feature of the STI system of the Democratic Republic of the Congo is the ageing researcher population. The number of full-time personnel in R&D has been on a sharp decline over the past 10 years. The pipeline of potential or aspiring researchers is also showing a decreasing trend: the number of PhD students is dropping, along with the general enrolment in tertiary education. Furthermore, even though the Democratic Republic of the Congo is improving its technological infrastructure (the access of the population and companies to electricity, Internet and digital services is increasing steadily), the number of technician profiles is sharply falling.

However, scientific publications have significantly increased over the past five years, thus demonstrating the relative productivity of researchers in the Democratic Republic of the Congo. Among the 16 countries of the Southern Africa Development Community (SADC), the country has fluctuated between seventh and eighth position regarding volume of scientific publications in the past 10 years. Health science is one of the most active research fields in the Democratic Republic of the Congo, and produces the most research publications (64 per cent).[146]

- **Declining research infrastructure requiring investment**

The research infrastructure of the country is also ageing and needs to be upgraded. The Democratic Republic of the Congo has previously benefited from key assets of research centres established during the pre-independence era, but these are currently obsolete. Some sectors have benefited from renovation, and have the potential to again propel the country to the forefront of research in some fields.

For instance, the Regional Nuclear Research Centre of Kinshasa, created in 1959, was the first nuclear reactor in sub-Saharan Africa. The Centre has two nuclear reactors that have been on extended shutdown since November 2004 due to safety problems as the site is threatened by soil erosion. In 2020, the Government authorized the restart of the research reactors, with prospects for the modernization of the Centre's equipment. Today, the Centre intends to carry out research activities with medical, biological, genetic and industrial aims.

Similarly, the National Institute for Agronomic Study was created in 1933. Well-endowed with financial and human resources, the Institute was composed of a network of 37 research stations, the most important being that of Yangambi. From 1945 to 1960, the Yangambi centre positioned itself as the most dynamic agricultural innovation hub in Africa. Despite strong desires to continue its mission, the research centre was hit hard by the general instability of the country. It was only in the last 15 years, thanks in particular to the improvement in the security situation, that scientific activities gradually resumed at Yangambi. The launch of a new European Union initiative to promote local development, conservation and applied research in 2017 was a turning point. Yangambi is now home to the Congo basin's first turbulence flux tower, hosting research that aims to better understand the contribution of forests to climate change mitigation. In addition, a wood biology laboratory was inaugurated in Yangambi in 2019, allowing on-site analysis of wood samples to improve policies for the sustainable management of the Congo basin forests.

146 UNESCO, *UNESCO Science Report*.

- **An institutional framework still maturing**

The institutional framework for STI in the Democratic Republic of the Congo is still maturing. There are observable signs of increased interest of public and private institutions in R&D. However, STI stakeholders have established few links and collaborations between each other.

Research is mostly funded by the Government, with the support of some of the development partners of the Democratic Republic of the Congo. The higher education system (public and private) funds 63.8 per cent of research, and the Government directly funds 34.5 per cent. A very small portion of research is funded by non-profit and international organizations, and no figures are recorded for investments from private businesses.[147]Though FDI to the Democratic Republic of the Congo has increased (US$27.3 billion in 2020), this has gone into the mining and telecommunication sectors,[148] and has not been invested back into research.

The Government has several public institutions in place for the advancement of STI: a Ministry of Scientific Research and Technological Innovation, and the Directorate for the Valorization of Research Results within this Ministry. There is also a Scientific Council, along with research centres such as the Institute of Research in Health Sciences and the National Institute for Agronomic Study.

> **The country's first science policy has just been validated by the actors of the national STI system and will soon be adopted by the Government.**

The science policy guidelines target six major priority areas for the development of the Democratic Republic of the Congo: food security and the demographic challenge; health and well-being; intensification of the industrial sector to face technological challenges; the sustainable management of natural resources and climate change; building a knowledge society and human capital development; and spatial planning, urban planning and housing. The plan for achieving progress in these areas is divided into three strategic axes: institutional capacity-building; capacity-building for research and innovation, including the improvement of human, financial and material resources of the sector; and strengthening the supply of STI knowledge, with the implementation of research programmes in the major priority areas. The target is to achieve a research intensity of 0.8 per cent of GDP by 2022 and 1 per cent by 2030.

A health research policy has also been implemented to fight against disease, improve maternal and infant health, promote a proper environment for health and develop robust health systems.[149]

Civil society and the private sector are also actively involved in national initiatives to promote STI. Created in 2017, Kininnov is the first and largest innovation forum in the Democratic Republic of the Congo entirely dedicated to the promotion of young entrepreneurs, project leaders and innovative companies. In the same vein, Science and Technology Week has been organized annually since 2014 by the local NGO Investing in People, in collaboration with the ministries in charge of research and education. The event aims at promoting know-how and knowledge in the fields of science and technology, and to encourage scientists' vocations. Today the Democratic Republic of the Congo counts 22 active technological hubs, incubators and accelerators. It is the country with the third highest number of active hubs in southern Africa, after South Africa and the United Republic of Tanzania.

147 Ibid.
148 Lloyds Bank, "Democratic Republic of Congo: investing in the Democratic Republic of Congo—investment framework and opportunities", October 2021. Available at https://www.lloydsbanktrade.com/en/market-potential/democratic-republic-of-congo/investment (accessed on 13 December 2021).
149 Democratic Republic of the Congo, Ministry of Health, Directorate of Studies and Planning. "Politique nationale de recherche sur les systemes de sante en Republique democratique du Congo", June 2004. Available at https://healthresearchweb.org/?action=download&file=DRCPOlicy.pdf (accessed on 13 December 2021).

- **Indigenous knowledge systems**

A common trend in the innovative practices in the Democratic Republic of the Congo is the ambition to use, promote and develop local resources and knowledge. One example is the Centre for Research in Ameliorated Traditional Medicine, a pharmaceutical laboratory that uses knowledge from traditional healers to conduct research and produce medicines. Examples of other STI initiatives in the Democratic Republic of the Congo are detailed in section 4.2.3.

4.3.3 Resilience of the national innovation system of the Democratic Republic of the Congo

COVID-19 produced a dynamism in medical research in the Democratic Republic of the Congo, as the Government and international donors provided new financial resources supporting research activity. The Government appointed a special Secretariat dedicated to fighting the pandemic, which was run by a local researcher. The INRB also led multiple field studies assessing different ways to tackle the disease through locally available means in 2020. The presence of indigenous knowledge systems in the Democratic Republic of the Congo has also contributed to the resilience of the country's national innovation system to shocks such as the pandemic.

The COVID-19 pandemic has also highlighted and offered opportunities to further build the resilience of the Democratic Republic of the Congo to future shocks. Previously, approximately 20 million inhabitants of the Democratic Republic of the Congo consumed mainly imported agricultural products.[150] However, with the restrictions on trade that accompanied the pandemic, imports have been limited, and consequently consumption of local products is more prevalent. COVID-19 could thus be a booster for the consumption and transformation of local resources. If this trend is sustained, local producers and innovators could see their businesses grow and their products valorized to a greater extent than before. Overall, the innovation system of the Democratic Republic of the Congo has remained dynamic and resilient throughout the challenges posed by the COVID-19 pandemic.

150 Serge Rombi, "DRC's drive to move forward", *Euronews*, 4 August 2021. Available at https://www.euronews.com/next/2021/08/04/drc-s-dynamic-drive-to-move-ahead-after-covid (accessed on 13 December 2021).

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Zerrougui, Leila (2018). Strengthening the rule of law and protection of civilians in the Democratic Republic of the Congo, *UN Chronicle*, 1 April.

Interviewees

Beya, Jean-Marie. Head of Teaching at the Polytechnic University of Kinshasa.

Malu, Raissa. President at Investing in People.

Mawoko, Philippe Kahutama. Professor at the University of Kwango.

Ndumba, Leon. Director of Valorization of Research at the Ministry of Scientific Research and Technological Innovation.

Ntondele, Luzolo. Pharmacist at the Centre de Recherche pour les Médicaments Traditionnels Améliorés (CMRTA).

Numbi, Berry. Managing Director at the Innovation Centre of Lubumbashi.

Yandju, Marie-Claire. Professor at the University of Kinshasa.

5. Lao People's Democratic Republic

Figure 5.1. Least developed country status indicators for the LPDR

Asia
Lao PDR

Population
7 million (2020)

LDC status
Scheduled for graduation in 2026

Well-being		
Human Assets Index *(composed of six indicators)* 72 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 10% (2018) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 76 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 2,449 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 3% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 6% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 27 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 9% (2017) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 83% (2017) LDC median: 89% *Source: ILO*

5.1 Country profile

The Lao People's Democratic Republic (LPDR) is an ethnically diverse, mountainous country situated in South-East Asia, and is the only landlocked country in the region. A French colony from 1893 to 1945, the country gained full independence as a constitutional monarchy in 1953. In 1975 Lao became the LPDR and signed a treaty of friendship and cooperation with Viet Nam. Since the 1990s, the LPDR has expanded its foreign relations both within and beyond Asia. The LPDR joined ASEAN in July 1997 and the World Trade Organization in 2016.

As with other countries of South-East Asia, the LPDR has enjoyed remarkable economic growth in the last two decades, graduating from low-income to lower-middle-income country status in 2011. The LPDR has also made development gains in education, health, life expectancy and poverty reduction. In line with this, in the 2018 triennial review of the UNCDP, it was decided that the LPDR met the criteria for graduation from least developed country status for the first time. In the 2021

triennial review the LPDR met all graduation criteria by a considerable margin, and was recommended by the UNCDP for graduation. As for Bangladesh, ECOSOC has endorsed the UNCDP recommendation and Lao PDR is scheduled to graduate in 2026.

From 1986 the Government of the LPDR began decentralizing control and introducing market-led reforms under the country's New Economic Mechanism. Structural reforms continued in the 1990s, providing a foundation for private sector development. This has had positive impacts on the economy—GDP growth averaged 6.4 per cent a year in the 1990s, and increased steadily to 8.5 per cent in 2010. Since then, GDP growth has slowed, reaching 5.5 per cent in 2019, and declining sharply to 0.4 per cent in 2020 with the advent of COVID-19. It is predicted to rise again to 3.6 per cent in 2021.[151]

> **Much of the economic growth has been driven by increased exports of goods and services, up from 11 per cent of GDP in 1990 to 33 per cent in 2016.[152]**

The top export of LPDR is electricity – in 2019 it exported electricity to the value of US$1.33 billion, making it the ninth largest exporter of electricity in the world.[153] The country's plentiful water sources and mountainous terrain enable it to produce and export large amounts of hydroelectric energy. With backing from Thailand and China, the LPDR is building a series of hydroelectric dams along the Mekong River. Other major exports include copper ore and refined copper, rubber and gold. Increases in exports have been accompanied by a move away from agriculture—in 1995, 85 per cent of the population were employed in the agricultural sector, dropping to a mere 6 per cent in 2019.[154] The tourism sector has increased rapidly: in 2019 international tourism generated US$934 million (trailing just behind mineral exports at US$1.43 billion, and electricity exports at US$1.32 billion), representing roughly 5 per cent of GDP.[155] This was negatively impacted by COVID-19 restrictions and the corresponding drop in tourism in the country.

In terms of fragilities, the non-transparent political environment of the LPDR could be considered a risk.[156] Indeed, in the 2020 Democracy Index report, the LPDR was ranked 161 out of 167 countries on the basis of five indicators (electoral process and pluralism, the functioning of Government, political participation, political culture and civil liberties).[157] Furthermore, in the Global Peace Index 2021, the LPDR is categorized as being in a positive peace deficit, which indicates that the country's peacefulness is greater than its underlying social structures indicate it could be.[158] This also means that peace in the country is comparatively more vulnerable to internal or external shocks and runs a higher risk of deteriorating into increased levels of violence. The LPDR had the third largest positive peace deficit of all the countries examined, with only Equatorial Guinea and Sierra Leone ranking higher. Economically, the LPDR has a high level of public debt, highlighted by the UNCDP in its analysis of the country's eligibility for graduation from least developed country status; the UNCDP also emphasized the need to address rural/urban inequalities, build disaster resilience and reduce environmental degradation. Furthermore, environmental and social risk factors can combine multiplicatively;[159] the LPDR is one of 20 countries considered to be at risk from the climate-conflict nexus.

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151 World Bank, "Lao PDR: economy recovers then falters again under COVID-19", 20 August 2021. Available at https://www.worldbank.org/en/news/press-release/2021/08/19/lao-pdr-economy-recovers-then-falters-again-under-covid-19 (accessed on 13 December 2021).

152 World Bank, "Exports of goods and services (% of GDP)—Lao PDR", World Bank national accounts data, and OECD National Accounts data files. Available at https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=LA(accessed on 13 December 2021).

153 Observatory of Economic Complexity, "Electricity in Laos". Available at https://oec.world/en/profile/bilateral-product/electricity/reporter/lao (accessed on 16 December 2021).

154 World Bank, "Employment in agriculture (% of total employment) (modeled ILO estimate)—Lao PDR", International Labour Organization, ILOSTAT database. Available at https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=LA (accessed on 8 December 2021).

155 Asian Development Bank, "The impact of COVID-19 on tourism enterprises in the Lao PDR: an initial assessment", *ADB Briefs*, No. 141 (June 2020).

156 Coface, "Laos", February 2021. Available at https://www.coface.com/Economic-Studies-and-Country-Risks/Laos(accessed on 13 December 2021).

157 Economist Intelligence Unit, *Democracy Index 2020: In Sickness and in Health?* (London, The Economist Intelligence Unit, 2021).

158 Institute for Economics & Peace, *Global Peace Index 2021: Measuring Peace in a Complex World* (Sydney, 2021).

159 Bodanac, Hyslop and Valente, "Understanding the climate-conflict nexus".

5.2 Key development challenges

5.2.1 Priorities of the national development agenda

The LPDR Government's current economic development priorities are elaborated in two long-term plans. Firstly, the 15-year strategy known as Vision 2030 outlines the LPDR's goal of becoming an industrialized middle-income country with sound infrastructure. In 2019, the Government endorsed an SDG road map and a comprehensive set of 238 SDG indicators under the purview of the National SDG Steering Committee. The LPDR also has a five-year strategy known as the National Strategy on Socio-Economic Development.

Figure 5.2. Progress on the SDG index in the LPDR

Source: Adapted from Sachs and others (2021).

5.2.2 Level of achievement of the SDGs

Major challenges remain in the LPDR for seven out of 17 SDGs. In particular, there are major challenges remaining for SDGs relating to health and sanitation, but progress towards these is increasing or on track to be achieved in 2030. For SDG 15 (life on land), major challenges remain and progress towards the goal is decreasing. This is discussed further in the sections below on agriculture and climate change. In terms of SDG 9 (industry, innovation and infrastructure), major challenges remain but progress is moderately increasing over time, as discussed further in the section below on the economy.

- **Agriculture and food**

The LPDR succeeded in more than halving malnutrition in its population, from 42.8 per cent in 1990 to 18.5 per cent

in 2015. However, despite this progress, rates of stunting remain high, affecting around one third of children under the age of 5.[160] Stunting patterns show strong inequality, with stunting rates twice as high in rural areas with no road access than in urban areas, and twice as high in highland ethnic groups than in lowland groups. The LPDR agricultural sector is facing serious challenges in meeting demand from both international and domestic markets, due to issues of farm productivity, produce quality and profitability, contributing to malnutrition and stunting.

- **Climate change and environment**

> **The LPDR is among the countries most vulnerable to projected trends of climate change, as its communities face significant climate-related hazards that are exacerbated by poverty, malnutrition and the high exposure of poor and marginalized communities.**

The LPDR experienced torrential rainfall in July 2018 caused by a tropical storm, overwhelming a dam in the south of the country which resulted in a very large wave that inundated villages and caused significant damage to houses, crops and roads. The north of the LPDR suffered more flooding caused by another tropical storm in August. The post-disaster needs assessment valued the total economic effects of the floods at an estimated US$371.5 million, with most damage to the agriculture and transport sectors.[161] The LPDR was hit once again by tropical storms and flooding in 2019, with at least 765,000 people affected and 19 killed. As many as 97 bridges, 747 schools, 43 health centres and hospitals, 462 stretches of road and 275,114 head of livestock and poultry were affected. Total damage was estimated to cost US$164 million.

- **The economy and jobs**

The LPDR has an abundance of natural resources such as copper and hydroelectricity, and the export of these resources to neighbouring countries has helped grow the economy greatly. In the case of energy, the World Bank and neighbouring Thailand have provided the financing and FDI for the technology and infrastructure necessary for industry. However, exports of natural resources have caused "Dutch disease": the increased value of the currency of the LPDR caused by successful exports has made manufacturing and other exports less competitive on global markets. In turn, companies which are now less able to compete with their foreign rivals can no longer provide quality jobs locally, thus forming a bottleneck or "natural resource trap".[162]

The LPDR was successful in fulfilling its Millennium Development Goals, including decreasing infant mortality and increasing primary education levels. However, in the absence of extra capacity in secondary and tertiary education, the university system became overburdened and there have not been enough professors and teachers to teach the young people entering schools and universities. University professors do not have time to dedicate to research, and a lack of domestic research funding means they are reliant on funding from foreign sources which have specific interests, such as agriculture, health and the environment, that are not always aligned with the research demands of industry (for example, engineering). As a result, industry is left with a lack of innovative solutions and isolated from the research that might remedy the situation.[163] Furthermore, there are not enough skilled workers entering the workforce.

The LPDR has made it a priority to improve its business environment and reverse the decline in the global ranking of ease of doing business—it ranked 137/141 in 2019, largely due to the fact it takes the very long time of 174 days to register a new business—in order to achieve greater macroeconomic stability and job creation. This is particularly relevant for MSMEs; while they represent a significant part of the private sector in the LPDR, accounting for about 99 per cent of all firms and 82 per cent of employment, they account for under 20 per cent

160 United Nations Children's Fund, "Lao People's Democratic Republic: nutrition", n.d. Available at https://www.unicef.org/laos/nutrition (accessed on 13 December 2021).
161 LPDR, Department of International Cooperation, Ministry of Planning and Investment, "2018 Lao PDR floods: results of the Post Disaster Needs Assessment", 2 November 2018. Available at https://rtm.org.la/wp-content/uploads/2018/11/Lao-PDR_PDNA-2018_-Floods_2-Nov.pdf (accessed on 13 December 2021).
162 Jeong Hyop Lee and others, "STI strategies for poverty reduction: the case of Lao PDR", Policy Research 2014–27 (Sejong, Science and Technology Policy Institute, 2014).
163 Ibid.

of GDP (compared to 40 per cent in Thailand and 3 per cent in Malaysia and the Philippines). The main factors holding back MSMEs in the LPDR are limited access to finance (due to overly cautious banks, high interest rates, a lack of financial services, a lack of business and financial planning and management, and low financial literacy), the practices of informal competitors (the lack of compliance with regulations on the part of informal firms, resulting in unfair disadvantages for formal firms) and an unreliable electricity supply.[164]

5.2.3 Relevance of STI to solving these development challenges

As outlined, the LPDR faces a number of significant development challenges, notably in terms of its agricultural productivity and the risks posed by climate change. In turn, these development challenges are hindering the development of the LPDR. However, STI are being successfully used to address these challenges.

- **Innovation in agriculture**

The Mekong Agritech Challenge, an agritech start-up accelerator funded by AusAID and the Asian Development Bank, aims to create jobs, spur innovation and impact rural communities in the LPDR and other countries in the Mekong region. Bolaven farms, a social enterprise based in the LPDR, participated in the accelerator programme and uses an innovative approach to organize famers collectively, connect them with impact lender and improve harvest quality and productivity in order to democratize wealth for community betterment.[165]

The Capacity Development for Agricultural Innovation Systems project (CDAIS) focuses on strengthening the capacity of the LPDR to innovate in selected areas of smallholder production including high-quality organic products, coffee, rice, rattan and bamboo. Key partners of CDAIS in the LPDR are the National Agriculture and Forestry Research Institute, the Food and Agriculture Organization of the United Nations (FAO) and the Centre for International Cooperation in Agronomic Research for Development. CDAIS aims to contribute to more efficient and sustainable agricultural innovation systems, by identifying challenges and solutions together with farmers, agribusiness and consumers. In this way, it hopes to improve the livelihoods of smallholder farmers, increase food security and fight rural poverty. CDAIS is working on projects to improve pig farming and cattle breeding, the cultivation of aquatic animal protein, and the growing of organic vegetables and quality rice.[166]

- **Innovative solutions to climate change risk**

> **In the LPDR, climate change is increasing the frequency and intensity of extreme rainfall, resulting in more severe flooding in vulnerable and rapidly growing cities along the Mekong River which currently lack adequate flood management.**

A US$10 million initiative, financed by the Green Climate Fund, builds the resilience of urban populations in the cities of Vientiane, Paksan, Savannakhet and Pakse. The project uses innovative ecosystem-based adaptation methods, such as increasing green spaces and permeable surfaces within cities to reduce run-off, and rehabilitating and protecting urban streams and wetlands.[167] A growing body of scientific research shows that these solutions can be vastly more cost-effective than "hard" infrastructure solutions. The results are expected to significantly reduce the economic burden of flooding, which is estimated to cost each affected household approximately US$1,000 after each heavy rainfall event.[168] The project will also generate several environmental and socioeconomic benefits aside from flood control, and use local knowledge.

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164 Keomanivone Phimmahasay and others, *Lao PDR Economic Monitor: Maintaining Economic Stability. Thematic Section: Constraints to Doing Business for SMEs* (New York, World Bank Group, 2019).
165 See https://match.mekongbiz.org.
166 CDAIS, "Laos", n.d. Available at https://cdais.net/home/pilots-countries/laos/(accessed on 13 December 2021).
167 LPDR and UNEP, "Funding proposal: SAP009—building resilience of urban populations with ecosystem-based solutions in Lao PDR", *Green Climate Fund*, 4 December 2019.
168 UNEP, UNEP DTU Partnership and World Adaptation Science Programme, *Adaptation Gap Report 2020* (Nairobi, UNEP, 2021).

Given the significant challenges that remain in the LPDR in terms of health and well-being, given the increasing Internet access and mobile phone usage the LPDR could consider using digital health solutions to a greater extent. Indeed, as explored elsewhere in these case studies, the COVID-19 pandemic has accelerated the use of digital health-care solutions in many countries because the traditional models of care have not been possible. There has been a rise in tele-health, with doctors making diagnoses via video call or digital messaging platforms. This has particular potential in the LPDR, where 64 per cent of the population lives in rural communities,[169] many of which are remote. Indeed, digital health solutions have been utilized with success in the LPDR during the COVID-19 pandemic, as now described.

5.2.4 Impact of COVID-19 in the LPDR

The LPDR has experienced significant setbacks since the start of the COVID-19 pandemic. Although efforts to contain the virus have largely been successful in health terms, negative economic effects have been felt due to declining trade and tourism. The pandemic is expected to cause the biggest economic slowdown in the LPDR in nearly three decades, putting the development gains of the last decade at risk and hindering progress towards the SDGs and ambitions for middle-income status. An estimated 383,000 people could fall back into poverty, translating into an increase in the national poverty rate of 5 per cent, with vulnerable groups being disproportionately affected. The pandemic is likely to cause greater hardship for women in the LPDR than for men, as its impact is concentrated in industries where women form most of the workforce, such as tourism and related services, retail trade, and manufacturing.

Furthermore, many children in low-income households are at risk of food insecurity and malnutrition, and their education is likely to be severely affected due not only to school closures but also to their parents' falling incomes.[170]

- **Examples of how STI have been successfully used to tackle COVID-19**

The LPDR was among the first countries in the world to deploy the Digital Health Information Software 2 (DHIS2) COVID-19 surveillance metadata package to monitor the spread of this new disease. DHIS2, an open-source web-based platform, is the world's largest health management information system, in use in 73 low- and middle-income countries. The system has been refined and expanded, including with the development of custom applications to monitor the treatment of patients and carry out contact tracing. Once vaccines started to become available, the DHIS2 COVID-19 vaccine delivery package was deployed, and later customized to include applications for self-registration for vaccination appointments and data entry at vaccination centres, as well as the generation of secure QR codes to produce verifiable vaccination certificates. By mid-2021, the LPDR had used this system to plan and register almost 2 million COVID-19 vaccine doses, and continues to use DHIS2 to track new infections, trace contacts and monitor the treatment of COVID-19 patients.

> **The LPDR, along with 13 other developing countries, is benefiting from a partnership forged in 2020 to harness satellite technology in tackling food insecurity resulting from the COVID-19 crisis.**

169 World Bank, "Employment in agriculture".
170 UNICEF, "Country office annual report 2020: Lao People's Democratic Republic" (New York, 2020).

A memorandum of understanding was signed by partners under the auspices of the United Nations Commission on Science and Technology for Development (UNCSTD) for the CropWatch Innovation Cooperation Programme. Participating countries participated in a two-month online course on how to use the CropWatch satellite technology in order to facilitate meaningful technology transfer, specifically in crop monitoring which will increase resilience to future shocks in food production systems (for example, due to climate change). CropWatch, used in China since 1998, is a system that uses satellite data to monitor crop conditions and integrates this with other climate-related data on drought, pests and diseases for better farm management. Use of this technology will thereby allow participating countries to build back better from the COVID-19 pandemic. The programme's partners include the United Nations Conference on Trade and Development (UNCTAD) and UNCSTD, the Alliance of International Science Organizations, and the Aerospace Information Research Institute of the Chinese Academy of Sciences.

5.3 STI snapshot

STI are clearly helping to transform the LPDR, in terms of addressing development challenges and increasing resilience to the food shocks caused by the COVID-19 pandemic. Here we take a deeper look at the STI system that supports this in a SWOT analysis.

5.3.1 STI system SWOT analysis

Table 5.1. Strengths, weaknesses, opportunities and threats of the national STI system in the LPDR

Strengths	Weaknesses
• The Small and Medium Enterprises Development Plan 2016–2020 outlines an entrepreneurship curriculum to be adopted in higher education and vocational schools, enhancing the management skills of MSME operators and creating new entrepreneurs, especially in youth, women, and students • Science and Technology Development Fund, established in 2014 to raise funds, support and promote R&D and encourage innovation, technology transfer and science and technology services • The creation of the ASEAN Economic Community in 2015 marked a milestone in regional economic integration in South-East Asia, opening opportunities to participate in regional value chains, something particularly important for the small and landlocked LPDR • The Regional Comprehensive Economic Partnership, a free trade agreement among 15 Asia-Pacific countries, is the largest trade bloc in history and will likely be of significant benefit to the LPDR in terms of knowledge and technology transfer to facilitate innovation	• The LPDR suffers a competitiveness deficit, ranking 113/141 in the Global Competitiveness Index for 2019,[171] making it the least competitive country in the East Asia and Pacific country group • It takes 174 days to start a new business in the LPDR, versus an average of 26 day across least developed countries and 20 days across the world)[172] • MSMEs in the LPDR have a lack of access to finance (due to overly cautious banks, high interest rates, a lack of financial services, lack of business and financial planning and management, and low financial literacy) • Informal competitors make it difficult for formal enterprises to succeed (poor compliance with regulations on the part of informal firms, resulting in unfair disadvantages for formal firms) • The LPDR lacks a vibrant and dynamic entrepreneurial ecosystem and deal flow developers (accelerators and incubators, institutional investors, knowledge institutions) and support service providers (financial intermediaries, software, legal firms) to support start-ups

171 Schwab, ed., *The Global Competitiveness Report 2019*.
172 World Bank, "Time required to start a business (days)", Doing Business project. Available at https://data.worldbank.org/indicator/IC.REG.DURS?end=2019&start=2003&view=chart (accessed on 13 December 2021).

- The LPDR National Chamber of Commerce and Industry initiated the establishment of an angel fund and investment network in 2017 in Vientiane which, financed by the Small and Medium Enterprises Promotion Fund, was disbursed in 2020 as loans of up to around US$110,000 to MSMEs via microfinance institutions
- BCEL (Public Lao Bank of Exterior Commerce) Community Money Express, a digital banking system launched in 2015 with the support of the Making Access to Finance More Inclusive for Poor People programme, has provided access to branchless banking for people in rural areas

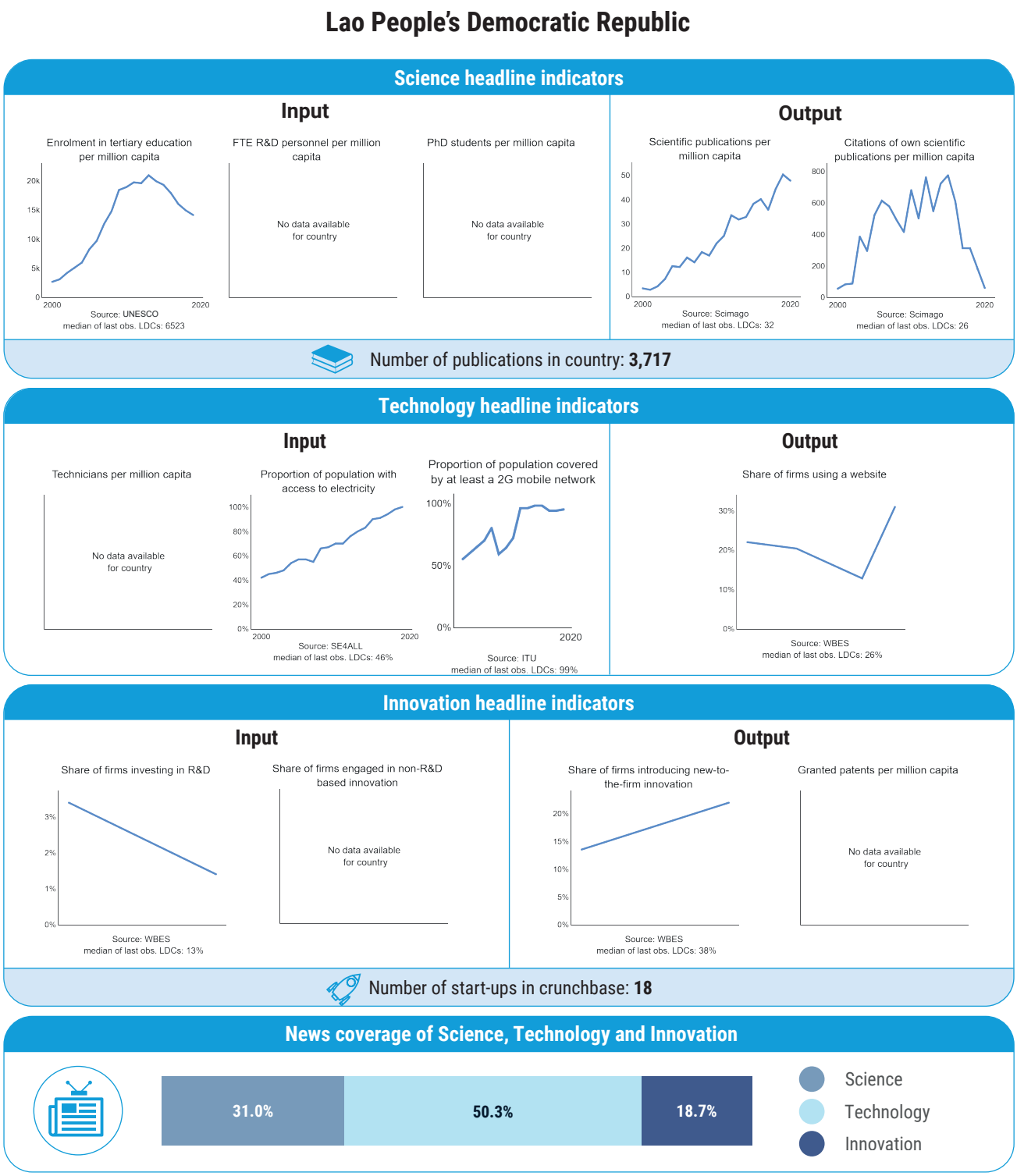
- Low new business density figure—0.04 new business registrations per 1000 people in 2018, compared to a mean of 0.35 for least developed countries
- A very small pool of researchers—76 per million population, with a target of 1,100 in the eighth National Socio-Economic Development Plan (NSEDP)
- Brain drain—an estimated 37 per cent of educated Lao live abroad[173]
- A lack of access to finance opportunities. For example, as of 2020, there was no established angel investment network in the country that could consolidate and organize angel investment activities. Entrepreneurs are often funded informally by family members and friends[174]
- Policy instruments such as tax incentives to encourage R&D and innovation are lacking in the LPDR
- Dissolution of the Ministry of Science and Technology risks the loss of a comprehensive focus on STI

Opportunities	Threats
• Demand for secondary and tertiary education is rising • Gender lens investing is in its infancy in the LPDR; however, several initiatives have addressed gender inequality in STI • In the Global Competitiveness Index 2019 the LPDR scores well on companies embracing disruptive ideas, ranking 52/141,[175] indicating resistance to change is not a major problem	• SEZs do not always result in the promised knowledge and technology transfer due to foreign firms using their own staff, materials and money[176] • Increased demand for higher education is not matched by an increase in the number of university places available • Companies in the LPDR find it a challenge to meet the certification standards of the International Organization for Standardization, making international cooperation with European countries more complicated[177] • Lack of information and communications technology skills in the general population must be remedied in order to render the digitization of services as accessible to all

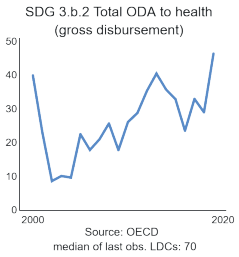
173 Tony Fielding, *Asian Migrations: Social and Geographical Mobilities in Southeast, East, and Northeast Asia* (New York, Routledge, 2016).
174 David Soukhasing and others, "The emergence of angel investment networks in Southeast Asia", Country Profiles for Angel Investment Networks in Southeast Asia, No. 3 (Jakarta and Tokyo, Angel Investment Network Indonesia and Sasakawa Peace Foundation, 2020).
175 Schwab, ed., *The Global Competitiveness Report 2019*.
176 Economist, "South-East Asia is sprouting Chinese enclaves", 1 February 2020. Available at https://www.economist.com/asia/2020/01/30/south-east-asia-is-sprouting-chinese-enclaves (accessed on 13 December 2021).
177 UNESCO, *UNESCO Science Report*.

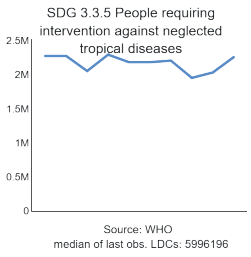
5.3.2 Key features of the STI system

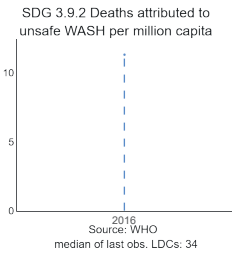
Figure 5.3. Key features of the STI system in the LPDR

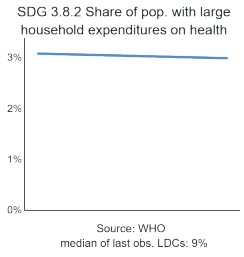


STI & COVID-19 & Health



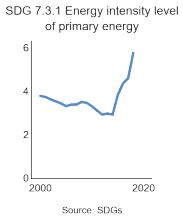


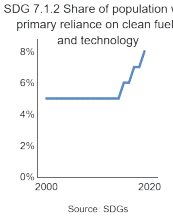


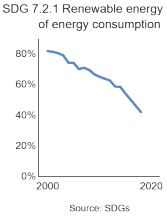


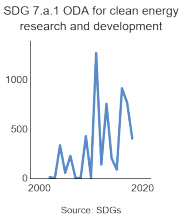
Publications 204: 5% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Clean Energy



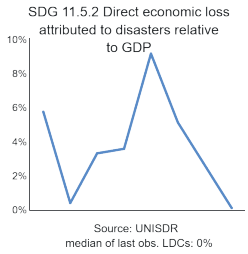


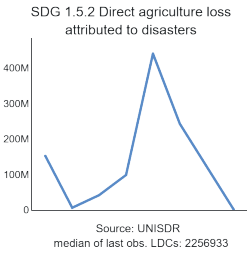


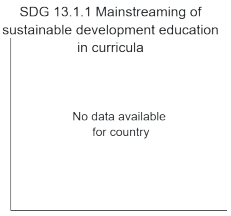


Publications 29: 0.7% of publications **Start-ups in crunchbase** 1: 5% of start-ups

STI & Climate Adaptation

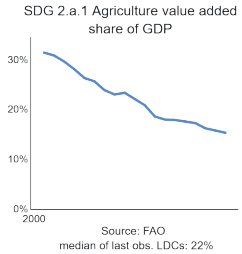


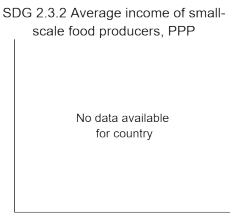


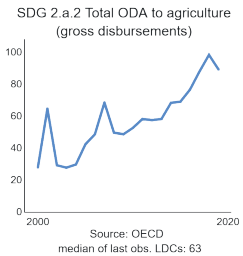


Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Agriculture

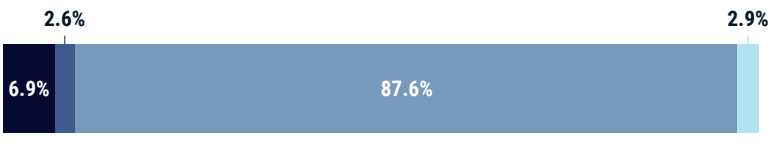






Publications 43: 1% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas



As the SWOT analysis and infographic show, the research infrastructure in the LPDR is currently deficient, with a lack of university places and a very small pool of researchers. This contributes to the low scientific output of the LPDR, although it should be noted that the number of scientific publications per million capita is in line with the average across all least developed countries. Technological advances will be enabled by the recent digital boom, which has seen a large increase in Internet access and mobile phone usage, discussed further in the section on the Fourth Industrial Revolution.

Innovation is still nascent in the LPDR; as shown in Figure 5.1, the share of firms investing in R&D is much lower than the average among least developed countries, at just 1 per cent of firms in 2020. The share of firms introducing new-to-the-firm innovation is also much lower than the least developed countries' average, at just over 20 per cent in 2020, compared to an average of 26 per cent across least developed countries. This is likely caused in part by the fact that the LPDR lacks a vibrant and dynamic entrepreneurial ecosystem, with a lack of deal flow developers (accelerators and incubators, institutional investors and knowledge institutions) and support service providers (financial intermediaries, software and legal firms) to support start-ups. On the other hand, there is some evidence of grass-roots innovation, with farmers using indigenous knowledge to solve new problems, as discussed below.

Governance

In 2011 the Ministry of Science and Technology (MOST) was created, in which four new research institutes and the National Science Council (first created in 2002) were housed. However, it was dissolved in March 2021.[178] Departments of the former Ministry will be transferred, along with all their public servants, to five departments under existing ministries, namely the Ministry of Education and Sports, the Ministry of Post and Telecommunications, the Ministry of Industry and Commerce, the Ministry of Agriculture and Forestry, and the Ministry of Energy and Mines. The dissolution has been implemented for the purposes of consolidation and to ensure that each Ministry can efficiently deal with science and technology matters pertaining to its core brief. However, this entails the risk of the loss of a comprehensive view of STI, with each Ministry pursuing its narrow goals individually.

In 2013, the Government of the LPDR sanctioned the Science and Technology Law, stipulating the principle of promoting science and technology, the budget for science and technology, and the role of the then Ministry of Science and Technology, among other issues. The legal instrument proposes that the Government shall aim to invest 1 per cent of the budget every year in R&D in science and technology, and shall continue to increase the budget every year towards that end.[179]

The Science and Technology Development Fund was established on 23 May 2014, with the aim of raising funds, supporting and promoting R&D, and encouraging innovation, technology transfer, and science and technology services. It provides financial resources for scientific research and technological development, technology transfer and promotion of innovation, with a particular focus on the promotion of innovation and the provision of awards to reward excellence in the work of scientists, technologists and young researchers.

Although a clear STI agenda has been presented in the most recent strategic plan of the LPDR, the eighth NSEDP (2016–2020), this has not always been translated into policy and legal instruments, and therefore may not yet provide sufficient directionality in R&D. The ninth NSEDP (2021–2025) has yet to be published as at December 2021, likely due to delays related to COVID-19, although a draft version was approved by the National Assembly in March 2021.[180]

178 Phayboune Thanabouasy, "Government of Laos dissolves Ministry of Science and Technology", *The Laotian Times*, 1 March 2021. Available https://laotiantimes.com/2021/03/01/government-of-laos-dissolves-ministry-of-science-and-technology/. Accessed on 13 December 2021.
179 Guillermo A. Lemarchand and April Tash, *Mapping Research and Innovation in Lao People's Democratic Republic* (Paris, UNESCO Publishing, 2018).
180 LPDR, Ministry of Planning and Investment, *9th Five-Year National Socio-Economic Development Plan (2021-2025)* (2021). Available at https://laofab.org/document/download/4870 (accessed on 16 December 2021).

The eighth NSEDP contains the following policy goals related to STI: i) to develop and improve science and technology as a potential sector for contributing to achieving the objective of the NSEDP; ii) to develop science and technology as a key driving force for rapid and stable economic growth, strengthen STI for industrialization and modernization, and promote the innovative economy; iii) to develop knowledgeable and competent human resources in the science and technology sector that contribute intellectually to national development; and iv) apply science and technology as a tool for effective environmental protection and sustainable development, including preparing for and responding to natural disasters effectively.[181]

- **The Fourth Industrial Revolution**

The LPDR lags behind other ASEAN countries in terms of accessibility, quality and affordability of Internet services, which impacts readiness for the Fourth Industrial Revolution; however, there are signs it is catching up. In January 2021, 48 per cent of the population were Internet users, up by 15 per cent from January 2020.[182] In 2020, the Ministry of Post and Telecommunications urged the Government to focus on the digital economy in order to speed up development in that sector,[183] and all ministries are making corresponding efforts towards digital transformation.

> **The use of e-commerce and e-banking flourished during the COVID-19 pandemic; the LPDR reported annual growth of 20 per cent in e-commerce users in April 2020 compared to the previous year.[184]**

For example, the e-commerce platform Plaosme (an initiative of the Ministry of Commerce and Industry and the LPDR National Chamber of Commerce and Industry, funded by the Asian Development Bank) is a trade platform for both online and offline businesses, and also provides investment opportunities. Similarly, online learning increased with the COVID-19 lockdown and resulting school closures. The Lao Asia Pacific Satellite Co. in collaboration with the Ministry of Education, designed an online education platform in March 2020.

- **Capacity to develop new indigenous solutions**

Farmers in the south of the LPDR have used local innovation and indigenous knowledge to diversify production and build resilience in their farming. In the past, rice fields in the area were full of fish, frogs, crabs, crayfish and insects in addition to the rice crops, which were collected and eaten and the surplus sold on, but there has been a dramatic decline in this aquaculture in recent years. By constructing fishponds and frog cages alongside rice paddies, farmers were able to increase their income by selling frogs (a local delicacy) at the market and eggs and tadpoles to other farmers, as well as adding protein to their own diets. In addition, the water from the ponds can be used to irrigate rice seedlings, especially if rains are late or poor, thereby buffering farmers from unpredictable weather. Finally, the insects provide feed for the fish, and the aquaculture acts as a biological pest control system for the rice. By utilizing indigenous knowledge, farmers were able to intensify their production sustainably and develop an ecologically and economically resilient system. The National Agriculture and Forestry Research Institute, together with the Centre for International Cooperation in Agronomic Research for Development and the FAO, is leading efforts to develop local innovation networks that promote learning and farmer-to-farmer knowledge exchange.[185]

5.3.3 Resilience of the national innovation system of the LPDR

As described previously, the LPDR lacks a dynamic entrepreneurial system—in fact, it is one of the least competitive countries in the region.[186] The COVID-19 pandemic revealed many frailties in the country, including the fragility of MSMEs which form the backbone of the country for job creation and the economy, accounting for more than 80 per cent of employment, and which are also an integral part of the national innovation system.

181 Lemarchand and Tash, *Mapping research and innovation in Lao People's Democratic Republic*.
182 Simon Kemp, "Digital 2021: Laos", *Datareportal*, 11 February 2021. Available at https://datareportal.com/reports/digital-2021-laos. Accessed on 13 December 2021.
183 ASEAN Post, "Can Lao move to a digital economy?", 15 November 2020. Available at https://theaseanpost.com/article/can-lao-move-digital-economy. Accessed on 13 December 2021.
184 OECD, *Economic Outlook for Southeast Asia, China and India 2020–Update: Meeting the Challenges of COVID-19* (Paris, 2020).
185 Patrick P. Kalas, "Local innovation and indigenous knowledge to diversify production and build resilience in Laos People's Democratic Republic", FAO, n.d. Available at http://www.fao.org/climate-smart-agriculture-sourcebook/enabling-frameworks/module-c1-capacity-development/c1-case-studies/case-study-c114-local-innovation-and-indigenous-knowledge-to-diversify-production-and-build-resilience-in-laos-peoples-democratic-republic/en/ (accessed on 13 December 2021).
186 Schwab, ed., *The Global Competitiveness Report 2019*.

MSMEs were severely impacted by the pandemic, but a new initiative implemented by the International Labour Organization in collaboration with the Ministry of Industry and Commerce and the Lao National Chamber of Commerce and Industry aims to support resilience in the sector.[187] The new project will work with financial institutions to support formal and informal MSMEs to access cash, credit and other financial services, as well as providing reliable information related to COVID-19 support measures and entrepreneurship development for MSMEs. Finally, the programme will also deliver business development services and training for owners and aspiring entrepreneurs, including in the informal sector, to build business and financial management skills, and stimulate innovative business ideas. Supporting MSMEs in this way will strengthen the innovation system and increase its resilience to future shocks.

The education system in the LPDR was unprepared for the COVID-19 pandemic. Teachers had insufficient capacity in remote learning techniques, and so when schools were closed in 2020 for up to two-and-a-half months, remote education solutions were limited.

Some educational channels were developed for radio and television, but online learning solutions were lacking. Remote education has now been included in the Department of Teacher Education's five-year development plan, demonstrating a commitment to upskilling in this area. The Australian Strategic Partnerships in Remote Education has teamed up Monash College in Australia and the Department of Teacher Education and the Ministry of Education and Sport in the LPDR, to deliver teacher education in remote learning. Lecturers at the participating teacher training colleges, and pedagogical advisers across the LPDR, will learn how to train teachers in the theory and practice of online pedagogy and upskill them in the use of technology on an online learning platform. This will ensure that the educational system will be more resilient to future disruptions. Building capacity in this way among teaching staff at higher education institutions could ensure the higher education system is also more resilient, as well as addressing the problem of demand outstripping supply in university places.

187 ILO News, "Building resilience and COVID-19 recovery for Lao PDR's micro, small and medium enterprises", ILO, 8 April 2021. Available at https://www.ilo.org/asia/media-centre/news/WCMS_779024/lang--en/index.htm (accessed on 13 December 2021).

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Interviewees

Chanthavong, Chanthone. Government Official and Statistics Director of Technology & Communication. Department of Planning and Cooperation, Planning Division at Ministry of Technology and Communication.

Vorabouth, Maaly. Director of Education and Sport and Statistics Centre, Ministry of Planning and Investment.

6. Lesotho

Figure 6.1. Least developed country status indicators for Lesotho

Africa
Lesotho

Population
2 million (2020)

LDC status
Member since 1971

Well-being		
Human Assets Index *(composed of six indicators)* 62 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 27% (2017) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 77 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 1,294 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 10% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 4% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 43 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 22% (2019) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 72% (2019) LDC median: 89% *Source: ILO*

6.1 Country profile

The "Mountain Kingdom" is a landlocked country entirely surrounded by South Africa's borders, and is the only African country whose entire territory stands over 1000 metres above sea level. The Kingdom of Lesotho gained independence from Great Britain in 1966 after a century as a Crown Protectorate.

Economically, Basutoland joined the Customs Union Convention of Cape Colony, Natal Colony, and the Free State Republic in 1891; that Convention became the Southern African Customs Union (SACU) in 1902, and it continues to stipulate measures sharing customs tariffs and integrating the economies of its member states. Lesotho is a member of the Common Monetary Area, and the value of its own currency the loti is pegged to the South African rand. Inflation tracks that of South Africa but is some 100 basis points higher.

Lesotho entered the least developed countries group in 1971 as a deeply impoverished agriculture-based economy. Most of the population of Lesotho continues

to live in rural areas and engages in crop production and cattle rearing. Agriculture contributes 5.8 per cent of GDP, with subsistence agriculture accounting for 86 per cent of occupational activity. This dependency on agriculture arises from the century of political and economic dominance of South Africa, and the enduring impact of the SACU lock-in.

The economies of Lesotho and of the other SACU members (Botswana, Eswatini and Namibia) are constrained by their dependency relationships with South Africa. Lesotho economy is dependent on remittances from migrant mine labourers, the sale of water and hydropower to South Africa, tourism, and revenues from the SACU that accounted for 37 per cent of government revenue in 2018/19. However, massive tariff flows are in effect counterbalanced by restrictions designed to limit competition with South African industry: an infant industry in Lesotho may only be protected if it can meet 60 per cent of domestic market demand. For its part, the Lesotho Government dominates the economy as employer and consumer of services, with its wage bill standing at 26 per cent of GDP. This dominance is accompanied by patronage networks that further distort the operation of market forces.[188] In 2014, unemployment stood at 28 per cent.

In the past, attempts at industrial diversification (stainless steel manufacturing, consumer electronics assembly and low-end textile manufacturing) were short-lived. In the last two decades, however, the United States of America's African Growth Opportunities Act (AGOA) of 2000 has significantly enhanced market access to the United States of America for qualifying sub-Saharan African countries. Lesotho thereby emerged as a leading producer of clothing brands and the largest textile exporter to the United States of America in sub-Saharan Africa. Alongside this industry is diamond mining, centred on the Letšeng, Mothae, Liqhobong and Kao mines that produced an estimated 240,000 carats in 2014, worth US$300 million. The Letšeng mine yields unique gemstones with an average value of US$2,172/carat and is thus the world's richest mine on an average price per carat basis.

Over the 1995 to 2020 period, GDP per capita in Lesotho rose by 70 per cent from US$684 in 1995, peaking at US$1178 in 2016. Subsequent austerity measures saw the contribution of the public administration-sector contract before the steep COVID-19 contraction to US$967 in 2020.[189] Key drivers of Lesotho's progress towards graduation include the benefits of the AGOA that will be in place until 2025, revenues from the Lesotho Highlands Water Scheme, and diamond mining.

Quite remarkably, The Global Competitiveness Report 2019 records the Lesotho Gini income coefficient at 54.2, slightly above Botswana (54.2) and Eswatini (51.5). South Africa stood at 63.0 and Namibia at 59.1, meaning that the SACU members have some of the highest Gini coefficients in the world. The 2021 triennial review of least developed country status placed Lesotho at the overall graduation threshold, but still far short of the GNI per capita graduation threshold of US$2,444.

Risks that may limit further progress include political instability, patronage and corruption, with such having emerged in Phase II of the construction of Katse Dam, with unfortunate spillover into South Africa's own patronage networks.

> **Climate change contributes to the danger of the current reality that Lesotho, like much of the southern African interior, is drought-prone, to the extent that hydropower capacity is increasingly vulnerable. In health terms a high burden of disease remains, with a lethal combination of HIV and tuberculosis endemic across the country.**

As such, Lesotho is a country that is constrained by unique geographic and economic dependency relationships.

6.2 Key development challenges

6.2.1 Priorities of the national development agenda

The Lesotho National Vision 2020 of 2005 offered a blunt diagnosis that "deterioration in the land and its people have ushered in a crisis in the social and moral fabric of our society. Unemployment is high, and poverty is deepening; stock theft and armed robbery have become the order of the day; corruption and nepotism are spreading like a cancer … It is a desperate situation that calls for desperate measures".[190]

188 UNICEF, *Political Economy Analyses of Countries in Eastern and Southern Africa: Case Study – Lesotho Political Economy Analysis*, June 2017. Available at https://www.unicef.org/esa/sites/unicef.org.esa/files/2018-09/UNICEF-Lesotho-2017-Political-Economy-Analysis.pdf; Trading Economics, "Lesotho GDP per capita", Trading Economics Database. Available at https://tradingeconomics.com/lesotho/gdp-per-capita (accessed on 23 December 2021).
189 Trading Economics, "Lesotho GDP per capita", Trading Economics Database. Available at https://tradingeconomics.com/lesotho/gdp-per-capita (accessed on 23 December 2021).
190 Lesotho, Ministry of Finance and Development Planning, *Lesotho National Vision 2020* (Maseru, 2018).

The Vision then proposed seven pillars of development—democracy, unity, peace, education and training, economic growth, management of the environment, and advancement in technology—and recognized that their attainment required political commitment, FDI and sound public-sector management. The plan for advancement in technology has included privatization of the telecommunications sector, and "increased budget allocation towards science and technology development, forging partnerships with other countries, strengthening science and technology education, as well as promoting science and technology research, innovation and development."

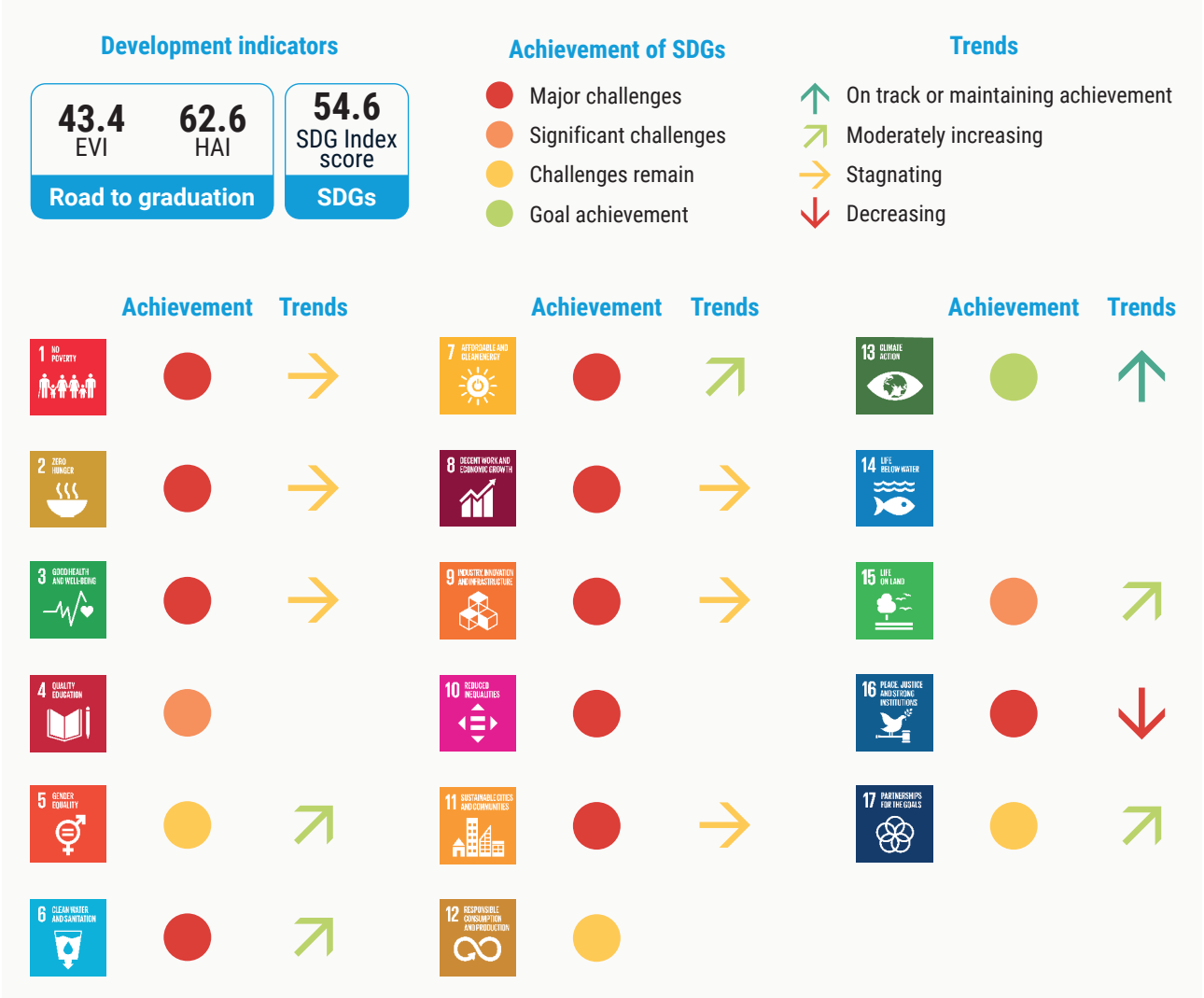
Lesotho is highly committed to the implementation of the SDGs, operationalized through the National Strategic Development Plan II (NSDP II), 2018–2023. The NSDP II is also aligned with the African Union Agenda 2063 and the Regional Indicative Strategic Development Plan. The preparation of the NSDP II and the Voluntary National Review process identified employment creation and inclusive growth as essential to reduce poverty and inequality. Effort would be applied to promote inclusive and sustainable growth (all 17 SDGs); strengthen human capital (SDGs 3, 4, 5, 10); build enabling infrastructure (SDGs 6, 7, 9, 11) and strengthen governance and accountability (SDGs 5, 16, 17).

6.2.2 Level of achievement of the SDGs

Lesotho has given high priority to realizing the SDGs, with the Prime Minister chairing the National Oversight and Advisory Committee. Lesotho duly participated in the 2019 Voluntary National Review on the Implementation of Agenda 2030, giving specific attention to SDGs 1, 2, 4, 8, 10, 13, 16 and 17.

Of these, notable progress was made on SDG 13 (climate action), though SDGs 1, 2 and 8 stagnated as a result of the economic downturn. Gains were recorded for SDGs 5, 6, 7 and 17, but the level of attainment of SDG 16 (peace, justice and strong institutions) declined as a consequence of ongoing political tensions.

Figure 6.2. Progress on the SDG index in Lesotho



Sectors that require concerted action to address the shortcomings noted in the National Voluntary Review,[191] and the uneven attainment noted in the Sustainable Development Report,[192] relate strongly to SDG 1 (no poverty), SDG 2 (zero hunger), SDG 4 (quality education), SDG 8 (decent work and economic growth), SDG 10 (reduced inequality) and SDG 13 (climate action).

The Government recognizes the pivotal role of research in informing and driving the attainment of the SDGs, in particular the need for gender responsive research, enhancing agricultural productivity, optimizing land use and the deployment of precision agriculture. Climate change and all associated human needs stand uppermost, with evidence-based methods to address forest depletion and water wastage, measures to increase household resilience, and data gathering in support of climate science investigations.

- **Agriculture, food, water and energy**

Agricultural products in Lesotho include potatoes, maize, beans, vegetables, fruit, milk, beef, game meat, mutton and wool, with market production confined to the plains in the west of the country. However, the World Food Programme estimates that 23 per cent of the population experiences food insecurity, with a third of children aged 6–59 months enduring chronic malnutrition. At close to 35 per cent in Lesotho, stunting is a widespread phenomenon, particularly among children of less educated or adolescent mothers. The Department of Agricultural Research maintains a watch on crop quality and disease, monitors livestock and conducts extension work.

Health security is further jeopardized by inadequate access to potable water and improved sanitation. Eighty per cent of the rural population in Lesotho still collect their drinking water from unprotected sources, and 66.2 per cent lack access to improved sanitation facilities.

Lesotho produces half of its electricity needs, the balance coming from the Southern African Power Pool. Access to electricity is uneven, with 44.6 per cent of households being connected. Only 6 per cent of rural households are on the grid; the rural poor thus depend on firewood and dried dung, both of which require considerable time and effort for collection, as energy sources for cooking. The cost of electricity is the lowest among SACU members, being 28 per cent below that of South Africa. The African Development Bank and the World Bank are active in funding the emergent renewable energy sector, the former for photovoltaic solar cells and the latter wind.

Hydroelectricity is also a major contributor to the grid. The Katse Dam on the Malibamat'so River has the second highest dam wall in Africa, and feeds water through to the Witwatersrand scarp in South Africa while providing electricity to Lesotho and South Africa through the Southern African Power Pool. The project was funded by the World Bank and constructed by a number of international and South African engineering concerns. Widespread corrupt practices during construction came to light in 1999.

- **The economy and jobs**

The economic growth of Lesotho is uneven, and the economy is in recession at the time of writing. Trade openness (the ratio of imports plus exports to GDP) in Lesotho stood at 139.4 per cent in 2019 (world average 91.6 per cent), with the ratio of imports to GDP at 94.2 per cent (world average 48.6 per cent). Remittances stood at 20.8 per cent (world average 4.7 per cent). This trade imbalance is buffered by the country's membership of the Common Monetary Area.

Industrial diversification is constrained by structural factors, and efforts to attract manufacturing for multinational corporations to the country—for instance in white goods, electronics and cookware—have been short-lived. At present, industry in Lesotho comprises food, beverages, textiles, apparel assembly, handicrafts, construction and tourism. The textile industries require little upskilling, as the factories arrive in semi-disassembled form and are assembled and maintained by foreign technicians. Women are the mainstay of the textile industry, a fact exacerbated by the situation that a third of employed men from Lesotho work in South Africa. While unemployment is measured at 28 per cent, little is known of the informal economy and the way it contributes to household resilience. Estimates suggest that the sector accounts for 72 per cent of productive activity.

- **Education**

Lesotho invests considerable resources in education, committing 7 per cent of GDP to this task, and providing seven years of free and compulsory education to all.

191 Lesotho, "Voluntary National Review on the implementation of the Agenda 2030 report 2019" (2019).
192 Jeffrey D. Sachs and others, *Sustainable Development Report Report 2021: The Decade of Action for the Sustainable Development Goals* (Cambridge, Cambridge University Press, 2021).

Even so, 30 per cent of adult men remain illiterate, compared with 12 per cent of women. In the early years of education, reading performance remains very weak. While 80 per cent complete primary education, gender skewing is in favour of girls, for whom the completion rate in 2018 stood at 92 per cent compared to boys at 68 per cent. For the upper-secondary level, the completion rates are 37 per cent and 27 per cent respectively. There have been gains in the proportion of qualified teachers, but other SDG targets have shown some weakening from 2014 to 2018, possibly as a result of lower economic growth and political factors.

> **In the academic year 2018, some 21,500 students were enrolled in higher education institutions in Lesotho.**

Graduates were distributed as follows: 28 per cent in business, law and management; 15 per cent in natural sciences, engineering and information and communications technology; 10.3 per cent in health sciences; 4.7 per cent in arts and humanities; 4.4 per cent in agriculture; and 3.5 per cent in social sciences. The imbalance towards qualifications that align with the services and government sectors may reflect a rational choice on the part of students. Those students who have the means and talent to progress to postgraduate study, especially at doctoral level, are inclined to study outside the country, with a large contingent in the university system of South Africa. Opportunities for science-based careers in Lesotho remain limited.

6.2.3 Relevance of STI to solving these development challenges

The response of the Lesotho Government to the United Nations Technology Bank survey identified the following five challenge areas for which STI should play a major role. Listed in priority order, these are: i) jobs and growth; ii) STIs and SDGs; iii) competitiveness, entrepreneurship and access to global markets; iv) agriculture (aiming towards self-reliance, and exports); and v) institutional capacity. Of these five challenge areas, agriculture arguably holds out the most promise, as it represents the dominant occupation for the people of Lesotho.

The Department of Agricultural Research holds the mandate for the extension of services in this sector, and is thus well-placed to improve land use, livestock health, agricultural variety and productivity. The Faculty of Agriculture of the National University of Lesotho (NUL) plays a complementary research role. In the case of agricultural innovation, the Department has developed two maize cultivars designed to address food and health security. One is a protein-enhanced sorghum variety that is, at time of writing, in late-stage seed multiplication; the other is an iron- and zinc-enhanced maize the dissemination of which may address the problem of infantile stunting. The maize is ready for dissemination.

- **Examples of how STI were applied to development challenges**

Lesotho faces exceptional challenges regarding the extent to which local business is crowded out by the competition from South Africa, the imbalances of the SACU and the practices of multinational corporations. This is why the AGOA has been of such importance for the diversification of the economy. Local entrepreneurs must therefore identify gaps in the market and value chains, and the risk entry associated with such. This requires business skills, finance and the willingness to take risks.

Regarding entrepreneurial culture in the country, the Global Competitiveness Index 2019 ranked Lesotho at 131, with business leaders showing high aversion to risk and an unwillingness to delegate authority.[193] The emergence of innovative companies has been slow; a limited diversity in the workforce, inadequate cluster development, an absence of international co-inventions, and weak multi-stakeholder collaboration are additional drawbacks.

One successful local entity is the Matekane Group of Companies (MGC), which grew from supplying construction materials to involvement in diamond mining, coal mining in Mozambique, yellow plant sales and hire, aviation services, farming, real estate and financial services. The company has 1,200 employees, of whom 100 are expatriates. MGC has an active corporate social investment programme, and donated a fully equipped COVID-19 testing laboratory to the Government. MGC is developing a project to provide sanitary products to teenage girls, and also provides scholarships for further study. MGC demonstrates Schumpeterian type III innovation in that it has both created new markets and entered established value chains. MGC's most recent innovation activity is the commercialization of cannabis, a crop illegally grown and used in Lesotho for generations. A processing plant has now been commissioned to produce cannabidiol (CBD) for

193 Schwab, ed., *The Global Competitiveness Report 2019*, p. 346.

medicinal uses, capitalizing on Lesotho's early decision to issue production licences.[194]

The NUL Innovation Hub was founded in 2018, with the aim to "financially support (a) product development and testing, (b) business incubation and (c) industrial scale application of products and services by NUL students, teachers and graduates." To this end finance is raised through the NUL Innovation Fund. The website declares the following incubation activities at NUL: chicken production; artificial stone cladding; biscuit manufacture; passive solar water heating; Rankine cycle electricity generation; a sign language mobile application; and a home security mobile application.[195] Other off-site incubation involves networking with the businesses of NUL graduates. The Innovation Hub has an active programme of science communication, and promotes STI through its annual conference and exhibition. However, interviewees suggest that the Innovation Hub is severely constrained by a lack of working capital, that in turn affects project selection. In a sense, the work of the NUL has been akin to supporting student projects, and a leg-up endowment is urgently needed.

Other examples are to be found in the field of information and communications technology services, where a number of science and engineering graduates from the NUL have positioned themselves as suppliers of solutions to the Government and to business.[196] These companies must manage risks including talent retention and dependence on government contracts. Obtaining capital is unproblematic, however, as contracts serve as collateral for early cash flow.

The above examples point to the potential for entrepreneurs who can identify opportunities, and indeed what the development economist Hirschman termed "slack".[197] Government policy formulators might well seek to understand how it is that such entrepreneurs emerge, how they identify and capitalize on slack, and what might be done to encourage others to take the risk of entering the Lesotho market against multinational competition.

6.2.4 Impact of COVID-19 in Lesotho

Even prior to the COVID-19 pandemic, Lesotho faced structural, macroeconomic and social challenges due to natural disasters, political instability and decelerating economic growth. Since early 2020, Lesotho has been negatively impacted by the evolution of the pandemic in South Africa, one of the most affected countries in Africa. Nevertheless, Lesotho launched a timely national response when the first cases of COVID-19 in the country were identified in May 2020. As of 20 August 2021, Lesotho had recorded 14,370 confirmed cases and 400 deaths as a result of COVID-19. However, Lesotho remains vulnerable to the pandemic, and at the time of writing is in the early stages of a third wave. Regrettably, political discord may hamper efforts to direct assistance to the neediest.

Steps to mitigate the economic impact of the pandemic include fiscal consolidation, and a World Bank-supported intervention to strengthen community-based nutrition service delivery in districts with very high stunting rates where up to 40 per cent of children under 5 display this condition.[198]

The UNCDP has assessed the impact of COVID-19 on the least developed countries, showing that Lesotho is third regarding the size of fiscal stimulus applied to mitigate the loss of livelihoods and the downturn in trade and services. Debt service suspension frees up government resources for application to domestic needs. The economy is particularly vulnerable to the downturn in remittances that has resulted from restricted cross-border movement.

> **Tourism has reduced by 70 per cent, with consequent job losses of catering and facility staff.**

GDP has contracted by nearly 10 per cent, compared with the expansion of 0.4 per cent that was expected before the pandemic. Social services show a decline of 25 per cent. Lesotho has limited financial levers with which to respond to these shocks, and the close linkage with the economy and porous borders of South Africa compounds the problem.

194 Rethabile Mohono, "MGC does it again, launches medical cannabis plant", n.d. Available at https://publiceyenews.com/mgc-does-it-again-launches-medical-cannabis-plant/(accessed on 13 December 2021).
195 National University of Lesotho Innovation Fund, "Projects", n.d. Available at https://www.nulif.org.ls/ (accessed on 13 December 2021).
196 See www.cbs.co.ls.
197 Albert O. Hirschman, *Exit, Voice and Loyalty* (Cambridge, MA, Harvard University Press, 1970).
198 FAO, "Nearly half of all children under five years in Lesotho are stunted, an indicator of chronic malnutrition", 11 August 2012. Available at https://www.un.org/humansecurity/wp-content/uploads/2017/08/Flyer-Home-Garden.pdf (accessed on 13 December 2021).

6.3 STI snapshot

6.3.1 STI system SWOT analysis

Table 6.1. Strengths, weaknesses, opportunities and threats of the national STI system in Lesotho

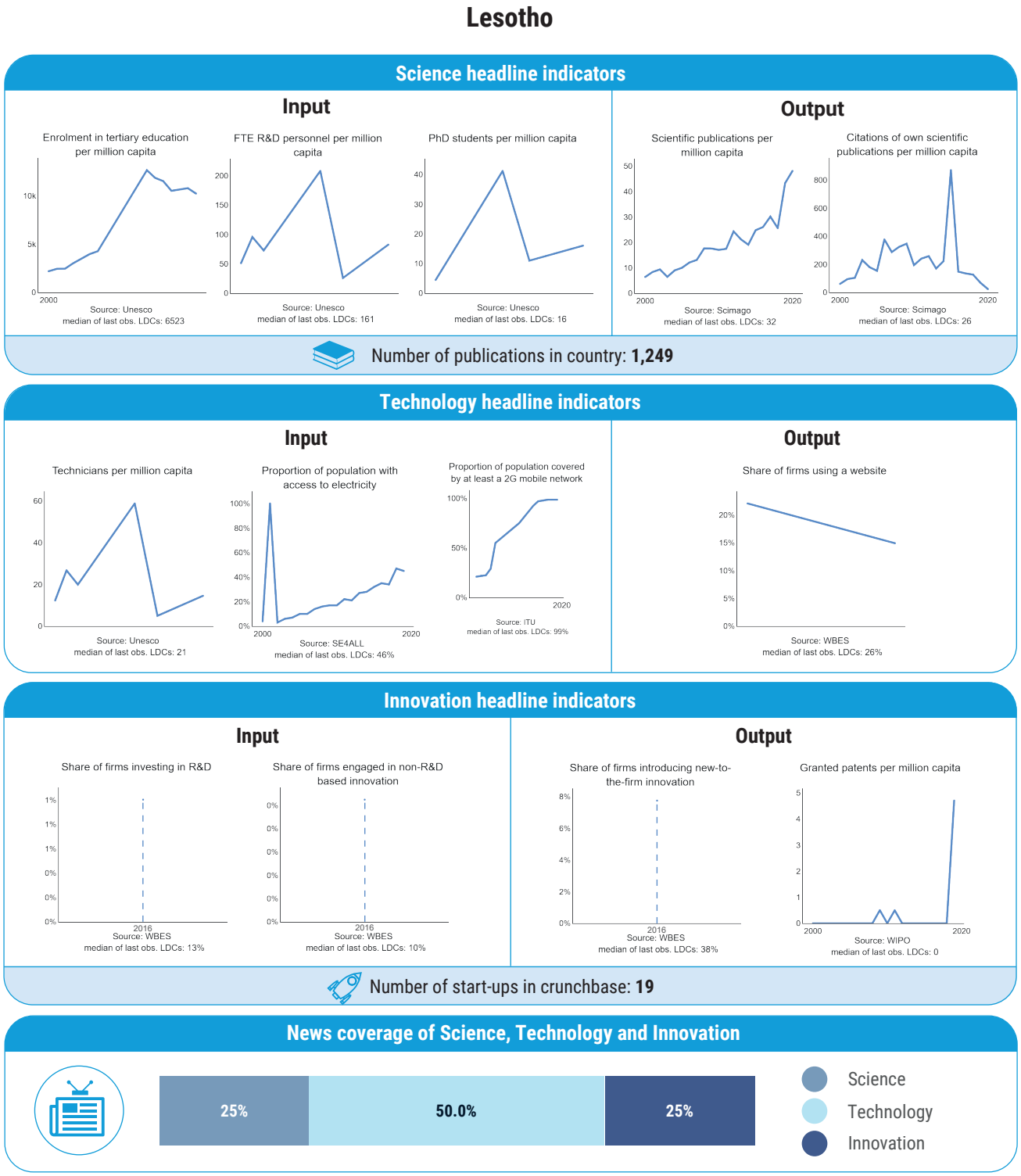
Strengths	Weaknesses
• NSDP II is aligned with the 2030 Agenda for Sustainable Development • Government actively working with the Organisation of African, Caribbean and Pacific States (OACPS) to develop a new research and innovation policy • There are positive relationships with multilateral organizations (World Bank, UNDP, WHO) • The NUL has, and maintains, high standards • Indigenous knowledge is deeply embedded in agricultural and health practices, and contributes to resilience • Financial infrastructure is sound and linked with peer institutions in the Common Monetary Area • The Lesotho diaspora in South Africa provides linkages with Government, commerce and the research system	• High levels of poverty with a burden of infectious diseases, notably HIV and tuberculosis • Heavy dependence on South Africa for food imports • SACU lock-in restricts the emergence of new industries, with resultant low diversification • Dependence on diamond mining is a risk as the market is very sensitive to global shocks • Communications infrastructure is underdeveloped — mobile and broadband penetration are low and expensive • Exceptional gender bias in that men have higher illiteracy rate than women, drop out of school earlier and generally underperform • The stock of researchers is small and R&D investment is correspondingly low, and expenditure dominated by clinical trials • Inadequate linkages among actors of the innovation system, with research skewed towards the public sector
Opportunities	**Threats**
• Entry into multinational corporations' value chains may be further developed in concert with local entrepreneurs • Development of a new STI policy with strong input from successful entrepreneurs and innovators • Linking of Lesotho sectoral innovation systems with peers in South Africa in the health, agriculture and mining sectors for collaboration and provision of scientific and technical services • Postgraduate study in South Africa remains accessible, affordable and of high quality • Increase the capacity of the NUL Innovation Hub to establish incubators in Maseru, Teyateyaneng and Mafeteng • Application of indigenous knowledge systems to frugal innovation solutions • Orderly adjustment of the regulatory environment to diversify the telecommunications market, expand coverage and product range, reduce cost and kick-start digitization • Expansion of renewable energy sources, especially solar and wind, the latter with 6-gigawatt potential	• Political instability remains an ongoing problem that is exacerbated by Government domination of the real economy • Economic lock-in to the SACU is both a benefit and a hindrance • COVID-19 has hampered the prospects for stronger economic growth and limits the funding of STI, especially for the NUL • Increased brain drain to South African institutions that offer better career prospects • Lesotho is drought-prone and highly vulnerable to climate change • The termination of AGOA in 2025 presents a challenge to the industries that currently enjoy tariff preference to the US market

Gender imbalance in education and literacy: illiteracy is more prevalent among men than women, and men tend to drop out of school earlier.[199]

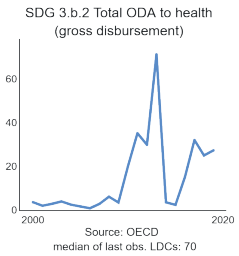
199 African Union, *African Innovation Outlook III* (Addis Ababa, African Union, 2018).

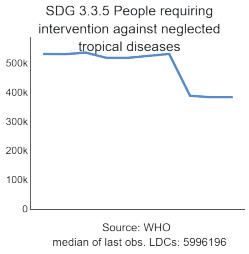
6.3.2 Key features of the STI system

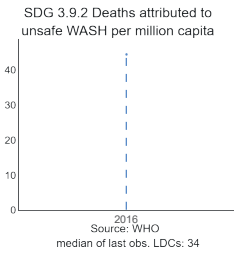
Figure 6.3. Key features of the STI system in Lesotho

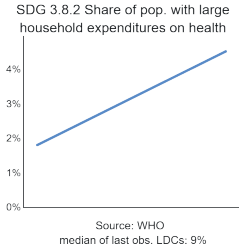


STI & COVID-19 & Health



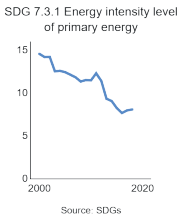


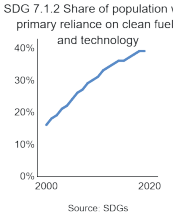


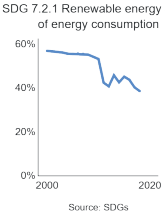


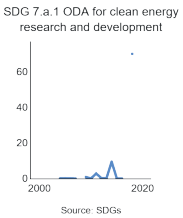
Publications 25: 2% of publications **Start-ups in crunchbase** 3: 15% of start-ups

STI & Clean Energy



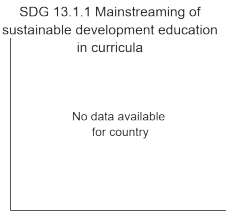






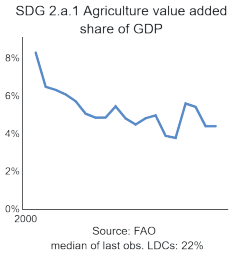
Publications 1: 0.08% of publications **Start-ups in crunchbase** 1: 5% of start-ups

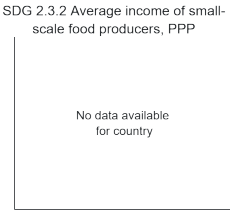
STI & Climate Adaptation

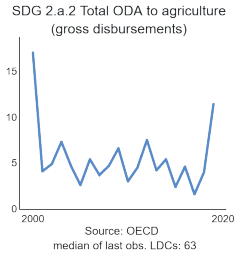


Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Agriculture

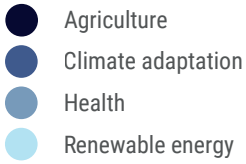






Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas



Lesotho faces almost unique development challenges, not only landlocked but completely surrounded by a single country. Lesotho is highly culturally homogeneous, enjoys the benefit of predictable revenue flows from SACU transfers and is integrated into the South African economy. One might compare the country with Singapore, which first lost its markets in mainland Malaysia, and then further lost revenues as a result of the closure of the British naval dockyard. Singapore's leadership then took the long view that the country's destiny lay in the development of its only real asset, people. Singapore in the 1960s is a useful example of how a Government may address the adversities of the loss of markets, and long-term dependency relationships, by developing the talents of the people. In Lesotho, investment in the people, whether engineers, accountants, administrators or scientists, will have a long-term pay-off.

Investment in science entails many choices, especially that of focus, and involves building appropriate institutions, be these virtual or concrete. The way these institutions relate one to another is addressed through the innovation system approach. Thus far, no reliable measure of the strength and value of such linkages is available, so that scientometric analysis only provides a set of proxy measures. However, bibliometric analysis of Lesotho-authored publications shows overwhelming concentration on the NUL. The inescapable conclusion is that that Lesotho, like many least developed countries and emerging economies, currently hosts a small, disarticulated knowledge development system.

As shown by the most recent data on the inputs to R&D, in 2015 Lesotho's GERD was estimated at 0.05 per cent of GDP. A total headcount of 118 researchers was recorded, of whom 34.8 per cent were women. No data were presented on R&D activity in the business sector. This may be the result of no measurement of business expenditure on R&D (BERD), or a lack of a shared understanding of what qualifies as R&D. As is described further below, R&D is conducted in the Lesotho business sector. Eighty researchers were found to be in the university sector, with the remainder in the Government. Data recorded by the Agricultural Science and Technology Indicators Network identifies 33 full-time equivalent researchers in agriculture.

Lesotho participates in a number of large-scale clinical trials (including on HIV),[200] the cost of which is included in GERD. Presently some 11 trials are under way or are recruiting participants. The number of researchers active in clinical trials is unknown. The Government is the main source of funds for higher education; the clinical trials are generally funded from abroad by philanthropists or the United States of America's National Institutes of Health. The Budget Book for 2020 provided no details of the budget for higher education.

Regarding scientific research output, over the period 2016–2020 researchers in Lesotho produced 400 peer-reviewed publications indexed on the Web of Science. A total of 157 were co-authored with scientists in South Africa, 115 with scientists in the United States of America and 46 with scientists in Switzerland, with a strong focus on health sciences.[201] As to innovation output, measured in intellectual property registrations, the World Intellectual Property Organization recorded 10 patent grants abroad in 2019, and 107 trademark filings in 2018. The Global Competitive Index for 2019 ranks Lesotho patents per million at rank 132. with trademarks at rank 122. The data do not distinguish resident from non-resident assignees.

- **Limited and underfunded knowledge diffusion system**

Linkages are central to the very concept of an innovation system, and take a number of forms. In a disarticulated system, linkages take the form of academic exchanges and the provision of new graduates with up-to-date skills in areas of scientific inquiry, with access to state-of-the-art equipment, and exhibiting fresh thinking in accounting, logistics, business management and more. Academics are also in a position to offer their consultancy services to the public and private sectors.

Given the small size of the research "system" in Lesotho, basic research will be unlikely to inform business activity. It is rather the case that user-driven applied research inquiry occurs on a limited scale. The shortage of research project funding results in collaboration being informal and ad hoc.

- **Governance and R&D policy**

The Ministry of Communication, Science and Technology has led STI policy development in Lesotho over the past two decades, and was responsible for crafting the National Science and Technology Policy 2006–2011.

200 See www.clinicaltrials.org.
201 See www.webofknowledge.com.

Lesotho, via its membership of the SADC, has ratified a number of protocols that have a bearing on STI development, including the SADC Protocol on Education and Training and the SADC Protocol on Science and Technology. The former confers domestic fee status on students from Lesotho who study in South Africa's universities. Lesotho also participates in the work of the SADC Organ for Science and Technology, and the African Science and Technology Indicators Initiative of the African Union, that has provided training in policy and measurement activities.

Resources are finite, and effective communication of priority areas for development must make the most efficient use of resources. The field of STI falls under the Ministry of Communication, Science and Technology. According to an interviewee, this subordinate status leads to severe underfunding for STI, estimated to receive only 0.03 per cent of the government budget. In effect, there is no official research budget, so that researchers must make do, and are dependent on foreign sources of funds.

At present there are no arms-length public research organizations, with the Department of Agricultural Research residing within its parent Ministry; the same holds for the Health Research Coordinating Committee. It may be timely to investigate the design and feasibility of granting management autonomy to the Department of Agricultural Research.

Regarding intellectual property rights, Lesotho is a member of the Paris, Berne and Rome Conventions, Patent Cooperation Treaty (PCT), the African Regional Intellectual Property Organization (the Banjul Protocol), the Madrid Agreement and Protocol and the World Trade Organization Agreement on Trade-Related Aspects of Intellectual Property Rights. There is currently no register of plant breeders' rights; however, Lesotho has signed the SADC Protocol for Protection of New Varieties of Plant (Plant Breeders' Rights), and once this has been ratified, the necessary protection will be in place. As of June 2020, Botswana was the ninth SADC Member State to sign. One additional signature is required for ratification across the SADC.

The NUL has declared an official intellectual property policy, effective 24 June 2021, that vests ownership of intellectual property arising from publicly funded R&D with the NUL. The policy, that draws on similar Bayh-Dole formalisms such as that of South Africa, lays out the conditions for disclosure, commercialization and benefit-sharing.

6.3.3 Resilience of the national innovation system of Lesotho

The main impact on STI resulting from the COVID-19 pandemic has been felt in the disruptions to funding, supplies and movement of personnel, and curtailed study opportunities in South Africa, the distance-based opportunities offered by the Internet notwithstanding. Gains in STI have been undermined, especially in food production initiatives, and STI awareness and capacity-building has all but ceased. On the other hand, COVID-19 has given new impetus to the Lesotho-South Africa bilateral S&T agreement and the identification of COVID-19 medicines.

As to better use of STI, and the intersection with indigenous knowledge systems, one interviewee noted that increased investment in agricultural research would be beneficial, "because Lesotho has ideal climatic condition with less pests; therefore, herbs that have been used from generation to generation only need to be further researched, as they are very helpful. Most people entirely rely on those plants." There is a strong belief among research professionals that the people of Lesotho demonstrate great strength in adversity, and that the country's widespread domestic agricultural practices enable her to withstand downturn. This suggests that placing even greater emphasis on agricultural improvement, and developing new methods, crops and cultivars in harmony with indigenous knowledge systems would offer the best returns on investment, both socially and economically.

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Interviewees

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Lebesa, Lefulesele. Director, Department of Agricultural Research.

Letseka, Moeketsi. United Nations Educational, Scientific and Cultural Organization Chair, University of South Africa.

Matekane, Sam. CEO, Matekane Group of Companies.

Mohlalefi, Sefika. CEO, Computer Business Solutions.

Sekaleli, Sekoati. Chief Research Officer, Department of Agricultural Research.

Thamae, Lefa. Director of Science, Technology and Innovation at Ministry of Communications, Science and Technology.

Thamae, Tim. Dean of Science, National University of Lesotho.

7. Mauritania

Figure 7.1. Least developed country status indicators for Mauritania

Africa
Mauritania

Population
4 million (2020)

LDC status
Member since 1986

Well-being		
Human Assets Index *(composed of six indicators)* 54 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 6% (2014) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 89 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 1,577 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 3% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 6% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 45 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 10% (2017) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 91% (2017) LDC median: 89% *Source: ILO*

7.1 Country profile

Mauritania is a part of the Sahel region located on the Atlantic coast of Africa. With only 0.5 per cent of the country being productive arable land, the country mainly relies on its vast expanses of pastoral land, its fisheries, the export of minerals (primarily iron ore) and, importantly, developmental aid which represented 5.5 per cent of the country's GNI in 2019.[202] As at 2020, Mauritania had a population of about 4.6 million. It is the fourth least densely populated country in Africa; however, the country has a high population growth rate, at 2.7 per cent in 2019.[203] Historically, much of the country's population was nomadic, with some sedentary

202 OECD, "Mauritania: aid at a glance: charts", 4 June 2021. Available at www.oecd.org/countries/mauritania/aid-at-a-glance.htm (accessed on 13 December 2021).
203 World Bank, "Open Data", World Bank database. Available at https://data.worldbank.org (accessed on 20 August 2021).

black Africans and enslaved groups engaged in farming in the more fertile south of the country, but droughts throughout the twentieth century made it increasingly difficult to maintain this lifestyle, and many people began to settle in rapidly growing urban areas.[204] Around 52.8 per cent of the population was living in urban areas in 2013.[205]

The country experienced economic stagnation from 1975 to 1984, resulting from the collapse of iron ore prices and extensive droughts, and characterized by socioeconomic problems.

In addition, tensions have erupted over policies related to national languages, education, land tenure and ethnic representation in the political apparatus.[206]

Mauritania has been a member of the World Trade Organization since 31 May 1995. The discovery and exploitation of oil and gas reserves on the Atlantic coast of Mauritania has recently raised hopes of future prosperity. Oil was discovered in the 1960s; however, no hydrocarbon development took place until the discovery of the Chinguetti oilfield in 2001. This oilfield's production started in 2006 at a rate of 75,000 barrels per day (BPD). However, production declined rapidly to 15,000 BPD in 2007, 7,000 BPD in 2013, and much lower volumes after that.[207] In 2015, the United States of America private firm Kosmos Energy made a major natural gas discovery, the Grand Tortue Ahmeyim gas field. The volume of gas potentially trapped in the offshore area is estimated to equal to around 8.9 billion barrels of oil equivalent, which could make it one of the largest hydrocarbon discoveries in the world, meaning that Mauritania could become a global energy player.[208] The potential for commercial hydrocarbons is significant, but still hampered by poor infrastructure, a changeable political landscape and significant technical and financial challenges.

Economic growth rose sharply in 2006 with the start of oil production, but declined with the subsequent decrease in oil production. In addition, political instability has negatively affected a wide range of macroeconomic variables, including GDP growth. GDP growth in Mauritania oscillated between 2.11 per cent in 2018 and 5.9 per cent in 2019. The effects of the COVID-19 pandemic on the deterioration of the global economy caused real GDP in Mauritania to contract by 3.6 per cent in 2020. The current account deficit reached a record of 17.6 per cent of GDP, due primarily to a one-third drop in iron ore exports and a halt in exports of fishery products.[209]

Mauritania entered the least developed countries group in 1986, with ECOSOC resolutions E/1986/103 and E/DEC/1986/153. Data from the 2021 triennial review published by the UNCDP still classifies Mauritania on this list. The review shows that Mauritania meets the inclusion eligibility criteria regarding GNI per capita (US$1,578), but not regarding the HAI (54.2) and Economic and Environmental Vulnerability Index (45.2). Mauritania is not listed among countries considered for graduation. The national poverty rate fell from 51 per cent in 2000 to 31 per cent in 2014. But 74 per cent of the poor live in rural areas and the effects of the COVID-19 pandemic caused the indicator on poverty headcount ratio at $3.20 per day to significatively decline.

The Government has opted for conservative fiscal and macroeconomic policies, but the country remains highly dependent on fluctuating global prices of commodities. The weak diversification of the economy means that the country's economy remains divided, with on one hand the profitable (and formal) extractive and fishery sectors, and on the other the informal urban and underdeveloped agricultural and livestock sectors.210 Extractive industries remain the engine of economic growth, representing approximately 25 per cent of GDP, 82 per cent of exports and 20–25 per cent of fiscal revenues.[211]

204 Katherine Ann Wiley, "Mauritania", Oxford Bibliographies, 25 February 2016. Available at www.oxfordbibliographies.com/view/document/obo-9780199846733/obo-9780199846733-0033.xml (accessed on 13 December 2021).
205 World Bank, "The World Bank in Mauritania: overview–context", 2 November 2021. Available at https://www.worldbank.org/en/country/mauritania/overview#1(accessed on 13 December 2021).
206 Bertelsmann Stiftung, "Country dashboard: Mauritania", BTI Transformation Index. Available at https://bti-project.org/en/reports/country-dashboard/MRT (accessed on 13 December 2021).
207 Mostefa Ouki, *Mauritania-Senegal: An Emerging New African Gas Province – Is it Still Possible?* (Oxford, United Kingdom, Oxford Institute for Energy Studies, 2020).
208 LNG World News, "Kosmos Energy makes major gas discovery off Mauritania", 28 October 2019.
209 African Development Bank Group, "Mauritania economic outlook" (2021). Available at https://www.afdb.org/en/countries/mauritania/mauritania-economic-outlook (accessed on 13 December 2021).
210 Bertelsmann Stiftung, "Country dashboard: Mauritania", BTI Transformation Index. Available at https://bti-project.org/en/reports/country-dashboard/MRT (accessed on 13 December 2021).
211 World Bank, "Open Data", World Bank database. Available at https://data.worldbank.org (accessed on 20 August 2021).

7.2 Key development challenges

7.2.1 Priorities of the national development agenda

In its National Strategy for Accelerated Growth and Shared Prosperity (SCAPP), Mauritania set its development agenda for the period 2016–2030. The strategy aims to support the achievement of the 2030 Agenda for Sustainable Development and is centred around three main priority objectives: i) the promotion of strong, sustainable and inclusive growth, and notably the strengthening of infrastructure to support growth; ii) the development of human capital and access to basic social services; and iii) the strengthening of governance. In addition, the strategy acknowledges the role of research and innovation for sustainable development, and has developed specific objectives and priority actions in relation to STI.

7.2.2 Level of achievement of the SDGs

The SCAPP identifies several development challenges, including the poor diversification of the economy, insufficient capacities of the private sector, weak human resources and limited access to primary health services in general and to maternal and child health in particular. In addition, there are challenges related to the quality of education and the mismatch of training with the needs of the labour market. Efforts remain to be made in the fight against poverty and in strengthening social cohesion, social protection and access to basic services (for example, drinking water and electricity), particularly in rural areas. Other challenges include the enhancement of environmental governance, in particular disaster risk reduction and the management of threats linked to climate change and to the development of the hydrocarbon sector in the marine environment.[212]

Mauritania faces major challenges in pursuing the achievement of 12 out of 17 SDGs. It is on track for achievement of SDG 13 (climate action), and is moderately progressing towards achievement of SDG 4 (quality education), SDG 6 (clean water and sanitation), and SDG 15 (life on land). SDG 1 (no poverty) is the only SDG with a decreasing trend.

The objectives of Mauritania's SCAPP are fully aligned with the SDGs. This coherence may be further strengthened by additional work on the definition of national targets and indicators. Several priorities remain to be addressed to reach the SDGs, including attaining a better geographical distribution of the population to reduce the costs of investments and promote access to services for all; encouraging women's entrepreneurship through specific funding mechanisms; modernizing the birth registration system; and ensuring access to a legal identity for all.[213]

These targets are yet to be achieved. Public spending tended to decrease in the past decade. Government expenditure on education gradually dropped from 2.294 per cent of GDP in 2012 to 1.895 per cent of GDP in 2019.[214] The birth registration system also remains an issue. In 2018 Human Rights Watch reported that the national civil registration process in Mauritania is still preventing many children from attending public school, and that many local NGOs consider the civil registration process as a major impediment to academic progress.

The following paragraphs focus on the development challenges that the country needs to resolve in order to make progress on a number of SDGs, in particular SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (health and well-being), SDG 4 (quality education), SDG 6 (clean water and sanitation), SDG 7 (clean energy), SDG 12 (responsible consumption and production), and SDG 13 (climate action).

- **Agriculture, food security and nutrition**

Half of the population of Mauritania depend on agriculture (livestock and cereal grain farming) for their income. Farming generates about 25 per cent of GDP, but is still highly dependent on rain-fed irrigation and therefore very vulnerable to weather patterns. Domestic food production is therefore unreliable, and the country depends on imports of food and food aid.[215] Mauritania

212 African Development Bank Group, Mauritania Liaison Office, *Country Strategy Paper (CSP) 2016-2020* (2016). Available at https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Mauritania_-_2016-2020_CSP_en.pdf.
213 Mauritania, *Mauritania's 2019 Voluntary National Review* (United Nations Economic and Social Commission for Western Asia, 2019). Available at https://arabsdgs.unescwa.org/en/read-digital-library-collaborate-voluntary-national-reports-arab-vnrs/mauritanias-2019-voluntary.
214 World Bank, "Open Data", World Bank database. Available at https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?locations=MR (accessed on 14 September 2021).
215 UNCTAD, *Science, Technology and Innovation Policy (STIP) Review of Mauritania* (New York and Geneva, United Nations Publications, 2010).

is self-sufficient in red meat and fish, but imports 60 per cent of other staple foodstuffs, especially rice, vegetables, sugar and cooking oil.[216]

- **Climate change and water**

Desertification, rising sea levels, water shortages and the loss of natural habitats are at the core of environmental challenges faced by Mauritania. Climate change exposes the country to a high risk of natural disasters. Climate hazards, in particular periodic droughts and floods, have strongly impacted agricultural production and animal husbandry in recent years. As a result of unpredictable seasonal rains and climatic conditions, the majority of the population remains chronically vulnerable to food insecurity and malnutrition. Moreover, in recent decades, severe floods have struck the capital city Nouakchott, where about one third of the population lives. The city is mostly below sea level and is particularly vulnerable to rising groundwater levels, seawater intrusion, porous soil, sand extraction and floods.

Household vulnerability is further aggravated by limited access to safe drinking water and widespread malnutrition. Only 68 per cent of the population have access to potable water, mostly in urban areas. In rural areas, there are recurrent acute shortages, leading to internal migration to the cities.[217] Effective water management and governance remains a challenge for Mauritania to meet needs in terms of drinking water and sanitation for people and water for agriculture and livestock.

216 International Fund for Agricultural Development, "Mauritania", n.d. Available at https://www.ifad.org/en/web/operations/w/country/mauritania (accessed on 13 December 2021).
217 African Bank Development Group, "Mauritania: on track to beating drinking water shortages", 28 November 2018. Available at https://www.afdb.org/en/news-and-events/mauritania-on-track-to-beating-drinking-water-shortages-18743. Accessed on 13 December 2021.

- **Education**

Despite progress in access and completion of basic education in the last years, the education system in Mauritania still faces significant challenges. The low quality of education is a major obstacle to the country's development. Only 39 per cent of primary schools in Mauritania offer a complete learning cycle, and only around 10 per cent of students obtain their Baccalauréat at the completion of their secondary education. About a quarter of teachers in the country are on short-term contracts, and are not fully qualified.[218]

- **Energy sources**

The SCAPP identifies energy sector as a priority for poverty reduction. The Government aims to expand electricity supply, and has set a target of producing 50 per cent of its energy from renewable sources by 2030. In addition to its oil and natural gas reserves, Mauritania is endowed with substantial renewable energy resources, including solar power, wind and hydropower. In 2015, the total production of electricity was 177 kilotonnes of oil equivalent, of which 80.7 per cent came from fossil fuels, 12.4 per cent from hydropower and 6.7 per cent from solar and wind.[219]

In terms of creating incentives for investment in the renewable energy sector, Mauritania has adopted regulatory and legal instruments and institutions that help promote and protect such investments. In recent years, Mauritania has also established specific institutions for the improvement of the business environment and the protection of investments, including the Higher Council for the Improvement of the Business Climate, the General Delegation for the Promotion of Investments and the International Chamber of Business Mediation and Arbitration, the latter a one-stop-shop for setting up a company. These initiatives have had a positive impact on the country's ranking in the World Bank's Doing Business report. In the 2018 report, the country made a significant jump from a position of 160 to 150.[220]

Mauritania has one State-owned electricity utility company, the Société Mauritanienne d'Electricité or SOMELEC. Independent power producers are not yet involved in electricity production. Despite high resource potential and opportunities for cross-border export, the power sector in Mauritania continues to face significant challenges, including access to financing, an inadequate grid network and electricity transfer, and a lack of a stable regulatory and tariff structure.[221]

7.2.3 Relevance of STI to solving these development challenges

Science and technology can play a decisive and pivotal role in achieving the SDGs through value addition to resources, job creation, the reduction of environmental pollution, the control and mitigation of natural hazards, increasing production, and improving the lives of people across different strata of the population. However, the research and innovation system in Mauritania is not yet adequately contributing to solving the countries' development challenges. This can be explained by several factors, including but not limited to insufficient research capacities, the lack of alignment of research with the country's development challenges, inadequate investment and a weak STI enabling environment.

7.2.4 Impact of COVID-19 in Mauritania

> **In addition to the development challenges described above, the effects of COVID-19 plunged the economy into recession and threatened to wipe out five years of development progress.**

Achievements on SDG 1 (no poverty) have been particularly challenged, with a previously positive trend going into reverse. Although iron ore prices held up, total exports decreased by 30 per cent due to weaker international demand. Seafood sales were affected by 40 per cent as a result of transport issues. Only sales of gold increased (by 25 per cent) owing to the surge in prices, as production elsewhere fell. This underperformance has impacted investment, with the share of GDP falling from 45 per cent to around 40 per cent in 2020, reflecting the decline in foreign investment which accounts for one third of total investment, and in public infrastructure investment. In 2021, investment is expected to remain below its pre-crisis level, one effect of which will be that production at the Grand Tortue Ahmeyin gas field has been pushed back to 2023. Households have had to confront rising prices for imported food products such as rice and wheat, fuel supply problems, and currency

218 UNICEF, "Mauritanie: éducation", n.d. Available at www.unicef.org/mauritania/éducation. Accessed 18 August 2021.
219 UNEP, "Energy profile: Mauritania" (2017).
220 World Bank Group, *Doing Business 2018: Reforming to Create Jobs* (Washington, D.C., World Bank Publications, 2018), p. 178.
221 USAID, "Mauritania: Power Africa fact sheet" (2021). Available at https://www.usaid.gov/powerafrica/mauritania (accessed on 29 December 2021).

depreciation. Transport and other services were also hit by the lockdown, while agriculture was impacted by drought in the Sahel, but should benefit from the government's focus on developing cereal crop growing in the south of Mauritania.[222]

- **Examples of how STI have been successfully used to tackle COVID-19**

Good practices have been noted on governance issues and information and communications technology innovations in Mauritania. For example, early in the pandemic, the Government set up an operational multi-ministerial task force to agree on measures to handle the crisis. The administration also changed its working methods; collaboration platforms such as Zoom or Microsoft Teams are widely used to organize trainings and multi-stakeholder meetings.

Technology has also been used directly in the fight against the pandemic. Stop Corona is a contact tracing application developed in Mauritania, which also educates its users and the public about how to avoid being infected, and the attitudes and behaviours to adopt if they test positive for COVID-19.

In the agriculture sector, the FAO launched several programmes aiming to enhance the resilience of the population against the impacts of COVID-19. These include the launch of a US$1.6 million programme introducing digital innovations to support youth employment and the resilience of rural areas in collaboration with the Ministry of Rural Development, and a US$700,000 project aiming to strengthen the resilience of vulnerable rural populations through innovative watershed management practices in partnership with the Ministry of Sustainable Development.

7.3 STI snapshot

7.3.1 STI system SWOT analysis

An analysis of the STI system in Mauritania highlights a range strengths, weaknesses, opportunities and threats, summarized in the table.

Table 7.1. Strengths, weaknesses, opportunities and threats of the national STI system in Mauritania

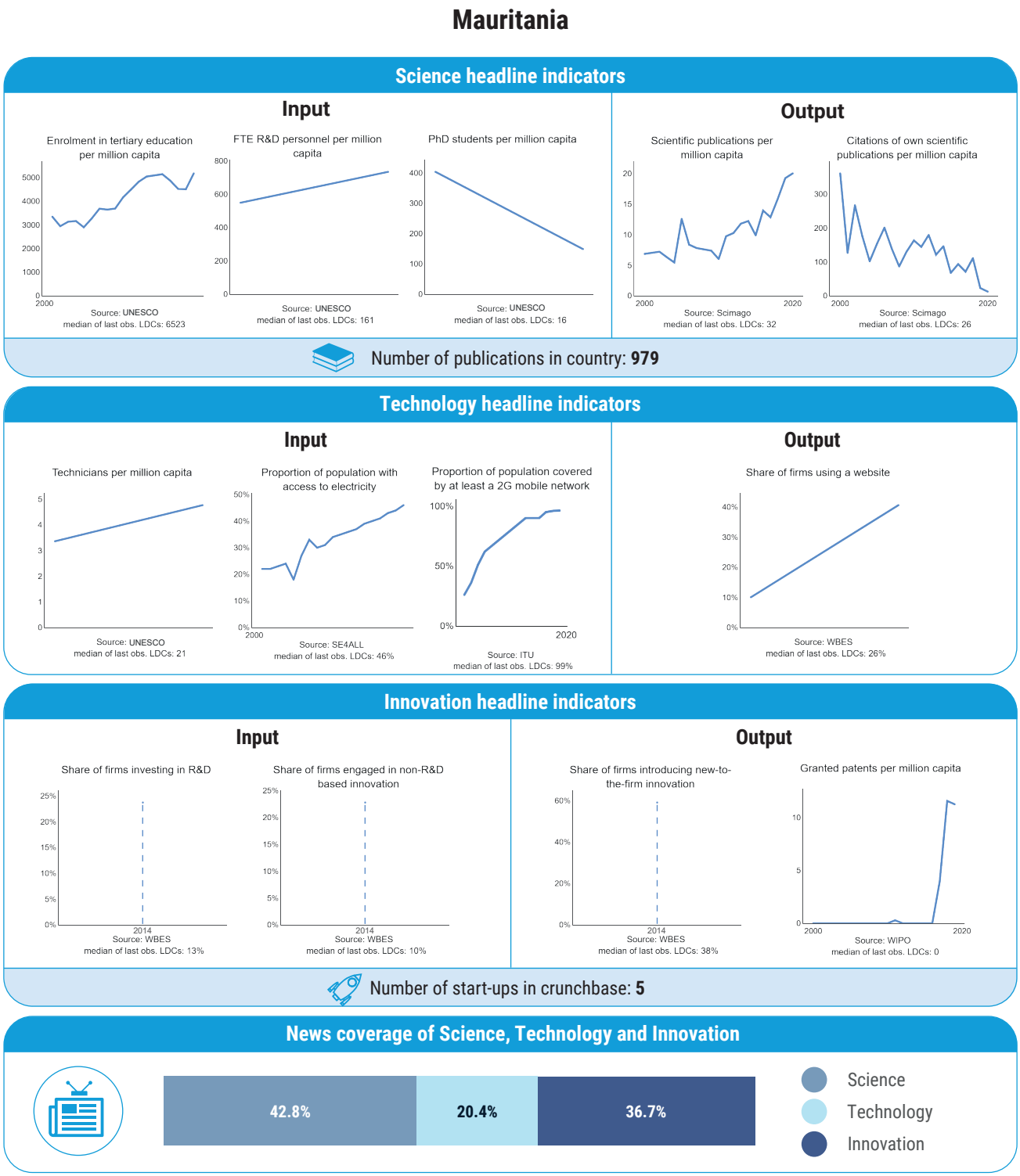
Strengths	Weaknesses
• The SCAPP is aligned with the 2030 Agenda for Sustainable Development • The Government is promoting the development of a digital economy and supporting access to the Internet throughout the country • Mauritania benefits from significant developmental aid that can be geared towards the development of a STI system • Quality research is carried out in the fields of chemistry, mathematics, biology, physics and computer science • Investments have been made for infrastructure development, such as fibre-optic Internet connection and 4G technology	• Low quality of basic education remains a major obstacle to the development of the country's STI system, that currently has a limited number of researchers and professors • Available skills are insufficiently aligned with the country's development challenges and needs, and university-industry linkages are weak • The industrial base is lacking diversity and still dominated by-products requiring little complexity in processing, namely extractives and low value added fishing products • As Mauritania imports 60 per cent of its food and export low value added products, it is highly dependent on the fluctuating global prices of commodities • Unequal access to education and health services, particularly in rural areas and for populations that have no citizenship • R&D investments are estimated at 0.01 per cent of GDP in 2018, with very little investment from the private sector • Weak infrastructure in transport, communications, power and water supplies constitute significant barriers to the enabling conditions for STI activities • Underperformance of the financial system hampers access to funds for innovation • Weak regulatory framework in terms of protection of investments, data and intellectual property

222 Coface, "Mauritania", February 2021. Available at www.coface.com/Economic-Studies-and-Country-Risks/Mauritania (accessed on 13 December 2021).

Opportunities	Threats
• Exploitation of oil and gas reserves could increase Government revenue and open opportunities for higher investments in R&D. • The government is currently working to develop a STI policy aligned with the country's development challenges. • Improvement of the business climate: the simplification of business registration procedures has made it easier and cheaper to both launch and run a business. • Commitment to develop affordable access to information and communications technology and Internet throughout the country and opportunities in terms of leapfrogging with digitization. • The government is working on enhancing the information and communications technology regulatory framework (including data protection, cybersecurity and digital identity) to unlock opportunities in the digital sector. • The government conducted an Open Data Readiness Assessment in 2016. • In December 2021, the government launched a call for proposals for the recruitment of a consultancy to provide technical assistance in the development of a start-up act. • The government aims to strengthen the STI ecosystem through the creation of new institutions and councils for research, innovation and digital strategy, such as the High Council for Digital Technology, the High Council of Scientific Research and the Higher Institute for Digital Technology. • Rise in the number of incubators and other entrepreneurship support centres, with some offering sectoral specialization (information and communications technology, agriculture, etc.). • New incubators and international cooperation programmes enhancing the interests of young people and women in entrepreneurship and innovation. • Renewable energy resources, in particular solar, wind and hydropower, are fields where STI can help enhance energy production and sustainability, and contribute to resolving current energy shortcomings. • Mobilization of the diaspora in the development of the country's STI system • Promotion of applied research to contribute to addressing the SDGs	• With temperatures rising 1.5 times faster than in the rest of the world, the Sahel region is highly vulnerable to the impacts of climate change. Without adequate research and innovation in the field, the country will face difficulties developing tailored solutions for stronger resilience to these threats. • The economic recession resulting from the effects of COVID-19 is limiting investment in the country, including in STI.

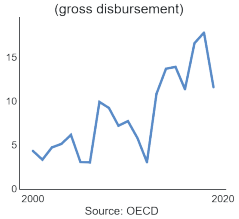
7.3.2 Key features of the STI system

Figure 7.2. Key features of the STI system in Mauritania



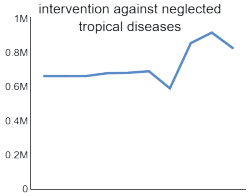
STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)



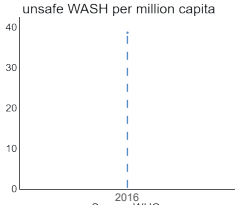
Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



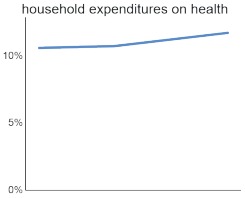
Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita



Source: WHO
median of last obs. LDCs: 34

SDG 3.8.2 Share of pop. with large household expenditures on health

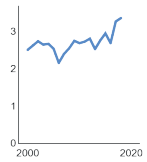


Source: WHO
median of last obs. LDCs: 9%

Publications 34: 3% of publications **Start-ups in crunchbase** 0: 0% of start-ups

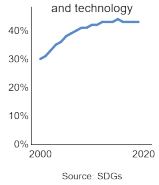
STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy



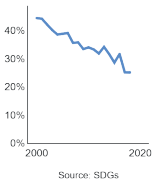
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



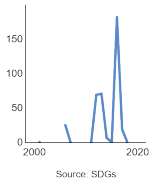
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development



Source: SDGs

Publications 2: 0.2% of publications **Start-ups in crunchbase** 1: 20% of start-ups

STI & Climate Adaptation

SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP

No data available for country

SDG 1.5.2 Direct agriculture loss attributed to disasters

No data available for country

SDG 13.1.1 Mainstreaming of sustainable development education in curricula

No data available for country

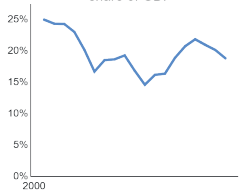
SDG 11.b.2 Share of local governments that implement local DRR strategies

No data available for country

Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP

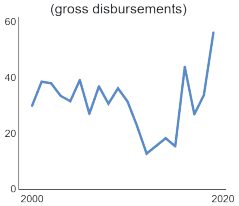


Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP

No data available for country

SDG 2.a.2 Total ODA to agriculture (gross disbursements)



Source: OECD
median of last obs. LDCs: 63

SDG 2.a.1 Agriculture share of Government Expenditure

No data available for country

Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas

• Governance

Prior to 2020, research and innovation was the responsibility of the Ministry of Higher Education, Scientific Research and ICT, which sought to develop and implement the Government's policy on STI. The Government's objectives in terms of STI development, as described in the SCAPP, led to the creation of a Ministry of Digital Transformation, Innovation and Administration Modernisation in 2020, with the main objectives of accelerating Internet access throughout the country and developing a relevant regulatory framework on data protection issues.

Mauritania has not yet defined a clear STI strategy. As Figure 7.1 indicates, reliable data do not exist on the most widely used indicators of innovative effort. However, the SCAPP set as top priorities the promotion of innovation and entrepreneurship, and the development of the private sector. The SCAPP also underlined the importance of developing an STI strategy and a higher education and research system aligned with the country's development priorities. It envisions the creation of new engineering courses, a business school, institutes in the fields of electronics and information and communications technology, and the operation of industrial facilities. It also aims to develop doctoral study in key priority areas such as information and communications technology, and the creation of a support fund for research. Mauritania has identified information and communications technology as a priority area for innovation and a pillar of socioeconomic development, and aims to transform education and health through digital technology. A project was launched with support from the World Bank—the West Africa Regional Communications Infrastructure Project aims to provide the whole country with high-speed Internet connection, through an undersea cable.

The new Ministry of Digital Transition, Innovation and Modernization of the Administration, and its Agency for Scientific Research and Innovation, were recently given the responsibility of developing and implementing an innovation policy. The Agency is currently developing the national STI policy using the Policy Support Mechanism set up by the Secretariat of the OACPS. The technical support was launched in July 2021, and is expected to achieve its objectives over a period of six months.[223] In addition, the Ministry is working on its digital strategy with the United Nations Economic and Social Commission for Western Asia. An action plan is under development and includes e-government services, road extension connectivity and data centre implementation. The Government's digital strategy aims to enhance the transparency of public action and resolve the difficulties in the national civil registration process.

• Knowledge production

Past and current research products have made little contribution to solving the country's major development issues. This is partly because basic research is predominant, and although it is important and needed, there is insufficient applied research. Applied research provides answers not only to the daily concerns of the population, but also directly or indirectly contributes to the satisfaction of the economic and social needs of the country. Among challenges for the country's higher education and research system is the need to increase the number of institutions performing research activities, and to direct their work towards more applied research, experimental development and technological innovation.[224]

STI inputs remain a challenge, in particular R&D spending, estimated at 0.01 per cent of GDP in 2018. Previously, about 92.8 per cent of R&D has been financed and undertaken by the Government, and only 7.2 per cent by the private sector. This very low private engagement requires redress if the ambitions of Mauritania in R&D are to be met.

The country has very low higher education enrolment rates. In 2019, Mauritania counted a total of only 23,417 students enrolled in all programmes of tertiary education, of both genders (37 per cent women). Science headline indicators for the period 2000–2020 illustrate a downward trend in the number of PhD students. In 2018, the number of R&D personnel was 734 per million population or 3,206 researchers, 24.5 per cent of them women.[225]

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223 OACPS, "Soutien à la mise en œuvre de réformes: elaboration d'une stratégie nationale de R&I en Mauritanie" (July– December 2021).

224 Mauritania, Ministry of Higher Education and Scientific Research, *Mauritanie: L'Enseignement Supérieur et la Recherche—Éléments d'Efficacité* (Dakar: UNESCO IIEP, 2018), p. 65, para. 4.4.5.

225 UNESCO Institute for Statistics, Data for the Sustainable Development Goals database. Available at http://uis.unesco.org (accessed on 20 August 2021).

The low number of researchers is an obstacle to the research performance of Mauritania, low in comparison with other African countries. The SCImago Journal & Country Rank positions Mauritania at 43 out of the 57 African countries ranked in 2020. In the period 1996–2020, researchers from Mauritania produced only 870 publications, with an H index of 47 and a total of 10,367 citations, thus an average of 11.92 citations per document.[226]

Despite an upward trend of scientific publications in Mauritania in the past two decades, the country's level of scientific output remains very low. Mauritania produced only 20 scientific publications in 2018; in comparison, Mali published 90 scientific articles in 2018, Senegal 388 and Morocco 5,057.[227] Nevertheless, there are areas where quality research is carried out in Mauritania. Chemistry, biology, physics, mathematics and computer science are fields that have higher standards of research in the country, with more outputs per researcher in international journals.[228]

- **Valorization of research and absorptive capacity**

The country's number of patent applications was 34 in 2017, including 2 applications by residents and 32 from abroad.[229] The 2019 Global Competitiveness Index ranks Mauritania 134 out of 141 countries (down slightly from 131/140 in 2018), with an overall score of 41. The country scores low on "innovation capability" (ranked 128 with a score of 26), with a low performance on R&D indicators: on "scientific publication" the country scores 54.8 and ranks 136, while on "patent applications per million population" it scores 0.2 and ranks 121.[230]

Research outputs rarely lead to contracts with industrial partners, creation of innovative companies or new products and services. A major barrier is the lack of consideration of third mission activities within the management of research careers, for instance patenting or university-industry partnerships.[231]

- **Human capital**

The capacity of Mauritania to innovate is also hampered by insufficient investment in its human capital. The country has less than a dozen specialized higher education institutions and counts just one university, the University of Nouakchott, which has five faculties. There is a growing number of private institutions including the University of Science, Technology and Medicine in Nouakchott, which opened its doors several years ago.

The World Economic Forum's Human Capital Index measures countries' ability to maximize and leverage their human capital endowment. With a Human Capital Index of 0.35 (and ranking of 150 out of 157 countries) in 2017, on average a Mauritanian child born today will only reach 35 per cent of their productivity potential endowment.[232]

Mauritania performs the poorest among its regional peers in terms of the quality of mathematics and science education.[233] Among the population, information and communications technology literacy is low. Public investment in developing the population's digital skills is low, and there are only a small number of private initiatives to develop information and communications technology literacy among the youth of Mauritania, such as the Google Developers Group and Women TechMakers (also financed by Google). The number of academics and researchers with skills in applied research is low.

> **To remedy this situation, the Government aims to support a number of information and communications technology-focused public schools that will play a key role in the ecosystem.**

These include existing schools such as the University of Nouakchott al-Aasriya with its supercomputer platform, the University Professional Institute and the Higher Technical School; but also the creation of new institutions, for example the Ecole 42 aiming to train young people who have no diploma in digital skills, and a

226 SCImago, "Mauritania", Scimago journal & country rank. Available at https://www.scimagojr.com/countrysearch.php?country=MR (accessed on 13 December 2021).
227 World Bank, "Scientific and technical journal articles—Mauritania", National Science Foundation, science and engineering indicators. Available at https://data.worldbank.org/indicator/IP.JRN.ARTC.SC?locations=MR (accessed on 14 September 2021).
228 Mauritania, Ministry of Higher Education and Scientific Research, *Mauritanie*.
229 World Intellectual Property Organization, "Statistical country profiles: Mauritania". Available at https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=MR (accessed on 20 August 2021).
230 Schwab ed. The Global Competitiveness Report 2019, p. 378.
231 Mauritania, Ministry of Higher Education and Scientific Research, *Mauritanie*.
232 World Economic Forum, *The Global Human Capital Report 2017: Preparing People for the Future of Work* (Cologny/Geneva, 2017).
233 World Bank Group, *The Untapped Potential of Mauritania's Entrepreneurial Ecosystem: Lessons from the Entrepreneur's Marathon* (Washington, D.C., 2019).

digital centre which aims to support the development of digital projects.

- **An emerging landscape of incubators**

The STI ecosystem in Mauritania is still under construction. However, in recent years, incubators have started growing in various fields.

- **FabLab-InnovRIM** was created in Nouakchott in 2014 as a space for innovation, technical incubation, prototyping and co-working. InnovRIM offers training and support for projects in the fields of information and communications technology, electronics, and automation. Incubated projects include the mapping of Nouakchott with the OpenStreetMap application, the development of a smartphone application on maternal health, recycling old tyres by transforming them into furniture and the design of solar cookers to reduce the consumption of firewood in rural areas. InnovRIM also offers computer recovery services, and computer training for young women and girls who have dropped out of school.

- **ILab** was designed by the Youth Chamber of Commerce of Mauritania as a co-working space aiming to offer each member an ecosystem of mentors, coaches and business partners to support innovators and entrepreneurs.

- **Hadina-RIMTIC** hosts and supports information and communications technology projects. The incubator organizes a yearly competition called the MauriApp Challenge, in which participants use technology to solve social and business problems.

- **Intaj** is an accelerator supporting the development of green MSMEs, supporting actors in this sector to adopt green practices, play a role in the transition to a low-carbon economy, and drive radical environmental innovations in the agricultural, industrial and services sectors.

- **The Komos Innovation Center** mentors and nurtures young entrepreneurs, empowering them to tackle issues in a range of sectors including education, health, agriculture, e-commerce, logistics, waste management and security.

7.3.3 Resilience of the national innovation system of Mauritania

COVID-19 has demonstrated the capacity of the national innovation system of Mauritania to stay resilient despite the political, economic and social changes affecting the country.

The pandemic has driven a rapid digitization in several sectors, including e-education, with several applications offering educational content during periods of school closure; the Ministry of Education has made use of some of these solutions. In addition, applications were created to develop home deliveries, electronic payment services and the logging of QR codes for polymerase chain reaction (PCR) COVID-19 tests with the Ministry of Health. Some of these applications were developed before the COVID-19 pandemic but were not distributed among the public before that time. This digital market readiness has been complemented by the creation of the Ministry of Digital Transition, Innovation and Modernization of the Administration in 2021, and its Agency for Scientific Research and Innovation.

COVID-19 has not obstructed the ongoing development of the country's STI policy using the Policy Support Mechanism of the OACPS, and the development of its digital strategy.

The level of R&D spending is not expected to increase in the near future, but investment in the development of universal and affordable access to the Internet should remain a priority for Mauritania.

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Ba, Abdoulaye Sidiki. Mauritania Ambassador at Next Einstein Forum's African Science Week.

Kane, Mariem, Head of Innovation. Agency for Scientific Research and Innovation, Ministry of Digital Transition, Innovation and Modernization of the Administration.

Zeine, Sidi Ould Moulaye. Secretary General. Ministry of Digital Transition, Innovation and Modernization of the Administration.

8. Mozambique

Figure 8.1. Least developed country status indicators for Mozambique

Africa
Mozambique

Population
31 million (2020)

LDC status
Member since 1988

Well-being		
Human Assets Index *(composed of six indicators)* 53 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 64% (2014) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 93 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 472 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* -110% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 5% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 41 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 3% (2015) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 96% (2015) LDC median: 89% *Source: ILO*

8.1 Country profile

In 2021, Mozambique's economy is expected to grow 2.1 per cent, despite experiencing a decrease of 1.3 per cent in 2020 due to the COVID-19 pandemic.[234] By 2025, the International Monetary Fund (IMF) projects growth as high as 11.3 per cent, indicative of a positive economic trend sustained by the nation's strongest industries: oil and gas. Recently, 10 trillion cubic feet of natural gas were discovered off the coast of Cabo Delgado Province in northern Mozambique, securing its status as an emerging player in the global oil and gas industry.[235] Oil and gas discoveries in the last few years in East Africa are the most prolific of any region in the

234 AllAfrica, "Mozambique: growth rate of 2.1 per cent forecast for 2021", 23 September 2020.
235 JA! and Friends of the Earth Mozambique, *The Impacts of the long Industry in Cabo Delgado, Mozambique* (BankTrack, 2020).

world.[236] Cabo Delgado is home to Africa's three largest liquid natural gas (LNG) projects: the Mozambique LNG Project (led by Total and worth US$20bn), the Coral South FLNG Project (led by Eni and ExxonMobil and worth $4,7bn), and Rovuma LNG Project (led by ExxonMobil, Eni and China National Petroleum Corporation (CNPC) and worth US$30bn).[237] Although natural resources and the oil and gas sector as a whole contribute 23 per cent to the country's GDP, it only employs 8.6 per cent of the population and requires heavy international capital investments.

Agriculture continues to employ the vast majority of the country's workforce (70.2 per cent) and contributed 26 per cent to the country's GDP in 2019.[238] According to FAO, smallholder farmers account for most of this sector's production, with some 3.2 million smallholder farmers accounting for 95 per cent of the country's agricultural production. Smallholder farmers in least developed countries work in sectors with traditionally low productivity. Despite the prominence of the agricultural sector in the country's economy, the nutrition situation in Mozambique remains precarious, with 43 per cent of children under five suffering from chronic malnutrition. This is mainly due to the low diversity of production, the low productivity of the traditional sector, and the difficulties accessing nutritious food.[239] Mining is a key sector in Mozambique, as it is home to some of the world's largest untapped coal deposits. Mozambique exported its first batch of coal in 2011 and expects to become the world's largest coal exporter.

Services are essential in connecting the country to the global value chain, as well as in providing value added job opportunities to Mozambicans. It contributes 39.9 per cent to the GDP and employs 21.2 per cent of the total workforce.[240] Forward-looking strategies include diversifying the economy from capital-intensive and heavy industries to more value added, labour-intensive but efficient types of services. There is significant

236 PWC, *Fuel for Thought: Africa Oil and Gas Review 2019 – Current Developments and a Look into the Future* (2019).
237 JA! and Friends of the Earth Mozambique, *The Impacts of the long Industry in Cabo Delgado, Mozambique* (BankTrack, 2020).
238 Statista, "Distribution of gross domestic product (GDP) across economic sectors Mozambique 2019", Statista database. Available at https://www.statista.com/statistics/507266/mozambique-gdp-distribution-across-economic-sectors/ (accessed on 3 September 2021).
239 Food and Agriculture Organization, "Mozambique at a glance ", n.d. Available at https://www.fao.org/mozambique/fao-in-mozambique/mozambique-at-a-glance/en/ (accessed on 3 September 2021).
240 Statista, "Distribution of gross domestic product (GDP) across economic sectors Mozambique 2019", Statista database. Available at https://www.statista.com/statistics/507266/mozambique-gdp-distribution-across-economic-sectors/ (accessed on 3 September 2021).

untapped potential in tourism, although it has been severely impacted by COVID-19-related border closures.

Unfortunately, the pandemic worsened the unemployment rate – which is expected to rise from 20 to 27.30 per cent – increased child labour, the proportion of which is approximately 22 per cent, and the informal sector.[241]

Nonetheless, GDP and GDP per capita in Mozambique remain low: GDP is just below US$ 15 billion, and GDP per capita is around US$ 1,300 (purchasing power parity (PPP), current US$). Furthermore, in 2019, public debt was at US$ 14.78 billion – 113 per cent of its GDP, and an increase of nearly 30 per cent since 2017.[242] The size of the country's public debt has been a matter of concern for many years. In 2016, the Government of Mozambique eventually revealed that it has debts of nearly US$ 1.2 billion, which led the IMF to cut its loans and caused the value of the country's currency to deteriorate, all symptoms of a delicate financial and economic situation.[243]

This economic scenario stems from an unstable period in the second half of the twentieth century. For nearly 500 years, Mozambique was a Portuguese colony, gaining its independence in 1975, following a 11-year war of independence.

The post-independence period resulted in a civil war, which ended in 1992. Since 1988, the country has been part of the least developed countries group. The country's colonial past, and its post-independence period marked by poor governance, have left their mark in the form of structural issues, particularly the lack of peace among political forces, widespread corruption, violation of human rights, reoccurring violent conflicts and a severe debt crisis.[244, 245]

As a result, poverty is still crippling the country: by 2014, about 63 per cent of the population lived on US$1.90 per day, and by 2021, the GNI was US$473 per capita, whereas the threshold income for graduation from least developed country status is US$1.222. As much as 90 per cent of Mozambique's economy is informal. Therefore, Mozambique has yet to ramp up the substantial momentum required to graduate: its Human Assets Index (HAI) is 53.9, whereas the graduation threshold is 66 or above.[246] The country ranks 181 out of 189 on the Human Development Index (2019).[247] In the World Economic Forum's Global Competitiveness Report 2019, Mozambique ranks 137th out of the 141 economies covered in the Global Competitiveness Index. Its overall score is below sub-Saharan Africa and the low-income group's average in nearly all indicators, notably human capital and framework conditions for an enabling environment (infrastructure, macroeconomic stability, information and communications technology adoption) where the country is reporting decreasing scores. The country also had a low score for its potential to innovate, ranking 125th out of the 141 countries and at the bottom end of the low-income group.[248] STI investment remains low, a fact further demonstrated by the country's extremely low GERD levels (less than 1 per cent of the national GDP).

The country's *Global Competitiveness Report 2019* analysis is substantiated by the World Bank country analytics and overview. Among the main challenges the country faces is its need to maintain economic stability and make additional efforts to improve economic governance and increase transparency. Furthermore, there is a need to support the private sector and diversify the economy away from low-productivity sectors (such as subsistence agriculture or the traditional sector) and capital-intensive but low value added

241 UNICEF Mozambique, "The children in Mozambique", n.d. Available at https://www.unicef.org/mozambique/en/children-mozambique (accessed on 10 September 2021).
242 Karin Strohecker, "Factbox: Mozambique debt crisis - What does the country owe, and to whom?", *Reuters*, 9 September 2019.
243 BTI, *Mozambique Country Report 2020* (BTI, 2020). Available at https://www.bti-project.org/en/reports/country-report-MOZ-2020.html#pos0 (accessed on 12 July 2021).
244 Transparency International, "Mozambique" (2020). Available at https://www.transparency.org/en/countries/mozambique# (accessed on 5 July 2021).
245 World Bank, *Mozambique Economic Update, February 2021: Setting the Stage for Recovery* (2021). Available at https://openknowledge.worldbank.org/handle/10986/35214 (accessed on 5 July 2021).
246 United Nations, Department of Economic and Social Affairs, and United Nations, Committee for Development Policy, *The least Developed Country Category: 2021 Country Snapshots"* (2021). Available at https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/Snapshots2021.pdf (accessed on 12 July 2021).
247 United Nations, Development Programme, *Human Development Report 2020 – The Next Frontier:.Human Development and the Anthropocene* (2020). Available at http://hdr.undp.org/sites/default/files/hdr2020.pdf (accessed on 12 July 2021).
248 Schwab ed., *The Global Competitiveness Report 2019*, pp. 407–410.

commodity-extracting industries and mining towards higher value added services (such as health and education).[249]

With regards to demographics and overall life conditions, both World Bank and the Global Competitiveness Index point to the fragility of Mozambique due to its high infant mortality, short life expectancy (50.6 years), low education levels (i.e. low number of schooling years, structural difficulties in fostering skills education among its active and future workforces, and a low pupil-to-teacher ratio in primary school, as well as high child labour), and low market flexibility (i.e. active labour-market policies, hiring and firing practices, cooperation in labour-employer relations).[250, 251]

The challenges faced by Mozambique are wide-ranging, but STI can support the elimination of these fragilities. The next sections explore these key challenges, and the country has defined priorities for its development as well as the specificities of its STI system and the resilience of the country when facing the COVID-19 crisis.

8.2 Key development challenges

8.2.1 Priorities of the national development agenda

Mozambique has the challenge of tackling multiple issues simultaneously: poverty, good health, quality education, gender equality, clean water, clean energy, creating decent work opportunities and economic growth. Since the 2030 Agenda for Sustainable Development (the 2030 Agenda) was adopted in 2015, the Government of Mozambique has taken actions to align its policies and budget to it, aiming at improving its performance towards achieving the SDGs.[252, 253] Based on the 2030 Agenda for Sustainable Development, Mozambique developed a long-term vision – the National Development Strategy (ENDE) 2015–2035 – aiming to build an equitable country and a peaceful society. Its main objective is "to improve the living conditions of the population through structural transformation of the economy, expansion and diversification of the productive base"[254] and it focuses on investment in industrialization as the main way to boost competitiveness.[255]

The government also launched a five-year programme (PQG 2020–2024) with three core priorities: 1) human capital development and social justice; 2) economic growth, productivity and job creation; and 3) strengthening sustainable management of natural resources.[256, 257] In 2020, Mozambique also adopted the National Framework of SDG Indicators (QNI), aligned with the PQG 2020–2024.

8.2.2 Level of achievement of the SDGs

Concerning progress towards the SDGs, Mozambique ranks 152nd out of 165 countries, making it challenging for the country to reach the SDG targets by 2030.[258] Figure 8.2 illustrates the country's performance on the SDGs, with 14 out of 17 targets having major challenges to address and scores across most categories either stagnating or moderately improving.

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249 World Bank, "Mozambique overview: Country profile", World Bank Database. Available at https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MOZ (accessed on 1 September 2021).

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251 Schwab ed., *The Global Competitiveness Report 2019*, pp. 407–410.

252 Mozambique, Ministry of Economy and Finance, *Voluntary National Review of Agenda 2030 for Sustainable Development* (2020). Available at https://sustainabledevelopment.un.org/content/documents/26313VNR_2020_Mozambique_Report.pdf (accessed on 4 August 2021).

253 United Nations Human Settlement Programme, *UN-Habitat Country Programme, Mozambique* (2019). Available at https://unhabitat.org/sites/default/files/documents/2019-05/hcpd_2019.pdf (accessed on 4 August 2021).

254 Mozambique, *Estratégia Nacional de Desenvolvimento (2015–2035)* [National Development Strategy of Mozambique (2015–2035)] (2015). Available at https://www.cabri-sbo.org/uploads/bia/mozambique_2015_planning_external_national_plan_author_region_portuguese_.pdf (accessed on 9 September 2021).

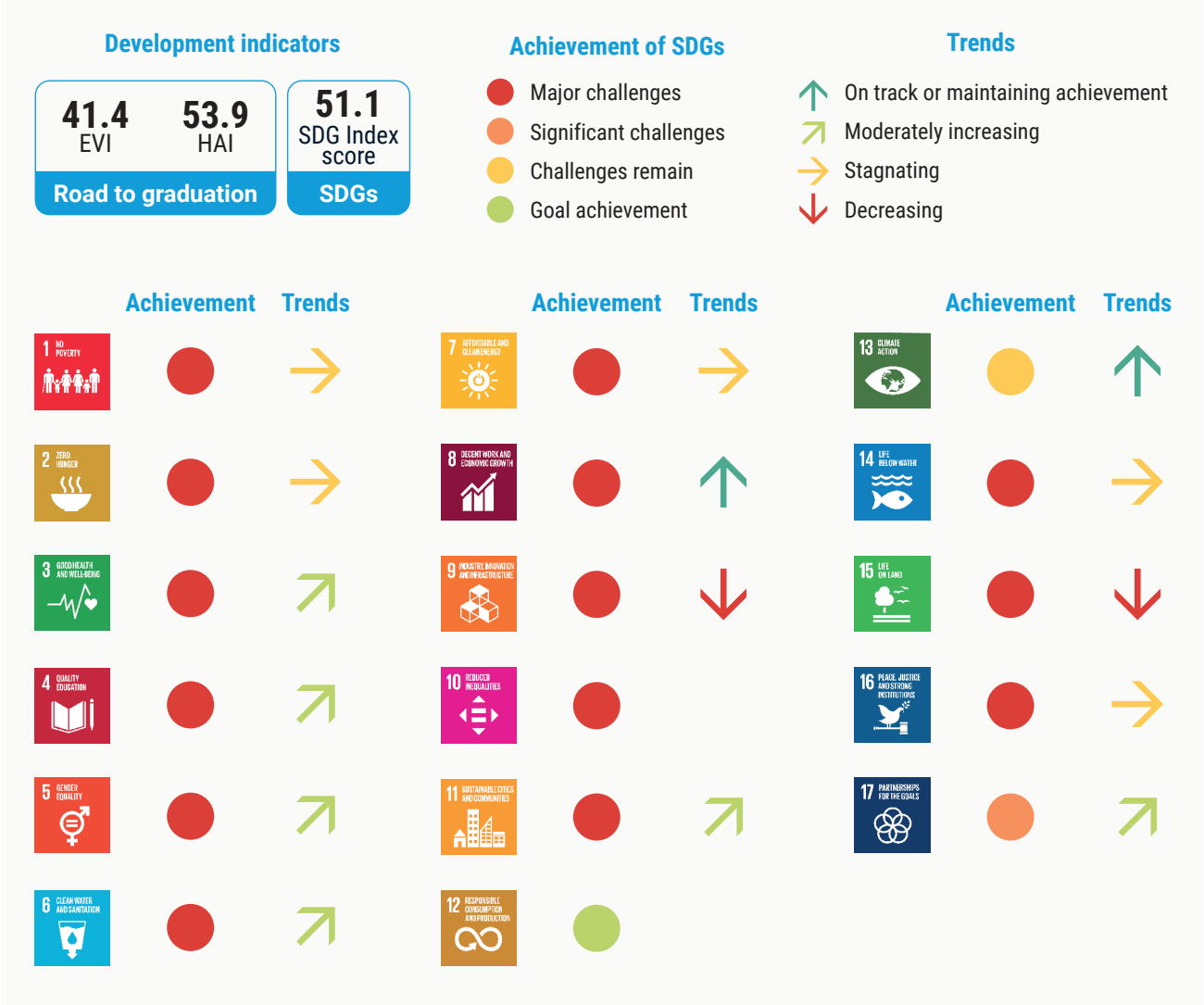
255 The pillars of action include: (i) the development of human capital, (ii) the development of production-based infrastructures focusing on small and medium-sized enterprises, (iii) research, innovation and technological development, and (iv) institutional articulation and coordination.

256 Mozambique, *Programa Quinquenal do Governo 2020–2024* [Five-year programme] (2020). Available at http://www.ts.gov.mz/images/PQG_2020.2024_Versao_AR__02042020-min.pdf.

257 For more information, see Annex 1.

258 Sachs and others "Mozambique", SDG Index Database. Available at https://dashboards.sdgindex.org/profiles/mozambique (accessed on 2 August 2021).

Figure 8.2. Progress on the SDG Index in Mozambique



Source: Adapted from Sachs and others (2021).

- **Education**

Mozambique has shown a clear commitment to education, undertaking several measures, such as abolishing school fees, providing direct support to schools and investing in classroom construction. Education is the sector that currently receives the highest share of the State budget, at over 15 per cent.[259] As a result, levels of school enrolment have increased between 2015 and 2018, with the proportion of girls enrolled in primary school reaching 48.2 per cent.

However, quality and improvement in learning are lagging. By 2018, only 4.9 per cent of students in the third grade had reading skills, and only 7.7 per cent had arithmetic skills. Moreover, only 4–6 per cent of children have access to preschool (at least one year).[260] Strikingly, only 16.9 per cent of the adult population finishes secondary education and only 7 per cent of the population pursues tertiary education (14 per cent of the female and 19 per cent of the male populations).

259 United Nations Children's Fund, "Education situation in Mozambique" (2017). Available at https://www.unicef.org/mozambique/en/education#:~:text=Education%20situation%20in%20Mozambique&text=It%20has%20abolished%20school%20fees,made%20investments%20in%20classroom%20construction.&text=About%201.2%20million%20children%20are,in%20the%20secondary%20age%20group (accessed on 10 September 2021).

260 Mozambique, Ministry of Economy and Finance, *Voluntary National Review of Agenda 2030 for Sustainable Development* (2020), p. 37. Available at https://sustainabledevelopment.un.org/content/documents/26313VNR_2020_Mozambique_Report.pdf.

Mozambique faces a shortage of skills in the national workforce to respond to increased industry activity.

Over the past 20 years, higher education institutions (HEIs) in Mozambique have grown dramatically, both in terms of number of institutions and in the profile of students.

This rapid expansion resulted from the reforms adopted to build a more inclusive system. However, this massive growth has posed enormous challenges in the functionality of the subsystem and in the quality of its teaching. Studies suggest that the challenges of Mozambican higher education are, among others, the quality of teaching, its consolidation and functional differentiation, its financing and research. It also suffers from a critical shortage of highly qualified or skilled professionals, gender gaps and high teacher-student ratios.[261, 262] Since 2000, there has been a rapid growth in the number of HEIs in Mozambique, but the average number of students who graduate remains unsatisfactory. This is an even bigger problem in the private sector, which attracts a small number of highly qualified professionals and academics.[263] At its current stage, research is not supportive of adequate industrial development, preventing productive sectors' ability to rely on HEIs for R&D projects. However, the lack of human resources – mostly in management and technical areas – can sabotage these investments, in a sector focused on productivity and competitiveness. In an attempt to ensure workers have the skills required to meet the needs of the labour market, the Government has increased its efforts to expand and improve the quality of technical and vocational education and training (TVET)[264] since the 2000s. Improvements include a new competency-based curriculum endorsed by the World Bank, new regulatory bodies in the landscape of TVET providers, and schools across the country being converted to reference institutes. After nearly two decades of reforms,[265] evidence demonstrates that TVET investments lead to young people getting into sustainable employment, higher incomes and reduced gender inequality, although there is clearly some way to go to ensure TVET institutes have the tools they need to train the next generation of workers.[266]

- **Agriculture, natural resources and energy**

The total agricultural land area of the country is estimated at almost 500,000 km^2, which is 62 per cent of the total area of the country. In 2013, the cultivated area was estimated at 12 per cent of the agricultural land, mostly arable land. As previously mentioned, agriculture contributes 26 per cent to GDP in Mozambique and is a key component of the country's development with around 70 per cent of the population depending on subsistence farming. Agricultural production is largely rain-fed and productivity is low, with some of the lowest yields in cereals in southern Africa due to both low inputs and poor access to the markets. There are 3.7 million farms that can be divided into two main categories:

- The smallholder "family" subsector accounts for about 98 per cent of the area under production and produces almost all the food crops, such as maize, cassava, rice and beans. It is characterized by its small area, low inputs, inadequate equipment and low yields and returns. Almost all production is rain-fed, as the farmers cannot afford to install irrigation systems. Within this sector, a small group of emerging commercial farmers exists who use some agricultural inputs and sell their products at local markets.

- Small- and medium-sized private companies represent the growing commercial subsector. These companies have some technological know-how, use agricultural inputs, generally have access to credit and, particularly in the south of the country, have

261 Luís Cristóvão and Pedro Massinga Jr, "Higher education in Mozambique during covid-19". *Journal of Progressive Research in Social Sciences*, vol. 11, No.1(2021), pp. 1–6.
262 Telma Amorgiana Fulane Tambe and.Lucas Lavo António Jimo Miguel, "Assessing emerging trends of expansion and women enrolments in the higher education system in Mozambique", *Women's Studies International Forum*, vol. 88 (September–October 2021).
263 Ibid.
264 Mott Macdonald, "Good skills lead to good jobs" (n.d.). Available at https://www.mottmac.com/article/37065/skills-for-employment-mozambique (accessed on 13 December 2021).
265 Anna Schnupp, "Is vocational education the fast track to employment in Mozambique?", *WIDERAngle*, May 2020. Available at https://www.wider.unu.edu/publication/vocational-education-fast-track-employment-mozambique (accessed on 7 September 2021).
266 Sam Jones, Ricardo Santos and Anna Schnupp, *Baseline Survey on the School-to-Work Transition of Technical and Vocational Education Graduates in Mozambique* (Maputo, WIDERAngle, 2020). Available at https://www.wider.unu.edu/sites/default/files/Publications/Report/PDF/report-mozambique-baseline-survey-2020-en.pdf.

access to irrigation. They are an important source of employment and notably contribute to technology dissemination and transfer. Their production supplies national markets, the agro-industries and exports.

The main export crops are cotton, cashew nuts, sugar cane, tobacco and tea,[267] yet the export potential of the country is untapped and the domestic market (mainly in urban areas) is increasingly dominated by fresh and processed produce from the SADC region. This is mainly due to the overall lack of integrated value chains, leading to production problems, lack of functional markets and issues related to market information systems, as well as limited access to financial services and credit.

At the national level, the country is virtually self-sufficient in terms of foodgrain production, with the exception of wheat and rice. However, this growth has been uneven spatially and natural disasters such as floods and droughts are a significant cause of temporary food insecurity. The 2000 flood and the 2016 drought, for example, resulted in higher imports of wheat to combat the food deficit. The proportion of the population that was undernourished was 25 per cent between 2014 and 2016 (FAO, 2016). Livestock is also significant with almost 1.3 million cattle and 4.1 million small ruminants in 2010, while in urban areas, beef and poultry provide more than 80 per cent of the meat supply to formal outlets.

The Rovuma Basin has a proven 2,400 billion m3 of gas reserves, with a projected 7.6 million tons of LNG exported per year. Very few of these reserves are provided to local communities, approximately 17,000 tons per year.[268] Nonetheless, in the upcoming years, the substantial increase in gas revenues from the basin will represent an opportunity for pursuing initiatives aimed at supporting local communities, particularly with primary education programmes, maintenance work in schools, oil and gas training initiatives, health-care initiatives, and eventually the creation of jobs locally through focused recruitment and skills training.[269]

Mozambique has committed to achieving the goal of universal access to affordable and sustainable energy by 2030. The PQG 2015–2019 estimated that 55 per cent of the population would have access to electricity by 2019 while the PQG 2020–2024 estimated that it would be 64 per cent by 2024. The achievement of these targets would relieve some of the pressure on the use of firewood and coal, one of the main energy sources used by the population for cooking, mainly in peripheral and rural areas for heating and lighting houses, which in some way contributes to the degradation of the environment and forests in the country. To accelerate the development of and access to electricity for the population that cannot afford to pay market prices, the country has adopted a policy of social tariffs under the Mozambique Energy for All Programme.[270]

Mozambique performs well on use of renewable energy (86 per cent) – well above the sub-Saharan African average (70 per cent in 2015). Despite its energy potential and the previously mentioned ambitious targets, only 24.7 per cent of the total population has access to electricity,[271] mostly due to limited transmission and distribution networks.[272]

Science and technology are instrumental to addressing and possibly solving some of the major challenges the country faces, thus playing a major role in reaching the national development goals.

8.2.3 Relevance of STI to solving these development challenges

Science, technology and innovation (STI) are universally recognized as key drivers for poverty eradication and essential components for achieving the SDGs. In 2019, scientists highlighted the vital role of STI and called for urgent and targeted action in the *Global Sustainable Development Report: The Future is Now: Science for Achieving Sustainable Development*. The history of development shows that no country or region has ever developed without embracing and mainstreaming

267 Food and Agriculture Organization, *Country profile – Mozambique* (2016). Available at https://www.fao.org/3/i9805en/I9805EN.pdf (accessed on 15 July 2021).
268 Eni, "Rovuma LNG: we produce and process gas off the Mozambique coast" (n.d.). Available at https://www.eni.com/en-IT/operations/mozambique-rovuma-lng.html.
269 Interview with Prof Vitória Lunga de Jesus, Technopolis group, 4 August 2021.
270 Mozambique, Ministry of Economy and Finance, *Voluntary National Review of Agenda 2030 for Sustainable Development* (2020). Available at https://sustainabledevelopment.un.org/content/documents/26313VNR_2020_Mozambique_Report.pdf (accessed on 4 August 2021).
271 Michael Kahn, *Mapping Research and Innovation in the Republic of Mozambique*. GO-SPIN Country Profiles in Science, Technology and Innovation Policy, vol. 9, (Paris, United Nations Educational, Scientific and Cultural Organization, 2021), p. 28.
272 Transparency International, "CPI 2020: Sub-Saharan Africa", 28 January 2021. Available at https://www.transparency.org/en/news/cpi-2020-sub-saharan-africa (accessed on 5 July 2021).

STI in its development agenda. In recent years, the Government of Mozambique has undertaken a process of restructuring the STI system, including its governance, institutions, funding mechanisms and deepening achievements in off-grid sustainable energy.[273]

In 2003, the Government of Mozambique, approved the Science and Technology Policy (PCT). Among its key objectives, it includes plans to develop a quality scientific research and innovation system as well as improve the national education and professional training system by building scientific and technological capacities. Three years after the PCT was approved, the Council of Ministers approved the Strategy for Science, Technology and Innovation of Mozambique (ECTIM) which had a 10-year implementation period (2006–2016).[274] The nine objectives listed in the ECTIM included the promotion of innovation and use of science- and technology-based approaches by poor and disadvantaged communities; the promotion of R&D and innovation in the productive sector; and the promotion of technology transfer. The ECTIM was instrumental in proliferating community-based interventions. Furthermore, in the wake of the ECTIM, various types of STI institutions and infrastructure were set up, such as technology parks. The Mozambique Research and Education Network (MoRENet) was also established to strengthen national human and institutional capacities and encourage the creation of synergies between higher education and research institutions.[275] The network includes both public and private academic institutions and research centres. Finally, the country's "Criando os Cientistas Moçambicanos do Amanhã" [Creating the Scientists of Tomorrow] programme was set up to encourage talented students in secondary education. This initiative is a partnership between the Ministry of Science and Technology and the Ministry of Education and Human Development.[276]

Around 15 years after the approval of the PCT and the ECTIM, Mozambique has revised its legal instruments to reflect the current context of research, innovation, and technological development. A tender was launched in April 2021 to review and update the Science and Technology Policy, as well as develop the Strategy for Science, Technology, and Innovation, which will have a 10-year implementation period (2021–2031).[277]

Among numerous strategic areas that the ECTIM identified as in dire need of STI investments to bolster the development of the nation, the priority areas are developing health infrastructure and access to treatments (including HIV and AIDS treatments),[278] developing agriculture, mitigating the consequences of climate change (for example, floods and food insecurity), stimulating economic growth and halving regional instability, conflict and migration.[279]

- **Specific examples of STI initiatives**

One successful example of the STI development focus in Mozambique is in the health sector. Since 2018, the Instituto Nacional de Saúde (National Health Institute) has undergone restructuring; it introduced health-related management, regulation and supervision of scientific

273 Michael Kahn, *Mapping Research and Innovation in the Republic of Mozambique*. GO-SPIN Country Profiles in Science, Technology and Innovation Policy, vol. 9, (Paris, United Nations Educational, Scientific and Cultural Organization, 2021), p. 28.
274 Mozambique, Ministry of Science, Technology and Higher Education, *Terms of Reference for the review and update of the Science and Technology Policy and the development of the Strategy for Science, Technology and Innovation Strategy of Mozambique* (2021).
275 Devex, "Mozambique Research and Education Network (MoRENet)", n.d. Available at https://www.devex.com/organizations/mozambique-research-and-education-network-morenet-123957 (accessed on 13 December 2021).
276 Plataforma dos Cientistas do Amanhã, "Sobre o PCCMA" (n.d.). Available at https://www.pccma.gov.mz/sobre (accessed on 28 September 2021).
277 Ibid.
278 United States Agency for International Development, "Global Health in Mozambique", 17 November 2021.
279 Mozambique, Ministry of Science, Technology and Higher Education, *Mozambique Science, Technology and Innovation Strategy* (2006).

activities, as well as technical and scientific autonomy, with the specific goal of fostering STI solutions to key health problems in the country.[280] Since then, the institute, in collaboration with several public-sector agencies and ministries, international organizations, academia and research centres (with a systemic approach) has already launched eight scientific programmes[281] to create technical and scientific solutions for the promotion and protection of health in Mozambique.

Tangible results include the implementation of policies and evaluation of strategies in the area of health research at local level; the promotion of health research at different levels of care; the conduction of clinical, biomedical, pharmacological, epidemiological, and health-systems research, based on national priorities; the contribution to the development, evaluation and promotion of the use of appropriate health technologies; and the development of human resources, particularly in the professional, technical and scientific area, specifically for health. For example, the women and children's health programme focuses on improving health indicators by identifying the factors associated with the health status of women and children, and their determinants. The environmental health programme develops technological platforms for alerting, responding, researching and teaching to support health public policies.

8.2.4 Impact of COVID-19 in Mozambique

In addition to its existing development challenges, Mozambique experienced significant economic setbacks due to the COVID-19 crisis.

Like many countries in the world, Mozambique declared a state of emergency and went into lockdown to diminish the impacts of the pandemic. The GDP contraction was 1.2 per cent lower than initially predicted in 2020. This was the first decline in nearly 30 years. Mozambique adopted a series of macroeconomic measures aimed at alleviating the economic crisis, including the partial suspension of monetary taxes and introduction of favourable credit lines for companies facing financial difficulties. As at August 2021, such measures are still in place, and the World Bank has recommended that remain in place for the foreseeable future. The World Bank also doubled its commitments to the country from 2020 to 2021 (to US$1.14 billion).[282]

The international community has provided financial support to bolster the country's COVID-19 response. For instance, the European Union has provided €100 million to be invested in education, health and social protection to respond to the crisis.[283] The World Bank has provided grants of over US$200 million since the crisis began, to fund vaccination campaigns and mitigate the impacts on people's lives.[284, 285] The IMF has provided a loan of US$309 million via its Rapid Credit Facility,[286] and additional credit was provided by other institutions.

- **Example of how STI have been successfully used to tackle COVID-19**

As part of its efforts to tackle COVID-19, Mozambique used its innovative health-care platform "PENSA", developed by the National Innovation Fund (FNI) in 2017. Through its website or via cell phone – a service which is free-of-charge – PENSA[287] provides information to citizens on health-related issues, such as symptoms, causes, treatment and prevention of infectious diseases, information on maternal and child health, and the location and contact details of health facilities. In one year, PENSA had over 300,000 visits from 100,000 people.

280 Among its competences, the institute is able to coordinate and supervise the national health agenda and its application; develop laboratories to contribute to solutions for diseases such as malaria; develop and promote – along with the relevant stakeholders – postgraduate education to health students; and finance research activities on the diseases that have the most significant effect on the country.
281 Mozambique, National Health Institute, "Programas Científicos" [Science Programmes], n.d. Available at https://ins.gov.mz/programas/ (accessed on 13 December 2021).
282 World Bank, "The World Bank in Mozambique" (2021a). Available at https://www.worldbank.org/en/country/mozambique (accessed on 13 December 2021)
283 European Commission, "Team Europe: EU provides €100 million to Mozambique for education, health, and social protection", 2 November 2020.
284 World Bank Group, "World Bank injects $115 million to boost COVID-19 vaccination in Mozambique ", 4 June 2021.
285 World Bank Group, "World Bank helps Mozambique mitigate impact of COVID-19 with a new $100 million grant", 22 October 2020.
286 International Monetary Fund, "IMF Executive Board approves US$309 million in emergency assistance to Mozambique to address the COVID-19 Pandemic", 24 April 2020.
287 Mozambique's national platform for health-related information. See https://www.pensa.org.mz/.

These visits were people seeking information on infectious diseases (35 per cent), other diseases (25 per cent), maternal and child health (13 per cent), Alô Vida (the country's COVID-19 hotline) (7 per cent) and health facilities (7 per cent), making "PENSA" a valuable STI tool for providing information about COVID-19, and thereby contributing to the containment of the pandemic in the country.[288]

8.3 STI snapshot

The SWOT analysis below provides the main elements that support or hinder the current STI system of Mozambique.

8.3.1 STI system SWOT analysis

Table 8.1. Strengths, weaknesses, opportunities and threats of the national STI system in Mozambique

Strengths	Weaknesses
• Existence of the National Innovation Fund • Existence of key governmental institutions with a clear mandate in the field of STI such as the Ministry of Sciences, Technologies and Higher Education • Increase in the number of HEIs since the 1990s • Clear improvements in STEM higher education, with the creation of excellence centres, as well as research facilities and innovation hubs	• Outdated STI strategy (2003) • Limited enabling environment for STI development and limited supporting capacities to improve critical challenges (for example, low indicator scores for innovation capability and STI adoption) • Weak innovation ecosystem: limited synergies between universities and industries • Challenging entrepreneurial environment: starting a business is time-consuming and costly (due to bureaucratic obstacles) and entrepreneurs' access to bank credit is rather weak • Weak educational performance, with a small share of the population reaching tertiary education • Lack of widespread awareness of the importance of STI • Limited access to the Internet and electricity • Low share of GDP dedicated to investments in STI • Gender gap among engineering and mathematics graduates in tertiary education • GDP contraction and reduction in foreign investments (in productive sectors such as oil and gas) due to the COVID-19 crisis and terrorism[289] – the resulting economic recession is foreseen to increase the country's public debt

288 Interview with Prof Vitória Lunga de Jesus, Technopolis group, 4 August 2021.

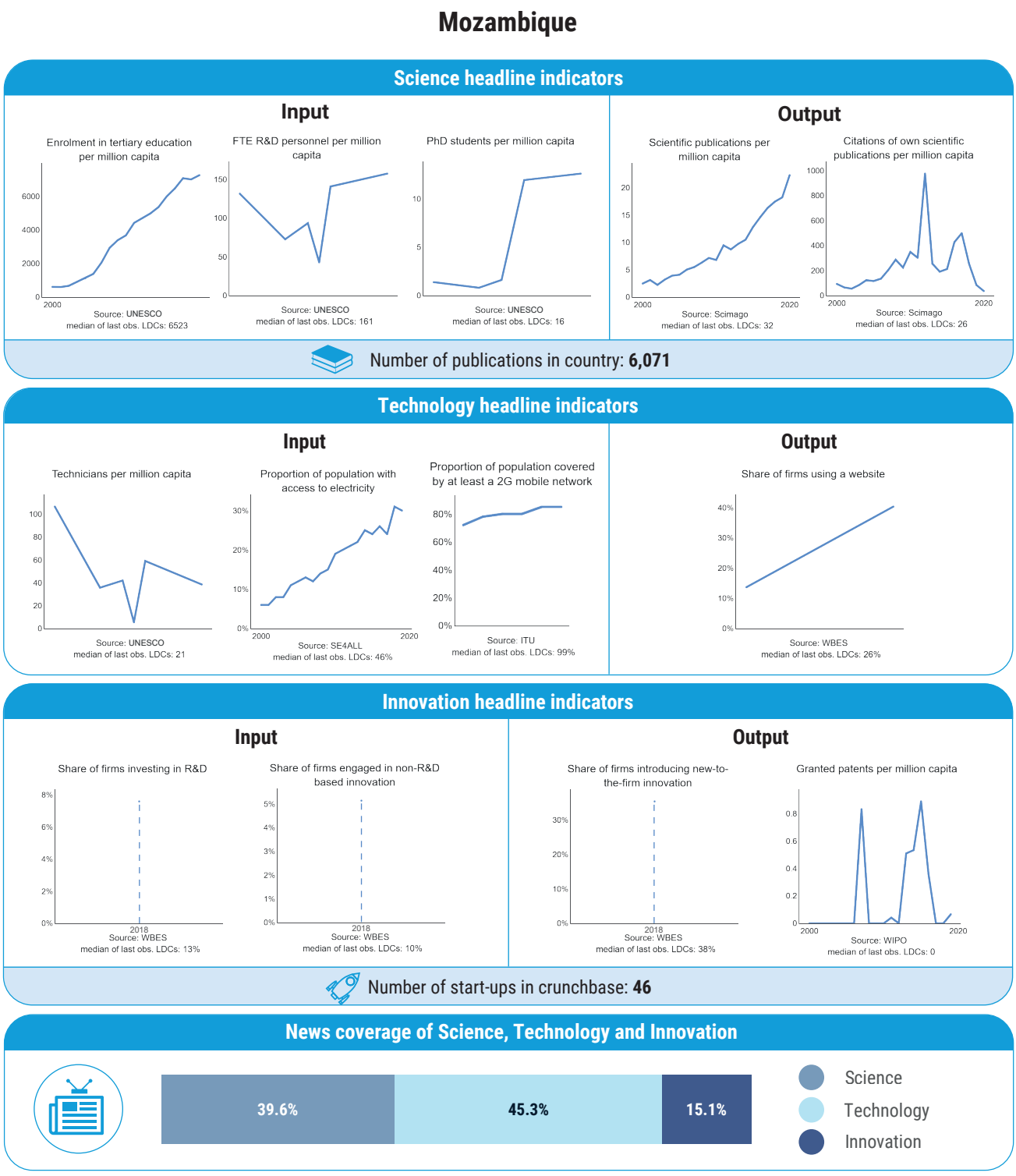
289 Since 2017, the local group loosely affiliated with the Islamic State (IS), known as al-Shabaab (no link to the al-Shabaab in Somalia) has been staging attacks in the northern Cabo Delgado Province, chasing away the central government, as well as the local population. The crisis has so far led to about 2,500 deaths, as well as the displacement of nearly 800,000 Mozambicans. Méryl Demuynck and Gijs Weijenberg, *The Upcoming SADC Intervention: A New Way Ahead to Combat Terrorism in Mozambique?*, 22 July 2021. Available at https://icct.nl/publication/the-upcoming-sadc-intervention-a-new-way-ahead-to-combat-terrorism-in-mozambique/.

Opportunities	Threats
• Growing potential of the STI ecosystem, with signals of growth in the last decade (for example, first incubators, science parks, accelerators providing services for start-ups and entrepreneurs) • Commitment to address the skilled labour shortage by investing in vocational training (especially in productive sectors such as the oil and gas industry) • Efforts to improve national economic governance and improve transparency (establishment of the Central Office for Combating Corruption) • Increase of gas income, given the exploration of the Rovuma Basin gas field • Progress in the field of sustainable energy through the development of renewable energy facilities which offer opportunities for collaboration with the research sector • Growing potential of indigenous innovation, especially using plants to provide solutions in the fields of health and nutrition • Launch of a review to update and modernize the national STI policy framework to provide strategic direction • Willingness of the private sector to access the STI system • Potential of diaspora to unlock greater perspectives for STI developments and increasing investment	• Increasing unemployment rate due to impact of COVID-19 • Booming population with low education (52 per cent aged under 18 years; only 7 per cent have access to secondary school[290]) • High levels of public debt (debt-to-GDP ratio stands at 110 per cent in 2020, according to IMF) • Low levels of STEM research and professional and technical skills, lack of engineering postgraduates, and extremely low level of doctoral graduates • Brain drain and loss of highly skilled graduates • High exposure to climate change and natural disasters

290 Scholaro Pro,"Education system in Mozambique", Scholaro Pro Database. Available at https://www.scholaro.com/pro/Countries/Mozambique/Education-System (accessed on 3 August 2021).

8.3.2 Key features of the STI system

Figure 8.3. Key features of the STI system in Mozambique

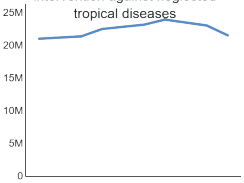


STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)

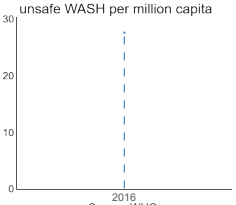
Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita



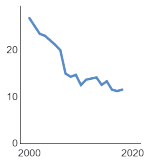
Source: WHO
median of last obs. LDCs: 34

SDG 3.8.2 Share of pop. with large household expenditures on health

Publications 309: 5% of publications **Start-ups in crunchbase** 0: 0% of start-ups

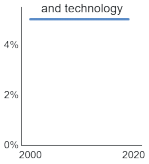
STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy



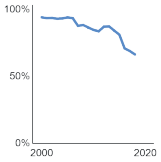
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



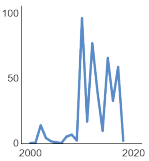
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development

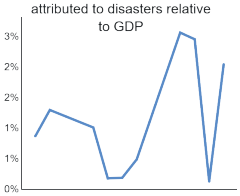


Source: SDGs

Publications 34: 0.6% of publications **Start-ups in crunchbase** 2: 4% of start-ups

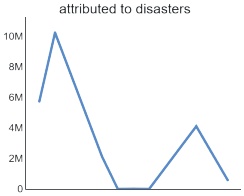
STI & Climate Adaptation

SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP



Source: UNISDR
median of last obs. LDCs: 0%

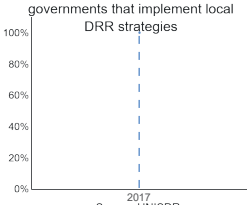
SDG 1.5.2 Direct agriculture loss attributed to disasters



Source: UNISDR
median of last obs. LDCs: 2256933

SDG 13.1.1 Mainstreaming of sustainable development education in curricula

SDG 11.b.2 Share of local governments that implement local DRR strategies

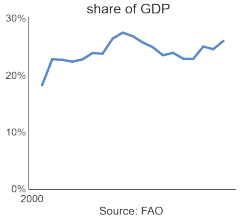


Source: UNISDR
median of last obs. LDCs: 44%

Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

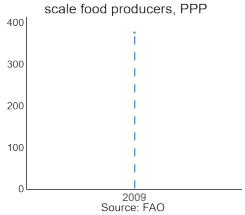
STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP



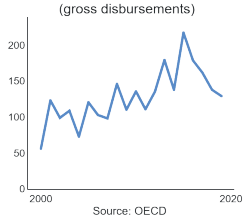
Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP



Source: FAO
median of last obs. LDCs: 714

SDG 2.a.2 Total ODA to agriculture (gross disbursements)

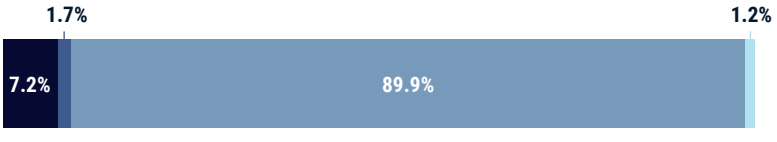


Source: OECD
median of last obs. LDCs: 63

SDG 2.a.1 Agriculture share of Government Expenditure

Publications 29: 0.5% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas



- Agriculture
- Climate adaptation
- Health
- Renewable energy

Figure 8.3 describes the key indicators relating to science, technology and innovation in Mozambique. These data highlight the potential and fragilities of the STI system in the country. Key findings include an increase in the number of graduates, an improvement in the quality of education, and a reliance on the diaspora for investments. The innovation system benefits from a strategy to support indigenous-born innovation.

With regards to the number of researchers, technicians and other personnel in R&D, from 2008 to 2015, there was a significant increase in the number of researchers and full-time equivalent (FTE). The researcher FTE rose from 19.53 per million population in 2008 to 41.48 per million population in 2015. Similarly, the number of researchers increased from 22.85 per million population in 2008 to 86.90 per million population in 2015. Nonetheless, in 2016 and in 2017, it appears that the FTE is declining in relation to the number of researchers. This may be a measurement artefact and warrants further investigation.

There has been a continuous increase in the number of academic publications on the country by Mozambican researchers, which are also relatively well cited. However, the results are well below the average for least developed countries, suggesting difficulties in building research capacities in Mozambique.

Technological progress is hampered by the lack of access to electricity faced by a large proportion of the population despite recent support provided in the form of a national programme to facilitate access to energy and a focus on renewable energy. The low adoption of digital technologies is exemplified by difficulties accessing mobile networks and the Internet. Investments in infrastructure are necessary to support and multiply the efforts of the private sector to use such technologies.

Innovation remains untapped in Mozambique as the country suffers from a lack of formal innovation, illustrated by its very low number of patents. The lack of available data is a possible result of the high informality rate in the country's economy. In the absence of a strong formal economy, it is also practically impossible to establish and benefit from collaborations between research and industry. Despite such issues, Mozambique supports indigenous innovation through its STI strategy as described in the bullet points that follow.

The main sources of data for compiling STI indicators are the survey of inputs to R&D and the Innovation Survey, implemented by the Ministry of Science and Technology and Higher Education:

- GERD was 2.2 billion Mozambican metical (MZN; current) – a modest nominal increase from the MZN 1.6 billion of 2014.
- Continued double-digit inflation implies a decline in the real value of GERD.
- The ratio of GERD to GDP was 0.33 per cent – almost unchanged since 2014.
- Nominal spending on GERD per capita doubled between 2008 and 2017.
- A total of 40 per cent of GERD was funded by foreign entities.
- R&D expenditure by the research institute sector and higher education sector were almost equal.
- Business expenditure on R&D (BERD) varied considerably between 2008 and 2017, falling to a reported low of 1 per cent of GERD.
- Basic research accounted for 29 per cent and applied research, 53 per cent, of GERD, respectively.
- R&D was concentrated in health and biomedical sciences (49 per cent), followed by social sciences and humanities (15 per cent) and agricultural sciences (14 per cent). This concentration reflects the conduct of large-scale clinical trials on infectious diseases (HIV, tuberculosis and malaria).
- Measured by socioeconomic objective, social sciences and humanities comprise 50 per cent of GERD.
- There was a 53-per cent increase in the number of researchers to a total of 3,168 between 2010 and 2016 and a 43-per cent decline in the number of engineering and technology researchers.
- In 2016, 468 researchers held doctorates (15 per cent of researchers) – a twofold increase since 2010.
- The gender ratio for researchers was 70:30 men to women.

Another source of information on STI performance is the Global Innovation Index report, jointly published by World Intellectual Property Organization (WIPO), INSEAD and Cornell University. The Global Innovation Index (GII) has seven categories, namely Infrastructure, Human capital and research, Creative outputs, Knowledge and technology outputs, Business sophistication, Market sophistication, and Institutions. In 2020, the country ranked 124th among the 131 economies featured in the GII 2020, tenth among the 16 low-income group economies, and twenty-first among the 26 sub-Saharan African economies. In the education subcategory, it ranked seventy-second, with funding for education ranked among the highest worldwide. Interestingly, innovation linkages were ranked forty-second. These positive characteristics led WIPO to place Mozambique at the middle rank among the low-income countries. Furthermore, since 2012, with the exception of year 2013, the country has been recognized as an "innovation achiever". Additionally, the data gathered from Mozambique have been recognized for their improved quality. However much of the improvement is the result of increased scientific publications, workforce "diversity" and trademark applications. It must be borne in mind that the GII compiles a mix of objective and subjective measures, making it difficult to ensure quality control of the subjective reporting.[291, 292]

- **Capacity to develop new indigenous solutions**

The ECTIM stresses the importance and role of indigenous knowledge.[293] Indeed, any relevant STI development should take into consideration and seek to be aligned with local contexts and benefit from indigenous knowledge sources.[294] Therefore, Mozambique has a vested interest in encouraging and supporting indigenous knowledge solutions, including, in some cases, their eventual large-scale projection, with the goal of reaching intellectual property rights institutions and commercialization along with bigger businesses. This is also the objective of the "Programa Inovador Moçambicano" (Mozambique Innovation Programme), developed by the Ministry of Science, Technology and Higher Education to support the creation of locally developed solutions for local issues. The programme fostered the development of technological solutions, for example, a machine that shells peanuts, which made local producers more efficient, and an ambulance bicycle that transports people in rural areas who are in urgent need of medical attention to health facilities. Both inventions have registered intellectual property rights. Additionally, in 2008, Mozambique opened its "Centro de Investigação e Desenvolvimento em Etnobotânica" (Ethnobotanical Research and Development Centre – CIDE). The aim of this institute is to facilitate research on existing traditional medicine practices and knowledge in the country, as well as to verify the effectiveness of drugs from natural sources. The centre's research can result in innovations in the national medicine scenario and contributions to the combating of widespread diseases such as HIV, AIDS and malaria. Moreover, the centre seeks to catalogue and register its achievements.[295]

- **Role of diaspora**

As is the case in many sub-Saharan States, brain drain – the loss of human capital – has been a major issue in Mozambique. Since it gained its independence in 1975, it is estimated that approximately 11.7 million Mozambicans have fled the State, many to neighbouring States such as Malawi and South Africa, but also to States on other continents, such as Portugal and the United States of America. Most fled due to security reasons, or in the case of highly skilled graduates, to seek better career opportunities.[296] Therefore, public investments in students (for example, in scholarships to study abroad) are often wasted, and efforts to repatriate skilled professionals are ineffective. Establishing stronger ties with the Mozambican

291 Michael Kahn, *Mapping Research and Innovation in the Republic of Mozambique*. GO-SPIN Country Profiles in Science, Technology and Innovation Policy, vol. 9 (Paris, United Nations Educational, Scientific and Cultural Organization, 2021).
292 World Intellectual Property Organization, *Global Innovation Index 2020: Mozambique* (2020). Available at https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020/mz.pdf.
293 For more information on the ECTIM, please see the section "Governance of the STI system".
294 Mozambique, Council of Ministers, *Estratégia de Ciência, Tecnologia e Inovação de Moçambique (ECTIM)* [Science, Technology and Innovation Strategy of Mozambique] (2021), p. 14. Available at https://www.mctes.gov.mz/wp-content/uploads/2021/07/Estrate%CC%81giadeCie%CC%82nciaTecnologiaeInovac%CC%A7a%CC%83odeMoc%CC%A7ambiqueECTIM.pdf (accessed on 9 September 2021).
295 See https://chuva-inc.github.io/galoa-static-files/doi/tantatinta/1_centro_de_investigacao_e_desenvolvimento_em_etnobotanica.pdf.
296 Martha K. Ferede, *Programme on Innovation, Higher Education and Research for Development. Policy Brief: Engaging the diaspora: potential for sub-Saharan African Universities* (Organisation for Economic Co-operation and Development, n.d.), p. 5. Available at https://www.oecd.org/sti/Engaging%20the%20Diaspora_Ferede.pdf.

diaspora could represent a sound alternative to these strategies.[297] Diasporas unlock great prospects for STI developments and increasing investment. In 2020, for instance, remittances comprised roughly 2.5 per cent of the country's GDP, demonstrating the great financial significance of the diaspora, which could potentially be increased even further.[298]

Mozambique has been taking steps to strengthen its relations with its diaspora. Recently, the diaspora has expressed increased interest in cooperating in various activities launched by ministries in Mozambique (including in STI fields). The State is currently working on the means to turn these opportunities into a beneficial cooperation to facilitate the country's development.[299] If a formal platform for engagement with the diaspora eventually materializes, it could become a relevant source of finances for STI advancements.

- **Governance of the STI system**

The key institution in the governance of the STI system is the Ministry of Science, Technology and Higher Education. This ministry is responsible for the National Innovation Fund (FNI), one of the core instruments for facilitating STI activities, along with the Ministry of Economy and Finance. The FNI aims to promote and finance the dissemination of scientific knowledge, scientific research, technological innovation, and training of researchers, thus contributing to the socioeconomic development of Mozambique. Its partners include the World Bank, UNESCO, and national development finance institutions in Canada, France, Sweden and the United Kingdom, among others. The FNI works towards its mission by issuing calls for research, organizing Science Weeks, facilitating publications and encouraging interactions between researchers (nationally and internationally), among other actions. Other ministries involved in STI activities include the Ministry of Industry and Commerce, the Ministry of Transport and Communication, the Ministry of Sea, Inland Waters and Fisheries and the Ministry of Education and Human Development.

Despite the efforts of the Ministry of Science, Technology and Higher Education and the introduction of the FNI, the GERD in Mozambique is 0.33 per cent of its total GDP – almost unchanged since 2014.[300] The country's focus on infrastructural development is fairly recent, meaning that the STI ecosystem in Mozambique is still evolving. Nevertheless, a defined strategy could be essential to provide clear directions to STI developments. The most recent STI strategy in Mozambique, the ECTIM, dates back to 2003, and needs to be updated, particularly to reflect recent developments in areas linked to the digital revolution and the green economy. The priority of this strategy is to boost economic growth, productivity, and job creation, as well as to strengthen the capacity of institutions to carry out scientific research and technological development.[301] Moreover, this strategy identifies a broad range of innovation areas, such as agriculture, education, sciences, health, energy, fisheries and maritime sciences, water and natural resources management, biotechnology, and tourism, among others. No STI policy document has been published in the last five years, highlighting the need for policy updates. The Government is currently revising the strategy, maintaining the same priority areas of the previous version of the ECTIM but adding further domains such as tourism, culture, climate change and the digital revolution.[302]

Overall, the Mozambique STI system includes some of the public-sector institutions, actors and intermediaries that are necessary to build a functional ecosystem. However, these institutions and actors, including public universities, public research organizations and department-based research institutes, may be operating suboptimally. In light of local and global developments, it is recommended that the STI policy of 2003 be updated, especially in relation to social and economic inclusion, addressing climate change and reinforcing efforts towards achieving the SDGs.

297 Martha K. Ferede, *Programme on Innovation, Higher Education and Research for Development. Policy Brief: Engaging the diaspora: potential for sub-Saharan African Universities* (Organisation for Economic Co-operation and Development, n.d.), p. 5. Available at https://www.oecd.org/sti/Engaging%20the%20Diaspora_Ferede.pdf.
298 World Bank, "Personal remittances, received (% of GDP) – Mozambique", World Bank Database. Available at https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS?locations=MZ (accessed on 20 September 2021).
299 Interview with Sergio Pereira, Ministry of Science, Technology and Higher Education, Technopolis group, 8 September 2021.
300 World Bank, "Research and development expenditure (% of GDP) – Mozambique", World Bank Database. Available at https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=MZ (accessed on 20 September 2021).
301 Ibid.
302 Interview with Prof Vitória Lunga de Jesus, Technopolis group, 4 August 2021.

8.3.3 Resilience of the national innovation system of Mozambique

COVID-19 has somewhat energized STI activities in Mozambique.[303] Certain HEIs and research centres have begun to engage in innovation activities to mitigate the pandemic, for example, production of masks and sanitation products, made using local materials. At the Universidade Eduardo Mondlane (Eduardo Mondlane University), for instance, as well as producing masks, the Faculty of Medicine has taken several actions to contribute to the COVID-19 response. These included studies on COVID-19 seroprevalence among health professionals assigned to hospital units in Maputo; the epidemiological and clinical profiles of confirmed and suspected cases of COVID-19 observed at Maputo Central Hospital; and a study entitled *What does the COVID-19 pandemic mean for HIV, tuberculosis, and malaria control?*[304]

Regarding the impacts of COVID-19 on education, Mozambique has followed the global trend of transitioning to virtual teaching and learning methods, and the Government has provided funds to HEIs to support this transition. Nevertheless, despite the Government having supported this transition, many HEIs faced numerous challenges in its implementation. These challenges mainly resulted from a lack of training of education professionals and students – for example, limited familiarity with the platforms used by the institutions. In this case, many have settled on using common and simpler means of communication, such as WhatsApp, which builds different class dynamics.

Moreover, the lack of infrastructure hindered and delayed this virtual transition. This was found to be the result of limited access to the Internet, or low-quality computers and mobile phones, tools which are essential to remotely engage in lectures.

> **The additional costs of online education were also cited as a challenge in the virtual transition, with many students not being able to afford enough Internet to continue their studies.[305]**

Mozambique needs additional funds to address the impact of the shock to the STI system. The examples presented in this report show that STI can play a significant role in addressing development-related issues, particularly reaching out to and mobilizing the country's population through awareness-raising campaigns. Communication is a key area for development, which could benefit from enhanced STI funds. A good example is the collaboration between the FNI and the Swedish International Development Cooperation Agency in the financing of seven studies on preventing the spread of COVID-19 in the specific socioeconomic context of Mozambique.[306] Research institutions in Mozambique could benefit from further financial assistance for the development of studies, as the FNI cannot afford to fund them all on its own. STI can also play a significant role in climate change mitigation and prevention, as the country is highly exposed to the adverse effects of climate change. Indeed, over the last 35 years there were 75 declared disasters in Mozambique, including 13 droughts, 25 floods, 14 tropical cyclones and 23 epidemics.

303 According to sources from the Ministry of Sciences, Technology and Higher Education.
304 Universidade Eduardo Mondlane, "Faculdade de Medicina e DSS apresentam acções contra a COVID-19" [The Faculty of Medicine and the Directorate of Social Services present their actions against COVID-19]. Available at https://www.uem.mz/index.php/noticias-recentes/1313-faculdade-de-medicina-e-dss-apresentam-accoes-contra-a-covid-19 (accessed on 13 December 2021).
305 Telma Luis Nhantumbo, "Capacidade de Resposta das instituiçoes educacionais no processo de Ensino-apprendizagem face à pandemia de COVID-19: impasses e desafios" [Responsiveness of educational institutions' teaching and learning processes to the COVID-19 pandemic: barriers and challenges]. *Temas Livres em Educação, Psicologia, Sociedade e Ambiente - Reconhecimento, identidades em movimento, conflitos e perspectivas educacionais diferenciadas*, vol. 25, No. 2 (July/December 2020), pp. 556–571.
306 All the studies are in progress and are expected to be published at www.fni.gov.mz as soon as they are complete.

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Interviewees

Cossa, Eugenia Flora. National Director of STI at Ministry of Science, Technology and Higher Education.

Lunga de Jesus, Vitória at the National Research Fund of the Ministry of Science, Technology and Higher Education.

Matangue, Mário at the Agriculture Division, Gaza Polytechnic Institute.

Pereira, Sergio at the Ministry of Science, Technology and Higher Education.

9. Myanmar

Figure 9.1. Least developed country status indicators for Myanmar

Asia
Myanmar

Population
54 million (2020)

LDC status
Met the criteria two consecutive times, but deferred by CDP

Well-being		
Human Assets Index *(composed of six indicators)* 73 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 1% (2017) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 93 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 1,262 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 5% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 1% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 24 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 0% (2019) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 81% (2019) LDC median: 89% *Source: ILO*

9.1 Country profile

Myanmar, formerly known as Burma, is endowed with a wealth of natural resources and a strategic location between China and India. A British colony since 1886, the country gained independence from Britain in 1948. Following a coup d'état staged by the military in 1962, it was ruled by the Armed Forces until the general elections of 2010, when a new government began ushering in a return to civilian rule and brought with it a wave of reforms. This improved its foreign relations.

On 1 February 2021, the military staged a coup and declared a one-year state of emergency. The military coup set back the country's democratic transition and had an immediate negative impact on an economy already weakened by COVID-19.

Economic growth in Myanmar up until the 2000s was mainly driven by natural resource-dependent industries. The country is rich in resources (oil and gas, minerals, precious stones and gems, agriculture, forestry and fishing) and continues to rely on them.

However, from 2010 onwards, the economy has shown signs of diversification. Developments include the expansion of offshore liquefied natural gas fields, large infrastructure investments (upgrading the Yangon-Pyay and Yangon Circular railways, as well as various roads), tourism and manufacturing (mainly garment exports). The Government of Myanmar introduced measures to improve the business environment, curbing corruption and promoting responsible and transparent business practices, and also opened up the services sector. Becoming a member of ASEAN in 1997 gave Myanmar access to a variety of markets and brought the country into regional value chains. Finally, Myanmar benefited from increased access for investment, with FDI growing from around 2–3 per cent of GDP in 2000–2010 to 7 per cent in 2017. The result of these reforms was remarkable economic growth: the economy grew at the rate of 7 per cent annually between 2011 and 2017, placing Myanmar among the five fastest growing countries in the world, and second only to China in the region in terms of historical growth acceleration (although it should be noted that this high rate of growth partly reflects the country's low starting point).[307]

Reaping the rewards of economic and political reforms since 2010, Myanmar was found to meet all three of the graduation criteria for the first time at the 2018 Triennial Review of the List of Least Developed Countries. According to preliminary data, it met the criteria again in 2021. However, the Committee for Development Policy noted with deep concern the state of emergency imposed in Myanmar in February 2021 and, not being able to review the negative impacts of the ongoing situation on the development trajectory of Myanmar, delayed recommendation for graduation until the 2024 triennial review.[308]

Indeed, political instability remains a key fragility in Myanmar. In combination with the impacts of COVID-19, the effects on the economy are likely to be challenging. GDP is predicted to fall by 18 per cent in fiscal year 2021, and the World Bank predicts the economy will be 30 per cent smaller in September 2021 than it would have been were it not for the dual shocks of COVID-19 and the military coup.[309] The ongoing conflict in the Rakhine state have also had a negative impact on FDI inflow, which decreased from 7 per cent in 2017 to around 2 per cent in 2018 and 2019.

Even before the military coup, the history of Myanmar was marred by conflict; it is home to some of the longest and most complex civil wars in the world, many dating from independence in 1948, when rebellions erupted across the country and numerous ethnic groups took up arms.

The same border zones that experience ethnic conflict are also fertile ground for the drug trade: Myanmar is the second-largest producer of the opium poppies used to produce heroin worldwide. A 2021 United Nations Office on Drugs and Crime report[310] on the Myanmar opium trade warned that the interplay between opium cultivation, heroin production and the illicit drug economy has had a clear impact on the conflict situation in Myanmar and the establishment of long-term peace and stability. Climate change is another source of fragility: Myanmar is one of the world's most disaster-prone countries, exposed to multiple hazards, including floods, cyclones, earthquakes, landslides and droughts. Myanmar is in the top three countries most affected by climate change in the period 1999–2018 according to the 2020 Global Climate Risk Index.[311]

9.2 Key development challenges

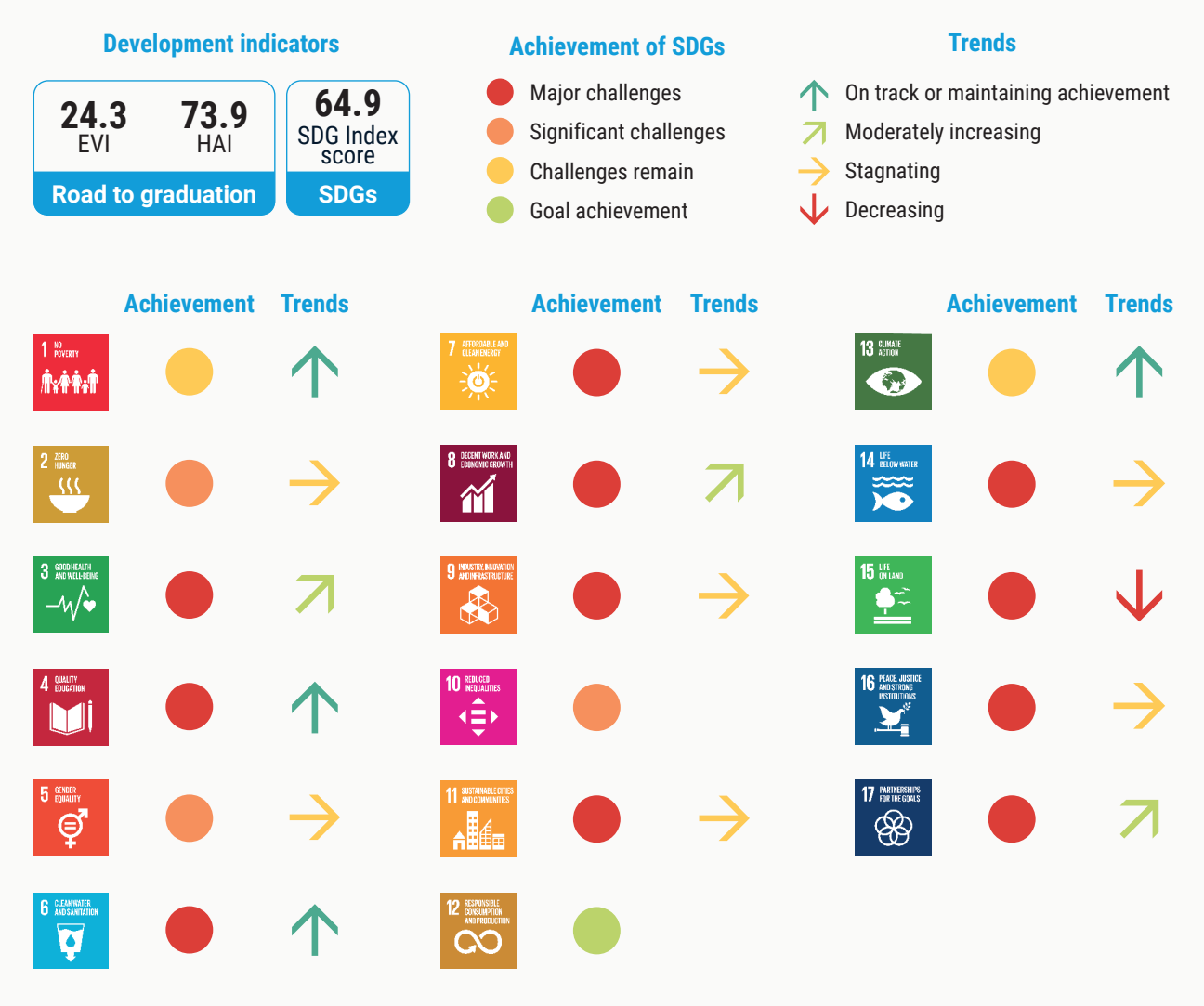
9.2.1 Priorities of the national development agenda

The Myanmar Sustainable Development Plan (2018–2030) provides a long-term vision of a peaceful, prosperous, and democratic country.[312] The plan outlines 28 strategies and 251 action plans, and specifies several cross-cutting themes: equity and inclusion, sustainability in all its forms, conflict-sensitive approaches and democratic principles. Goal 3 of the plan contains several strategies relating to STI and these are outlined in more detail below.

307 World Bank Group, *Myanmar, Economic Transition Amid Conflict: A Systematic Country Diagnostic* (Myanmar, 2019a).
308 United Nations, Committee for Development Policy, *The 2021 triennial review of the list of LDCs* (2021).
309 World Bank Group, *Myanmar Economic Monitor July 2021: Progress Threatened; Resilience Tested* (Washington, D.C. 2021).
310 United Nations Office on Drugs and Crime, *Myanmar Opium Survey 2020: Cultivation, Production, and Implications* (2021).
311 David Eckstein and others, *Global Climate Risk Index 2020: Who Suffers Most from Extreme Weather Events? Weather-related Loss Events in 2018 and 1999 to 2018* (Berlin, Germanwatch, 2020).
312 Pillar 1: Peace and stability (Goal 1: Peace, national reconciliation, security and good governance; Goal 2: Economic stability and strengthened macroeconomic management); Pillar 2: Prosperity and partnership (Goal 3: Job creation and private sector-led growth); Pillar 3: People and planet (Goal 4: Human resources and social development for a 21st century society; Goal 5: Natural resources and the environment for the prosperity of the nation)).

9.2.2 Level of achievement of SDGs

Figure 9.2. Progress on the SDG Index in Myanmar



As shown in Figure 9.2, major challenges remain in Myanmar for 11 out of 17 SDGs, and this is likely to have worsened in recent times. Specifically, Myanmar has significant challenges in terms of health, well-being and sanitation (SDGs 3 and 6), although progress for these is moderately increasing. Furthermore, there are significant challenges in terms of life on land (SDG 15), and progress on this goal is decreasing. Access to electricity is a significant challenge in Myanmar and this has long hampered development; this is addressed in the sections that follow.

- **Agriculture**

Although Myanmar is on track to eradicate poverty by 2030, there are still significant challenges to overcome to reach the goal to achieve zero hunger and malnutrition, and progress towards this goal has stagnated. Agriculture accounts for about 70 per cent of jobs in rural areas and among poor households, but despite having fertile soils and abundant water sources, agricultural productivity in Myanmar is low. For example, one day of work harvesting in Myanmar generates only 23 kg of rice, whereas Thailand and Vietnam achieve outputs of 547 and 429 kg, respectively.[313] Farm practices are labour-intensive, with farmers in Ayeyarwady spending

313 World Bank Group, *Myanmar: Analysis of Farm Production Economics* (Washington, D.C. 2016).

more than 100 days per hectare on monsoon rice paddies, compared with 52 days in Cambodia, 22 days in Vietnam and 11 days in Thailand. Low productivity is a result of multiple factors, often associated with the undersupply of public services such as research and rural infrastructure.[314] Incomes from agriculture have already contributed to at least half of poverty reduction in the last decade and improvements in agricultural productivity would increase this contribution.

- **Climate change and environment**

A heavy reliance on non-renewable assets and irresponsible extraction of natural resources is accelerating environmental degradation in Myanmar. Deforestation is a particular problem and increased significantly when the timber market was opened up to the private sector: it is estimated that 20 per cent of forest cover was lost between 1990 and 2010.[315] For the period 2000–2019, Myanmar was second only to Puerto Rico in terms of being affected by climate change-related natural disasters, which caused an average of 7,056 fatalities and a GDP percentage point loss of 0.80 per year.[316] Forests have a significant role to play in reducing the risk of natural disasters, including floods, droughts, landslides and other extreme events. They are also an important economic and social resource, critical to the culture and livelihood of communities across Myanmar. As such, sustainable forest management (SFM) is crucial in Myanmar.

- **Urban/rural inequalities and access to energy**

Myanmar is one of the few countries in the East Asia and Pacific region where the income of the bottom 40 per cent of the population grew more slowly than the national average (2.0 versus 2.8 per cent annualized growth) from 2005 to 2015. Inequality rose over the same period and was accompanied by steady urbanization, with rural areas lagging in most dimensions of welfare, from stunting and educational attainment to access to electricity and basic sanitation. Improvement in these areas is fundamental for a fair start in life, and for the opportunity to move out of poverty and vulnerability.[317]

In terms of access to energy, initial vast improvements were made from 2005 onwards: in 2005, 50 per cent of households used candles as their main source of lighting, but this plummeted to 7 per cent by 2017.[318] However, in 2019, only 68 per cent of the population had access to electricity, falling to 58 per cent in rural areas[319] – one of the lowest electrification rates in South-East Asia. Although energy-sector reform (including increased supply of clean energy) is one area that Myanmar has the focused on in its climate-mitigation efforts, progress has been limited. One reason for this is that until 2019, regulated tariffs were below costs, which discouraged private investment in the sector.[320] The plentiful water supply in Myanmar means there is great potential for the use of hydroelectricity as an alternative energy source, but development has stalled due to public opposition to its potential environmental impacts (since it could damage the river basin ecosystem) and social impacts (since it would displace villages). The actual impacts on river systems are largely unknown due to a lack of reliable baseline data and post-development information, but smaller-scale impacts (substantial changes to river functions and processes, as well as the loss of unique social and environmental values) are becoming evident. Progress has also been stalled by working in conflict-affected areas, limited natural resource data and limited government capacity and resources.[321]

9.2.3 Relevance of STI to solving these development challenges

Although Myanmar faces significant challenges in agricultural productivity, deforestation and access to energy, several STI-related initiatives have attempted to address these challenges, as discussed below.

- **Agritech to improve agricultural productivity**

The boom in connectivity that occurred in Myanmar when it opened up (from 4 per cent mobile penetration in 2014 to over 80 per cent in 2017) has allowed the development of various digital initiatives targeting farmers' needs in the country. For example, the Htwet Toe app, launched in 2016, addresses farmers' lack of information about

314 Ibid.
315 World Bank Group, *Myanmar, Economic Transition Amid Conflict: A Systematic Country Diagnostic* (Myanmar, 2019a).
316 David Eckstein and others, *Global Climate Risk Index 2020: Who Suffers Most from Extreme Weather Events? Weather-related Loss Events in 2018 and 1999 to 2018* (Berlin, Germanwatch, 2020).
317 World Bank Group, *Myanmar, Economic Transition Amid Conflict: A Systematic Country Diagnostic* (Myanmar, 2019a).
318 Ibid.
319 World Bank Group, "Access to electricity, rural (% of rural population) – Myanmar". Available at https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=MM (accessed on 13 December 2021).
320 World Bank Group, *Myanmar, Economic Transition Amid Conflict: A Systematic Country Diagnostic* (Myanmar, 2019a).
321 International Finance Corporation, *Strategic Environmental Assessment of the Myanmar Hydropower Sector* (Yangon, World Bank, 2018).

proper farming techniques, crop prices and weather patterns. Farmers can use the app to upload photos of their crops and receive diagnoses and remedies from agronomists to improve their productivity – to date, they have provided answers to 100,000 queries.[322] Tun Yat, an online platform launched in 2017, addresses the issue of low-quality physical farming infrastructure by connecting growers with tech-enabled tractors and harvesters. As at September 2021, there were 1,432 farmers using Tun Yat (of which 1,074 are smallholders), which yielded an average saving of US$43 per farmer.[323] The Golden Paddy app was launched to increase the safety and security of the food supply by allowing access to information such as agronomic advice, market prices and weather information.

- **Sustainable forest management**

SFM is largely dependent on the availability of reliable and up-to-date information on the extent and quality of forests, based on periodic monitoring, and there is a clear role for increased use of STI in achieving this. Projects are currently in place to build the capacities of young technicians in the use of new technologies to monitor forests including remote sensing and geographic information systems. Other projects are using innovative approaches in ecosystem monitoring in Myanmar that are sensitive to local conflicts and human rights, particularly important in Myanmar where conflicts are ongoing.[324]

- **Technology to improve domestic and international transport links**

Myanmar has a relatively young population, with those in the 15–29 years age bracket accounting for 40 per cent of the working population. This section of the population – particularly those living in rural areas – need access to the jobs and economic opportunities found in cities, but domestic transport links are outdated and slow. Hitachi, a social innovation organization, is upgrading the signalling system of the railways in Myanmar, a project that when completed will reduce commuting times by 40 per cent. Hitachi is also implementing an electronic data interchange system in the country's ports that will allow ships to enter and leave the port faster and make logistics and terminal handling easier, thereby increasing regional integration with ASEAN countries.

- **Technologies and information communications technology for access to electricity**

> **Only 16 per cent of rural households in Myanmar are connected to the electricity grid, and a lack of access to electricity severely hampers economic development.**

Although diesel generators are available as an alternative option, these are expensive, noisy and create pollution. Many telecommunications towers in rural areas of Myanmar are off-grid and run off these diesel generators: there are currently more than 10,000 off-grid towers in Myanmar that use an estimated 125,000,000 litres of diesel per year, emitting more than 300,000 tons of greenhouse gases. In 2017, a 10-plant pilot scheme was successfully completed in Sagaing Region, whereby 10 telecommunications towers and four villages in off-grid areas were given access to electricity via their solar-hybrid power plants at a price lower than diesel.[325] The pilot is based on a pioneering business model, in which the reliable and clean energy produced by solar-hybrid power plants is used to power off-grid telecoms towers in rural areas. As such, mobile network operators and tower companies are the anchor clients, buying the electricity generated by the hybrid systems on long-term contracts. Distributed generation micro power plants are then set up around such areas, powered by a combination of photovoltaic (PV) solar modules, diesel generators and energy storage solutions, with surrounding communities connected through mini-grids. In this way, the connection is extended to nearby communities, including households, schools, shops and businesses. The model is designed to be commercially viable.

The innovative renewable energy plants will deliver power for the first time to an estimated 25,000 people spread across 175,000 km^2 in the Sagaing and Magway Regions, the Mandalay Division and Naypyidaw Union Territory. Previously, these communities had no choice but to rely on diesel, liquid fuels including kerosene, and candles for their lighting needs.

322 See https://directory.growasia.org/htwet-toe/.
323 See https://tunyat.com.
324 Food and Agriculture Organization of the United Nations, "Towards innovative, conflict-sensitive and human rights-based approaches to forest monitoring", 16 June 2020.
325 See https://www.yomamicropower.com.

The country is also seeing the rapid expansion of grid-connected rooftop solar systems for commercial buildings. The grid-tied rooftop systems reduce commercial and industrial customers' electricity bills with sustainable and green electricity powered by solar energy. Solar power has become a much more viable source of energy in Myanmar due to the rapid reduction in the cost of solar panels and battery storage, in combination with the steep increase in electricity prices in July 2019, which doubled rates for businesses and as much as tripled rates for households.

Given the significant challenges that remain in Myanmar in terms of health and well-being, in addition to the increasing access to the Internet, electricity and mobile phone usage, Myanmar could benefit from the increased use of digital health solutions. Furthermore, 70 per cent of the population lives in rural areas where it is difficult to access doctors. Indeed, the COVID-19 pandemic has accelerated the use of digital health-care solutions in Myanmar, as in many other countries. HOPE Telecare, launched in Myanmar in 2021, is an all-in-one digital health-care platform staffed by volunteer doctors that aims to provide free health-care services to the public. However, digital health and education solutions are clearly dependent on the Internet and although access to the Internet is steadily increasing the country, during the recent political instability there have been mobile data disruptions (and mobile data is the main source of Internet in the country), wider broadband Internet shutdowns overnight and blocks on social media such as Facebook, which is the site most frequently visited on the Internet for many in Myanmar.

9.2.4 Impact of COVID-19 in Myanmar

The pandemic (and its associated containment measures) weakened consumption and investment, and disrupted business operations and the supply of labour.[326] Economic activity was predicted to gradually pick up in the 2020–2021 financial year, but the military coup has prevented this. Myanmar is now experiencing the dual shock of a third wave of COVID-19 – by far its deadliest yet – in addition to the disruption resulting from the military coup of February 2021.

326 World Bank Group, "Myanmar Economic Monitor December 2020: coping with COVID-19", 15 December 2020.

In May 2020, Phandeeyar, a Myanmar innovation lab and information technology hub, launched the Open Innovation Platform "Doh Phandee". The platform was intended to provide concrete and scalable solutions to the issues raised by the COVID-19 pandemic. This was achieved by identifying technical experts – so-called "ZeeKwets" – who use their experience to solve the problems of small- and medium-sized enterprises (SMEs) on the one hand and to help scale the solutions developed so that they can be widely applied in Myanmar on the other.[327] As in many countries, the use of online learning increased during the COVID-19 lockdowns in Myanmar in an attempt to ensure that children and young people could continue learning but the Internet disruptions that have become commonplace since the military coup are hampering these efforts.

During the COVID-19 pandemic and associated lockdowns, there was an increase in gender-based violence. In Myanmar, violence against women is widely perceived as a domestic issue rather than a public issue and 21 per cent of married women in Myanmar have experienced spousal violence. Not only did the COVID-19 control measures put women and girls at greater risk of experiencing gender-based violence, it also made it more difficult for them to seek help. United Nations Population Fund (UNFPA) organized online training on gender-based violence in emergency contexts for Department of Social Welfare safe house and helpline staff. More than 40 participants from across the country took part in this online training, in which they learned practical tips and skills to adapt gender-based violence service provision to the COVID-19 context, including how to take a crisis call, how to carry out safety planning, how to update referral pathways, how to operate safe houses during the COVID-19 pandemic, remote psychological first aid, staff care and self-care, among other skills.[328] Because Internet access in Myanmar is fairly high, online help regarding gender-based violence was accessible to a wide audience.

9.3 STI snapshot

STI is clearly helping transform Myanmar. Section 9.3 takes a deeper look at the STI system that supports this in the form of a SWOT analysis and then examines some key features of the system in more detail.

9.3.1 STI system SWOT analysis

Table 9.1. Strengths, weaknesses, opportunities and threats of the national STI system in Myanmar

Strengths	Weaknesses
• The Myanmar Sustainable Development Plan outlines the role of creativity and innovation in contributing to the development of a modern economy and includes a clear action plan to achieve this.[329] • Pre-February 2021, innovation hubs were beginning to appear. • Unusually, 76 per cent of researchers in Myanmar are women.[330] However, this is likely because the average researchers' salary is not sufficient to support a family, so men seek higher paid employment elsewhere.[331]	• Decades of isolation from regional markets have left global value chains underdeveloped. • The use of technology and innovation remains low in SMEs, making it difficult for them to compete.[332] • State-owned enterprises prevail, with risks of inefficiencies. • Political instability, corruption, an inadequately educated labour force and limited access to financing make doing business in Myanmar difficult.[333]

327 See www.pem-consult.de/news/myanmar-open-innovation-platform-to-meet-economic-challenges-raised-by-the-corona-virus.html.
328 See https://myanmar.unfpa.org/en/news/unfpas-online-training-boosts-capacities-myanmars-social-welfare-staff-provide-gbv-services.
329 Myanmar, Ministry of Planning and Finance, *Myanmar Sustainable Development Plan (2018-2030)* (2018).
330 Susan Schneegans, Jake Lewis, and Tiffany Straza, eds. *UNESCO Science Report 2021: The Race Against Time for Smarter Development* (Paris, United Nations Educational, Scientific and Cultural Organization, 2021).
331 BBC News, "100 Women: Where do women outnumber men in science?", 9 November 2017.
332 Asian Development Bank, *Asia Small and Medium-Sized Enterprise Monitor 2020: Volume I—Country and Regional Reviews* (Mandaluyong City, 2020).
333 Klaus Schwab, *The Global Competitiveness Report 2015–2016* (World Economic Forum, 2015).

- There is a strong presence of women in the tech industry, perhaps because 70 per cent of graduates from computer universities are women.[334]
- The 2014 National Education Law (amended in 2015) emphasized the need for quality assurance at all levels of education.
- The Myanmar Investment Law (2016) lists a variety of tax benefits for investors, with the aim of increasing foreign investment in the prioritized sectors.
- The Myanmar Foreign Investment Law and Myanmar Special Economic Zone Law (2014) entitle foreign investors to special benefits and tax incentives.

- Limited access to markets hinders the growth of SMEs, since they are unable to produce quality products that meet international standards or to deliver their products to relevant markets.[335]
- Venture capital and business angel networks are only nascent.
- Lack of collaboration between researchers and the private sector and limited research funding, especially from the private sector.[336]

Opportunities	Threats
• "Greenfield advantage": with the right technology, Myanmar could leapfrog intermediate stages of development and build a fit-for-purpose economy equipped for the modern world. • Increasing numbers of accelerators and incubators. • Plenty of room for private sector-led growth, helped by the ease of setting up a business and the increasing new business density. • The Myanmar Sustainable Development Plan (2018–2030) advocates for strengthened links between academia, research institutions and the private sector but does not specify any particular measures to achieve this. Concrete action plans would ensure better knowledge-sharing. • Demographic advantage: in 20 years, 67 per cent of the population of Myanmar will be of working age. Investing in youth now by improving STEM education in schools could lead to huge dividends for innovation.	• Political instability threatens to set the country back in terms of STI development, in addition to all other areas of development. • Declining FDI flows.

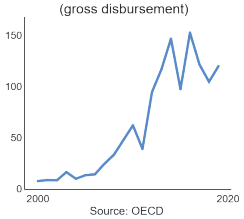
334 Konrad Staehelin, "Why women are driving Myanmar's IT sector growth", *Frontier*, 13 November 2019.
335 Asian Development Bank, *Asia Small and Medium-Sized Enterprise Monitor 2020: Volume I—Country and Regional Reviews* (Mandaluyong City, 2020).
336 Susan Schneegans, Jake Lewis, and Tiffany Straza, eds. *UNESCO Science Report 2021: The Race Against Time for Smarter Development* (Paris, United Nations Educational, Scientific and Cultural Organization, 2021).

9.3.2 Key features of the STI system

Figure 9.3. Key features of the STI system in Myanmar

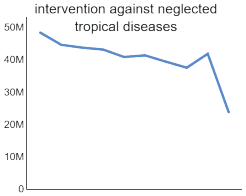
STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)



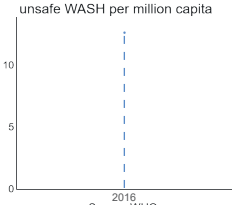
Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



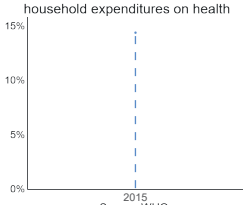
Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita



Source: WHO
median of last obs. LDCs: 34

SDG 3.8.2 Share of pop. with large household expenditures on health

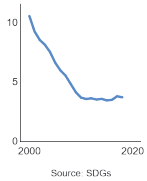


Source: WHO
median of last obs. LDCs: 9%

Publications 171: 2% of publications **Start-ups in crunchbase** 12: 5% of start-ups

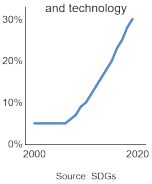
STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy



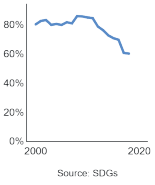
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



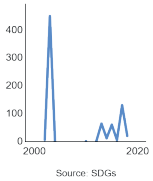
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development

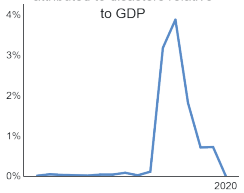


Source: SDGs

Publications 25: 0.4% of publications **Start-ups in crunchbase** 1: 0% of start-ups

STI & Climate Adaptation

SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP

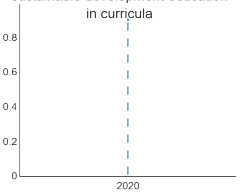


Source: UNISDR
median of last obs. LDCs: 0%

SDG 1.5.2 Direct agriculture loss attributed to disasters

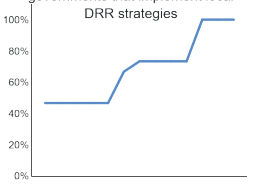
Source: UNISDR
median of last obs. LDCs: 2256933

SDG 13.1.1 Mainstreaming of sustainable development education in curricula



Source: UNISDR
median of last obs. LDCs: 0

SDG 11.b.2 Share of local governments that implement local DRR strategies

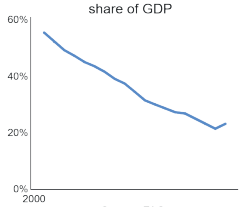


Source: UNISDR
median of last obs. LDCs: 44%

Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP

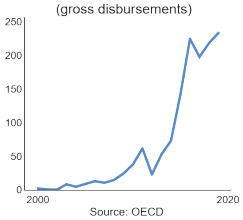


Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP

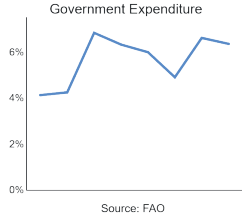
No data available for country

SDG 2.a.2 Total ODA to agriculture (gross disbursements)



Source: OECD
median of last obs. LDCs: 63

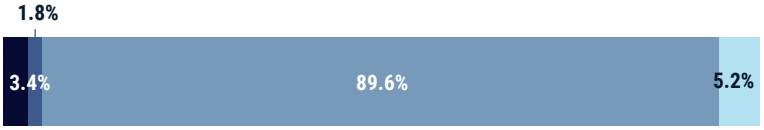
SDG 2.a.1 Agriculture share of Government Expenditure



Source: FAO
median of last obs. LDCs: 4%

Publications 11: 0.2% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas



- Agriculture
- Climate adaptation
- Health
- Renewable energy

As Table 9.1 and Figure 9.3 show, the innovation system in Myanmar is underdeveloped but expanding, supported by a strong sustainable development plan, which is discussed in more detail in a later section. It has a nascent research ecosystem with very little government funding, but rising enrolment in higher education and an increasing scientific output. However, there is a need for more collaboration between researchers and business: for instance, there is little innovation in business, with just 2 per cent of firms investing in R&D; the average for the least developed countries group is 13 per cent). Indeed, Myanmar lags behind other least developed countries across nearly all innovation indicators and support for innovation in the form of incubators, accelerators and investment opportunities is also low. However, there is evidence of grass-roots innovation in Myanmar, particularly in the form of low-cost renewable energy solutions, installed and sustained by local social entrepreneurs and rural communities without government or donor funding. This is discussed in more detail below.

- **Governance**

In 2021, the Ministry of Education (Science and Technology), or MoE-ST, was reformed into two separate ministries: the Ministry of Science and Technology and the Ministry of Education. The newly formed Ministry of Science and Technology now administers the country's science and technology R&D affairs. This was a very positive development that demonstrated that Myanmar has a continuous commitment to STI development.

The Myanmar Sustainable Development Plan 2018–2030[337] is the overarching national development strategy and contains several substrategies relevant to STI development in the prosperity and partnership pillar (with the ultimate goal of job creation and private sector-led growth). In particular, strategy 3.7 seeks to encourage greater creativity and innovation, which will contribute to the development of a modern economy. A series of well-thought-out action plans (along with strategic outcomes, relevant agencies, economic policies, and SDG targets) are identified in this development plan to achieve this strategy.[338] Furthermore, the national Science, Technology and Innovation Law was enacted in 2018. These developments serve as further evidence of the commitment that Myanmar has made to STI development.

Building on the Science, Technology and Innovation Law, an STI policy was developed in collaboration with the UNESCAP, with the aim of making Myanmar the next "Asian Tiger" and supporting sustainable and inclusive development. The policy outlines a range of instruments to achieve outcomes relating to education, research, innovation and synergies between businesses and academia. These include (but are not limited to) developing a national plan for digital education, establishing a national research budget allocation system for research institutes and universities, developing a sectoral National Innovation Plan (NIP) for information and communications technology and developing a benefit-sharing mechanism for research organizations and researchers.

- **Infrastructure**

Innovation support in Myanmar is nascent. The Yangon Innovation Centre is the city's largest innovation hub and offers programmes on investor readiness, some of which target young innovators. In 2020, the Innovation Hub was launched, specializing in developing and marketing of "green" products. The Small and Medium Enterprise Development Agency (SMEDA) sponsors a programme that dispenses technology and offers advisory support (but no financial assistance). Other incubators and accelerators include Impact Hub Yangon, Lithan's TechUP (an accelerator for beginners), Myanmar ICT Development Corporation (which fosters collaboration between the government and private sector), Phandeeyar Accelerator (a six-month programme), Rockstart Impact, SPRING Accelerator (specializes in innovation that helps women and children), and the UMG Idealab incubator.

337 Myanmar, Ministry of Planning and Finance, *Myanmar Sustainable Development Plan (2018-2030)* (2018).
338 Ibid.

Myanmar still lacks sufficient angel investors to invest in start-ups at the seed level, in addition to mentors. A small but focused group of investors include Seed Myanmar (which has made a total of eight investments since 2018), Phandeeyar Accelerator (which has made 17 investments to a total of US$2.4 million), BOD Tech Ventures (which focuses on social and national development as well as tech start-ups), Delta Capital Myanmar (which most recently invested US$7 million in Easy Microfinance) and Myanmar Young Entrepreneurs' Association's Angel Network. Furthermore, in 2019 there were just two angel investment networks in Myanmar. Faircap Angels positions itself as an ecosystem builder and educational organization and has a preference for businesses with women founders and social equality. Ticket sizes range from US$5,000–US$1 million with most deals made between US$20,000 and US$100,000. Myanmar Angel Network has been operating since January 2017 and comprises local and foreign angel investors that finance and mentor start-ups and help to build the community. It invests as a syndicate in seed stages of between US$25,000 and US$250,000.

- **Absorptive capacity**

Absorptive capacity is still very limited in Myanmar, with little evidence of new knowledge assimilation or application. The lack of knowledge assimilation is likely due to a lack of collaboration between researchers and the private sector: all university research funding comes from the government and from abroad – the private sector does not fund research. Additionally, no researchers are employed in the private sector: the government employs 70 per cent of researchers and the academic sector the remainder. There is also very limited evidence of any kind of application of new technologies in the private sector– in 2015, there were zero patent applications per million population.[339]

The majority (90 per cent) of businesses in Myanmar are SMEs (as at the end of 2019[340]), of which 57 per cent are in the food and beverage sector, 9 per cent in construction materials, 7 per cent in mineral and petroleum products, 2 per cent in garments and 26 per cent in other sectors. However, large conglomerates, some with foreign investors, still account for a large part of private-sector activity. The government aims to foster private-sector-led growth, which represents a major change given that State-owned enterprises are prominent, accounting for 12 per cent of GDP in 2018. Despite the recent opening of the economy, decades of isolation from regional markets have left global value chains underdeveloped, and few firms are innovating.

Myanmar scored 3.3 out of 7 on the 2015 Global Competitiveness Index, ranking 131 out of 140 countries. Out of the various pillars that make up this index, Myanmar scored particularly poorly on business sophistication and innovation. The most problematic factors for doing business were listed as access to financing, inadequately educated workforce, policy instability and corruption.[341] However, in terms of the ease of setting up a business, Myanmar ranks fairly highly, at 58 out of 140 countries (in 2020[342]), and the World Bank states that in 2019 it took just seven days to set up a business in Myanmar.[343] Given the key role of SMEs in economic development, this is a positive result.

> **According to Seed Myanmar, technology companies were only recognized as a separate sector in 2017, previously being counted among services firms.**

The use of technology and innovation among SMEs in Myanmar remains low. This is despite the fact that one of SMEDA's three departments is the Technology and Market Promotion Department. E-commerce is dominated by larger established competitors, which made it difficult for SMEs to participate.

339 Klaus Schwab, *The Global Competitiveness Report 2015–2016* (World Economic Forum, 2015).
340 Asian Development Bank, *Asia Small and Medium-Sized Enterprise Monitor 2020: Volume I—Country and Regional Reviews* (Mandaluyong City, 2020).
341 Klaus Schwab, *The Global Competitiveness Report 2015–2016* (World Economic Forum, 2015).
342 Soumitra Dutta and others, eds. *Global Innovation Index 2020: Who Will Finance Innovation?* (Ithaca, Fontainebleau and Geneva, Cornell University, INSEAD and World Intellectual Property Organization, 2020).
343 World Bank Group, "Access to electricity, rural (% of rural population) – Myanmar". Available at https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=MM (accessed on 13 December 2021).

- **Capacity to develop new indigenous solutions**

Myanmar has a long history of locally developed, low-cost renewable energy solutions, installed and sustained by local social entrepreneurs and rural communities over the past 30 years, without government or donor funding.[344] For example, 80 per cent of the 15,000 rice mills in Myanmar run on rice husk biomass gasifiers, a clean form of biomass energy developed within the country. In addition to reducing the cost of electricity, gasifiers help to repurpose the large amount of husk waste produced by rice mills, which would otherwise be discarded and affect the ecology of local rivers. The leading gasifier engineer and manufacturer in Myanmar built his first gasifier 30 years ago and having successfully demonstrated the technology, formed an inventors' cooperative to train local fabrication workshops to manufacture gasifiers. His company has since built and sold more than 700 gasifiers for various agri-SMEs and has also electrified villages and townships with biomass mini-grids. In 2006, he received an ASEAN Energy Award for his biomass gasifier mini-grids.[345]

9.3.3 Resilience of the national innovation system of Myanmar

Myanmar is facing the double blow of COVID-19 and political instability. Estimates suggested that the impact of the COVID-19 pandemic would have raised the national poverty level from 25 per cent to 36 per cent, but if the current political instability continues, it is estimated that this will rise to 48 per cent. As in many countries, the COVID-19 pandemic in Myanmar brought about a flourishing of the digital revolution, with increases in e-commerce, e-learning and e-payments. However, the current political instability has been very damaging, as it is reversing the progress made by the previous government in putting STI on the agenda, with systematic Internet cuts, strikes, and service disruptions holding back the digital advances made during the early days of the pandemic.

344 Hivos, *Accelerating Myanmar's Invisible People Power: Opportunities for Bottom-up Decentralized Renewable Energy in Myanmar* (2021).
345 Ibid.

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Interviewees

Anonymous. Government Official, Yangon.

Anonymous. Legal Professional, Myanmar.

Anonymous. Telecommunications Professional, Myanmar.

Myint Htoo, Nilar. Principal at National Management Degree College, Myanmar.

10. Niger

Figure 10.1. Least developed country status indicators for Niger

Africa
Niger

Population
24 million (2020)

LDC status
Member since 1971

Well-being		
Human Assets Index *(index of education and health)* 35 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 45% (2014) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(index of various State-level risks)* 95 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 528 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 2% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 13% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(index of various economic risks)* 48 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 8% (2017) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 81% (2017) LDC median: 89% *Source: ILO*

10.1 Country profile

Niger is a landlocked State in west Africa that shares borders with two economically strong countries (Algeria and Nigeria), four countries crippled with political instability or insecurity (Burkina Faso, Chad, Libya and Mali), and Benin. About 65 per cent of the land is desertic and difficult to control. Niger has been included in the least developed country group since 1971.[346]

Niger has displayed an economic dynamism over the last two decades with GDP growing at an average annual rate of 9.82 per cent, from US$2.44 billion in 2001 to US$ 13.7 billion in 2021. However, the GNI per capita of US$ 529 (2021) remains one of the lowest across the continent and far below the least developed country graduation threshold of US$ 1.025. Agriculture contributes 42 per cent of GDP, industry 17 per cent and services 41 per cent. Agricultural production in Niger is

346 United Nations Department of Economic and Social Affairs, "Least Developed Country category: Niger profile". Available at https://www.un.org/development/desa/dpad/least-developed-country-category-niger.html (accessed on 15 October 2021).

mainly carried out by small family farms and is geared towards self-sufficiency. This activity provides 80 per cent of employment in Niger. Manufacturing industries, most of which have been established in Niamey, produce chemicals, food products, textiles, farming equipment, and metal furniture. The formal private sector contributes less than 10 per cent of the country's GDP, consisting of a multitude of small local enterprises and large international companies.[347] Uranium and petroleum are the two main natural resources in Niger. The country is one of the world's top 10 leading producers of uranium with a market share of around 7 per cent. Niger became an oil producer in December 2011, with the Agadem field operated by China producing 20,000 BPD. Production could be increased to 110,000 BPD, with internal consumption estimated at 7,000 BPD.

The pandemic, the closure of the borders with Nigeria and the security crises slowed the economic dynamism that Niger experienced in the last decade. In August 2019, to mitigate the smuggling of goods, Nigeria closed its land borders with neighbouring countries, blocking the movement of goods. The country's economic growth fell from 7 per cent in 2018 to 5.9 per cent in 2019 and 1.2 per cent in 2020. The reopening of the border with Nigeria, the resumption of major investment projects (contributing 30 per cent of GDP) and the normalization of supply chains suggest that Niger will experience economic recovery in 2021.[348]

The country's current GNI of US$529 is expected to grow to US$888 by 2026,[349] suggesting that Niger may indeed reach the GNI graduation threshold by 2035. However, Niger is highly unlikely to improve its current HAI of 35.6 or its Economic and Environmental Vulnerability Index of 48.5 within the same time frame, suggesting that graduation based on at least two criteria is out of reach. As a matter of fact, Niger is witnessing a conjunction of crises including regional political instability, terrorist attacks and climate change. It has witnessed periods of democratic transition (1991–1993), political instability and cohabitation (1995–1996), coups d'état (1996, 1999, 2010) and military regimes (1996–1999, 2010–2011). In 2021, the country experienced its second democratic transition. Terrorist attacks on civilians in the region have increased since 2017 despite military assistance from foreign armies. Finally, according to the United Nations and NGOs in the region, about 29 million inhabitants in the region need humanitarian assistance and protection, which puts additional pressure on the government.

Niger should graduate from least developed country status in two stages: a purely technical graduation followed by a "meaningful" graduation.

> **Niger has the sixth-largest reserve of uranium in the world and is in the top 10 leading producers of uranium with a market share of around 7 per cent.**

Since December 2011, Niger has been an oil producer with the Agadem field operated by China and gold mining is booming. Niger could follow the graduation path of Botswana (whose growth was spearheaded by mining extraction) and Equatorial Guinea (whose growth was spearheaded by oil production), to achieve a purely technical graduation based on the income-only criterion. This would not prevent the country from pursuing a meaningful graduation by investing in the necessary structural changes to achieve sustainable human development through the improvement of its HAI and its Economic and Environmental Vulnerability Index.[350]

10.2 Key development challenges

10.2.1 Priorities of the national development agenda

By 2035, the long-term development objective in Niger is to "build a modern, democratic and united country, well governed and peaceful, open to the world, as well as an emerging economy, where the benefits of progress made are equitably shared."[351] To achieve this vision, the government must adopt disruptive trajectories to cope with regional political instability, terrorism, climate change, an education system unable to train the minimally required human capital to modernize and transform the economy, complex tensions over land and

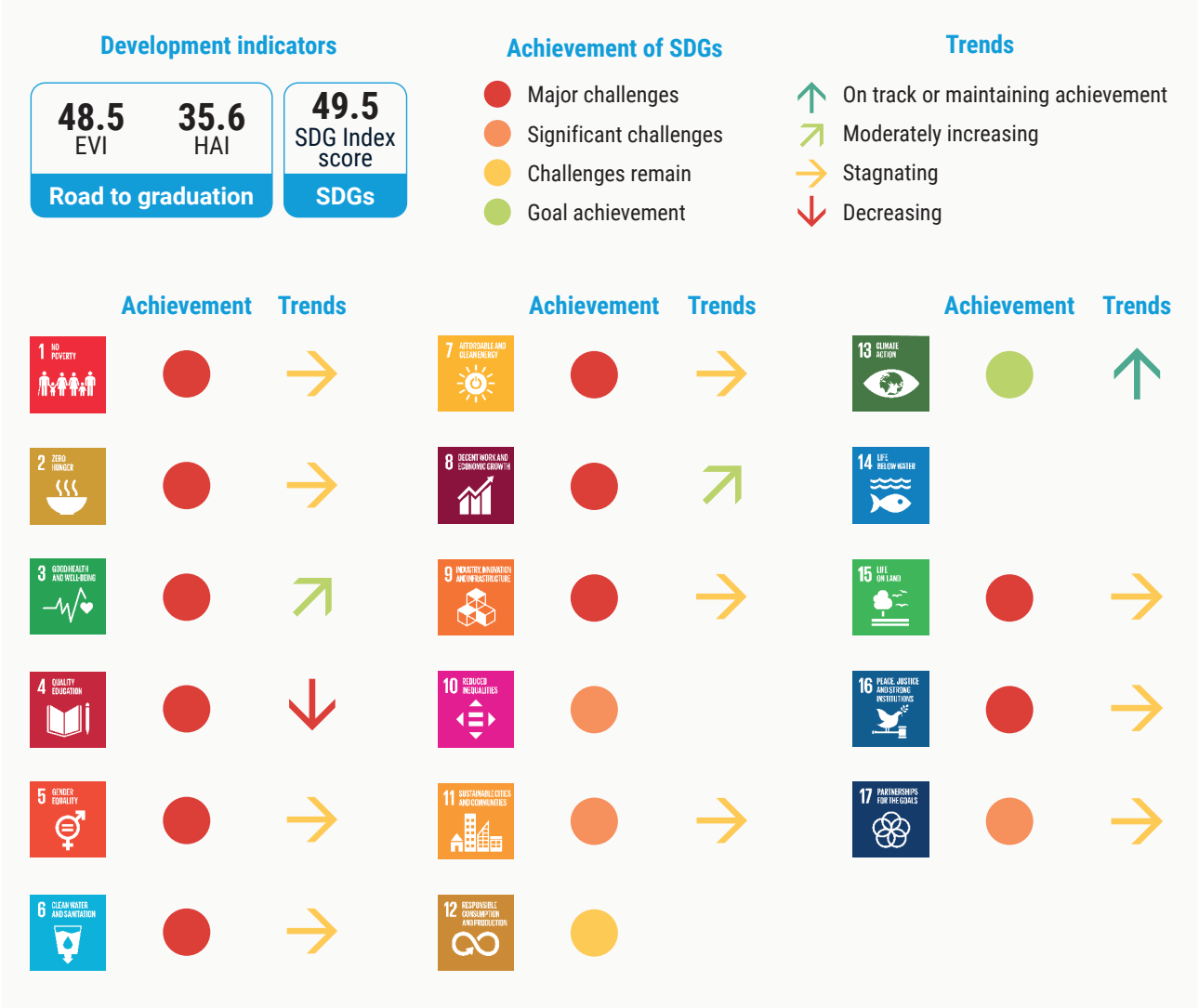
347 African Development Bank Group, *Niger, Country Strategy Paper 2018 – 2022* (African Development Bank, 2018).
348 Statista, "GNI per capita, Country Outlook: Economy – Niger", Statista database. Available at https://www.statista.com/outlook/co/economy/niger (accessed on 5 October 2021).
349 Ibid.
350 United Nations Development Programme, Regional Bureau for Africa, *Graduation of Least Developed Countries* (LDCs): Emerging Issues in a New Development Landscape (2021).
351 Niger, Ministry of Planning, *Niger, 2035: Un pays et un peuple prospères. Tome - I : Diagnostic, Enjeux & Défis. Stratégie de Développement Durable et de Croissance Inclusive* [Niger, 2035: A Prosperous Country and People. Volume - I: Diagnosis, Issues and Challenges. Sustainable Development and Inclusive Growth Strategy] (2017).

natural resources and the creation of jobs in step with the influx of young people entering the labour market.[352]

10.2.2 Level of achievement of the SDGs

Progress is being made on SDGs 2 and 3 since the nutritional status of the population from 2015 to 2020 has improved. This is reflected in the decline of 2.3 percentage points in overall acute malnutrition, and almost 2 percentage points in severe acute malnutrition. In addition, the state of health of the population has improved, leading to a gain in life expectancy at birth of one year from 2016 to 2019. A survey carried out by the National Institute of Statistics (INS-Niger) on the impact of COVID-19 revealed that 97.4 per cent of those who needed health services for another illness were able to seek treatment. The main obstacle to accessing health services when needed is a lack of resources. As regards SDG 8, Niger has shown resilience in the face of various security shocks, a drop in the price of its main export ore (uranium), floods, border closures, climate change and COVID-19. The average GDP growth rate over the period 2016–2019 was 5.9 per cent. Towards the achievement of SDG 13, Niger has adopted strategic frameworks to deal with shocks and other climatic hazards. However, the number of flood victims increased more than fourfold between 2018 and 2020, from 142,715 to 639,870.[353]

Figure 10.2. Progress on the SDG Index in Niger



352 The objectives are: i) a secure country; ii) a modernized State; iii) a significantly increased level of human capital; iv) an effective demographic transition; v) a radically transformed rural sector; vi) a competitive private sector.

353 Niger, Ministry of Planning, *Revue Nationale Volontaire sur les Objectifs de Développement Durable au Niger* [Voluntary National Review on Sustainable Development Goals in Niger] (2018).

This section focuses on the three most pressing development challenges. Peace and security is an enabler for a thriving STI ecosystem, while demographic trends, agriculture and food security all have linkages with several SDGs. For instance, the challenges that result from the rate at which the population increases go hand in hand with good health and well-being, quality education, decent work and economic growth, agriculture and food security and are therefore linked to SDG 1 and SDG 2.

- **Peace and security**

Because of its geographical position, Niger is confronted with considerable security threats on practically all its borders. For instance, the area known as the "three-border region", where the territories of Burkina Faso, Niger and Mali meet, is the epicentre of terrorism in the Sahel region. The economy of Niger is dominated by the rural sector, a major contributor to GDP and export earnings. Agriculture and breeding – the main components of this sector – employ more than 80 per cent of the working population. Both components are severely affected by increased and repeated terrorist attacks. As a consequence, agriculture yields are usually difficult to predict as farmers living in the south find it increasingly difficult to access their fields in the north. In addition, cattle breeders find themselves stranded and thus cannot engage in transhumance. Addressing this threat requires well-thought-out security strategies such as the deployment of national forces and mixed forces (for example, the G5 Sahel Joint Force created in 2017 by five countries: Burkina Faso, Chad, Mali, Mauritania and Niger).

- **Human capital**

The population of Niger, estimated at 24 million people in 2021, is expected to increase to 41.4 million by 2035 and 65.6 million by 2050 (assuming stable fertility and mortality in the next 30 years). The economic capacities (massive job creation, enhanced education level, access to health care) of the country must therefore be aligned with this rate of population growth (3.8 per cent per year) to prevent increased social and political risks and reduced income for the population.

Currently, the level of education and training of the population is insufficient to allow rapid economic development.

> **The education system is facing a deficit in infrastructure: unfinished schools, absence of water points, lack of sanitation equipment, an unstable electric supply, lack of fencing.**

Other issues adversely affecting the education system in Niger include working conditions limiting the appeal of working in the teaching profession and insecurity leading to the displacement of the population. These multiple challenges have consequences (for example, the deficit of physical infrastructure prevents the deployment of digital infrastructure which has a negative impact on digital literacy and access to state-of-the-art teaching equipment such as smart classrooms), which impact the overall quality of the education system[354] and ultimately hamper progress on SDG 4.

Another equally important challenge to address in relation to demographics is the need to transform the health system which is currently characterized by its poor health coverage (51.35 per cent in 2019). Issues within the health system include:

- a lack of quality emergency obstetric and neonatal care
- insufficient human resources
- a poorly managed supply chain for medicines, vaccines, contraceptives and therapeutic food supplies
- poorly maintained equipment and infrastructure
- weak institutional mechanisms to improve the quality of care
- a lack of financing by the State.

Infectious and parasitic diseases such as malaria, pneumonia, diarrhoea, measles, meningitis, cholera, tuberculosis, HIV, AIDS and intestinal worms are still widespread in Niger, as are non-communicable diseases

354 Anne Goujon, Guillaume Marois and Patrick Sabourin, "Deriving Niger's demographic and education future to 2062 with stakeholders: which results?" *Population Research and Policy Review*, vol. 40 (2021), p. 617–627.

such as diabetes, high blood pressure, heart disease, cancer and malnutrition.[355, 356]

- **Agriculture, food security and nutrition**

A large part of the population in Niger is still vulnerable to food insecurity, with 14.5 per cent of households moderately to severely food-insecure and 32.4 per cent at risk of becoming food-insecure. The main drivers of chronic food insecurity in Niger are the recurrent droughts experienced by the country, which have weakened the agro-silvopastoral production systems, resulting in land degradation and low soil productivity; limited resources and capacity to invest in improving agricultural production systems; and the disengagement of the State in structural adjustment measures that have limited input subsidies and advisory support to producers. Despite the vastness of pastureland in Niger, livestock feed is in short supply, creating food insecurity for the more than 35 million heads of cattle estimated to be in Niger. To resolve the issue, farmers exploit areas under cultivation, engage in cross-border transhumance or carry out forced destocking. The consequence of households living on livestock by-products is even greater vulnerability.

10.2.3 Relevance of STI to solving these development challenges

- **Climate-smart agriculture**

Climate-smart agriculture (CSA) technologies and practices present opportunities for addressing climate change challenges, as well as for economic growth and development of the agriculture sector. Some practices already widely employed by farmers in Niger include [357] water spreading bunds and weirs, fertilizer microdosing, and composting. To improve productivity, farmers are using traditional irrigation methods, soil fertility management techniques and conservation agriculture practices. The issue of climate-related impacts on animal feed availability is addressed by using fodder crops and crop residues. Cost-effective natural regeneration is used to restore degraded land, leading to an improvement of cereal crop yields, fodder availability, protection of crops from strong winds and above-ground biomass.

- **Leveraging the digital economy**

The digital economy is an important driver of innovation, economic growth and inclusion in education, health care and finance. Leveraging the digital economy would make education more accessible and would be an opportunity for Niger to decouple population growth from the need to invest massively in building expensive infrastructures. The same holds true for access to health care, through telemedicine and the use of emerging technologies or access to financial services using innovations that change the way that people do business. However, there are important digital infrastructure-related challenges. Like most African countries, Niger has adopted a pyramidal physical infrastructure model, starting with community health workers at the bottom, health posts, health centres, district hospitals, and provincial hospitals and referral clinics at the top. While presenting some clear advantages in term of giving access to the entire population, this system will strongly benefit from digitization with the interoperability of vertical and horizontal health systems, as well as from strengthening and expanding service offerings at the base of the pyramidal system.

To fully leverage the digital economy, it is important that technology is inclusive. However, there are gaps in coverage between urban and rural areas with half of the population not covered by mobile broadband:[358, 359] 76 per cent of Nigeriens have no mobile Internet and 17 per cent face affordability challenges (they have 3G or 4G network coverage but do not use it for many reasons including affordability or lack of digital literacy or electricity). Only 6.4 per cent of Nigeriens are connected to the Internet and are active mobile Internet users.[360] Regarding school coverage, out of the 19,435 schools in Niger (of which 15.70 per cent are secondary schools and 84.30 per cent

355 Niger, Ministry of Health, *Plan Stratégique National de la Recherche en Sante 2013–2020* [National Strategic Plan for Health Research] (2013).
356 United States Agency for International Development, *Health: Niger Fact Sheet* (2021).
357 International Center for Tropical Agriculture and others, *Climate Smart Agriculture in Niger*, CSA Country Profiles for Africa Series (Washington, D.C. International Center for Tropical Agriculture, Bureau for Food Security and United States Agency for International Development, 2020).
358 International Telecommunication Union, *Building Smart Villages: A Blueprint. As Piloted in Niger* (2020).
359 Food and Agriculture Organization of the United Nations, "World Bank provides $100 million to help accelerate digital transformation in Niger", 23 July 2020. Available at www.fao.org/e-agriculture/news/world-bank-provides-100-million-help-accelerate-digital-transformation-niger.
360 Giga, "Country analyses and plans: Niger", presentation, 2021. Available at https://gigaconnect.org/wp-content/uploads/2021/03/Niger-Opportunity-Brief.pdf (accessed on 29 December 2021).

are primary schools), only 80 schools are connected to the Internet. Most primary schools (89 per cent) are in rural areas, and 92 per cent of primary schools have no electricity. According to Central Bank of West African States (BCEAO) statistics, nearly 82 per cent of the working population is excluded from financial services, compared with an average of 45 per cent among States in the West African Economic and Monetary Union (UEMOA).[361] The financial inclusion rate, which estimates the percentage of the adult population holding an account in banks, postal services, national savings banks, the Treasury and microfinance institutions, now including e-money account holders, stood at 17.5 per cent in 2019, compared with the average of 60.1 per cent in the area. The weak financial inclusion performance has been exacerbated by the COVID-19 pandemic which has negatively impacted the delivery of financial services. The opportunity here lies in further developing and leveraging financial technologies, following the examples of countries such as Kenya and Nigeria, for example. While Kenya has managed to achieve a close to 100-per cent financial inclusion with its mobile solution, Nigeria is increasingly positioning itself as a major player in payment infrastructure.

The Niger 2.0 Smart Villages project was launched in August 2018 by the Government of Niger and its partners: International Telecommunication Union (ITU), Food and Agriculture Organization (FAO), UNESCO, WHO and the World Bank, with the goal of expanding Internet access to digitally enabled services in the education, health, agriculture and commerce sectors for rural populations as part of the "Niger 2.0" Strategic Plan to achieve the ambitious goal of 100-per cent coverage. The plan and its structure, for which the National Agency for the Information Society (ANSI) is responsible, comprises four pillars: online public administration services, the creation of an innovation and technology city in Niger, digital promotion and the "Smart Villages" project.[362] One concrete outcome is the modernization of public administration, as described in the next subsection. ANSI is also involved in Giga, a global initiative to connect every school to the Internet and every young person to information, opportunity and choice. ANSI is leveraging this initiative to achieve last-mile connectivity for various essential services such as schools.

- **Modernizing the public administration**

In line with the previous subsection, a new public service portal dedicated to administrative procedures to allow Nigerien citizens to consult 80 administrative procedures, as well as to request a Nigerien nationality certificate, a criminal record, a building permit, or a tax exemption for a company, among other requests, will launch in January 2021. To make the portal accessible to as many people as possible, the site has an audio description of each step with translations into Hausa and Zarma. Funded by the French Development Agency (AFD) with a total of just over 450 million CFA francs (700,000 euros), the design of this digital platform was led by ANSI, in partnership with the High Commission for the Modernization of the State (HCME) and supported with the know-how of the Nigerien start-up ecosystem and the Nigerien diaspora. This portal will facilitate the work of State employees and help improve the productivity, traceability and transparency of administrative procedures carried out by government departments (such as immigration and visa processing or passport issuance) while also facilitating the accessibility and permanent availability of quality public services to users, regardless of their place of residence.[363]

10.2.4 Impact of COVID-19 in Niger

The COVID-19 pandemic has exacerbated already difficult situations in a wide number of economic and social sectors in Niger: health, poverty, markets, mobility, sustainability, nutrition and education.

In 2020, it led to supply disruptions, along with an inflation rate of 2.8 per cent, following a 2.5 per cent deflation rate in 2019. On the demand side, consumption and foreign investments from China and Europe sharply declined. The income per capita dropped by 3 per cent and poverty rose by 1.3 per cent.

> **The closure of schools is expected to lead to higher dropout rates and the number of people living in extreme poverty is expected to increase in 2021.**

361 Central Bank of West African States, *Rapport Annuel sur la Situation de l'Inclusion Financiere dans l'UEMOA au Titre de l'Annee 2019* [Annual Report on the State of Financial Inclusion in the WAEMU for the year 2019] (2020).
362 See https://villagesintelligents.ne/strategie-niger-2-0/.
363 See www.afd.fr/fr/actualites/les-services-publics-du-niger-ont-leur-portail-web.

According to WHO, as at 8 September 2021, Niger had 5,888 confirmed cases and 199 deaths, and as at 28 August 2021, had administered 491,738 doses of COVID-19 vaccines. The health-care system was already fragile before the pandemic struck and had to face several shocks at the same time. Firstly, Niger is a highly malaria-endemic State and is also an endemic State for other tropical diseases, which became neglected with the outbreak of the pandemic. In April 2020, Niger reported new polio outbreaks due to vaccine deprivation, while the nation had just tackled a 24-month outbreak in December 2019. As for the pandemic itself, health-care facilities are reported to be poorly equipped: they lack infection prevention and control measures, patient triage systems and isolation zones. Facing these three shocks simultaneously has put additional pressure on the health-care system.

At the household level, school closures are expected to lead to higher dropout rates. The pandemic has brought economic activities to a halt due to the lockdown and other preventive measures imposed by the Government of Niger, leading to a risk of recession and increased poverty rate. Real growth fell from 5.9 per cent in 2019 to 0.8 per cent in 2020, owing to the pandemic and terrorist attacks. Inflation stood at 2.8 per cent in 2020, fuelled by supply disruptions and speculative behaviour. It is estimated that the number of people living in extreme poverty will increase by 300,000 in 2021.

• The role of STI in the COVID-19 response

The COVID-19 pandemic has tested the health-care and disaster-management systems of Niger and the agility of policy responses to a public health catastrophe. These responses can take many forms including ventilator manufacturing, oxygen production facilities and contactless payments. Niger has focused on enabling access to information to a wide range of the population.

- **Interactive voice response (IVR) to deliver life-saving information amid COVID-19.** The Government of Niger launched the Stop Corona Niger IVR campaign to bring essential social services closer to citizens.[364] The IVR campaign builds on the Niger 2.0 Smart Villages project and BeHe@lthy BeMobile, two initiatives coordinated by ITU and other United Nations organizations. The campaign is a collaborative effort between four telecommunications companies (Airtel, Moov, Niger Telecoms and Orange) and three local digital technology companies (Dev4smart, Novatech and Visicom). The IVR service is easily accessible: users simply call the free-of-charge 701 number, available in five national languages including French, Fulfulde, Hausa, Kanuri and Zarma-Songhai. The 701 service provides information about COVID-19 prevention measures and what to do in case of infection. The breakdown of users by language reflects the campaign's focus on people living in rural and areas, representing more than 81 per cent of the population. Since the start of the pandemic in March 2020, around 95,000 citizens have accessed health advice on COVID-19 either through the IVR platform or by receiving text messages on their mobile devices.

- **A chatbot on WhatsApp to answer COVID-19 queries.** The Government of Niger through the Ministry of Public Health and ANSI, in collaboration with Facebook Inc. and United Nations Children's Fund (UNICEF), launched a chatbot on WhatsApp, an instant messaging service.[365] The goal is to provide users with accurate and timely information about COVID-19 in the country and respond to any related queries. The service is designed to give prompt, reliable and official information 24 hours a day. In addition, several doctors and communicators have been made available to respond directly to any queries.

- **Mapping of health facilities in Niger.** An interactive map of health facilities in the city of Niamey was developed as part of the COVID-19 response to help the population access public and private health centres and pharmacies. Establishments are visible on OpenStreetMap. This map, published on the website of the Ministry of Public Health, will be continuously updated.

364 MyITU, "Interactive voice response: delivering life-saving information amid COVID-19 in Niger", 19 January 2021. Available at www.itu.int/en/myitu/News/2021/01/19/08/29/Interactive-Voice-Response-life-saving-information-COVID-19-Niger.
365 United Nations Children's Fund, "Niger launches a chatbot on Whatsapp to answer COVID-19 queries", 5 May 2020. Available at www.unicef.org/niger/press-releases/niger-launches-chatbot-whatsapp-answer-COVID-19-queries.

10.3 STI snapshot

10.3.1 STI system SWOT analysis

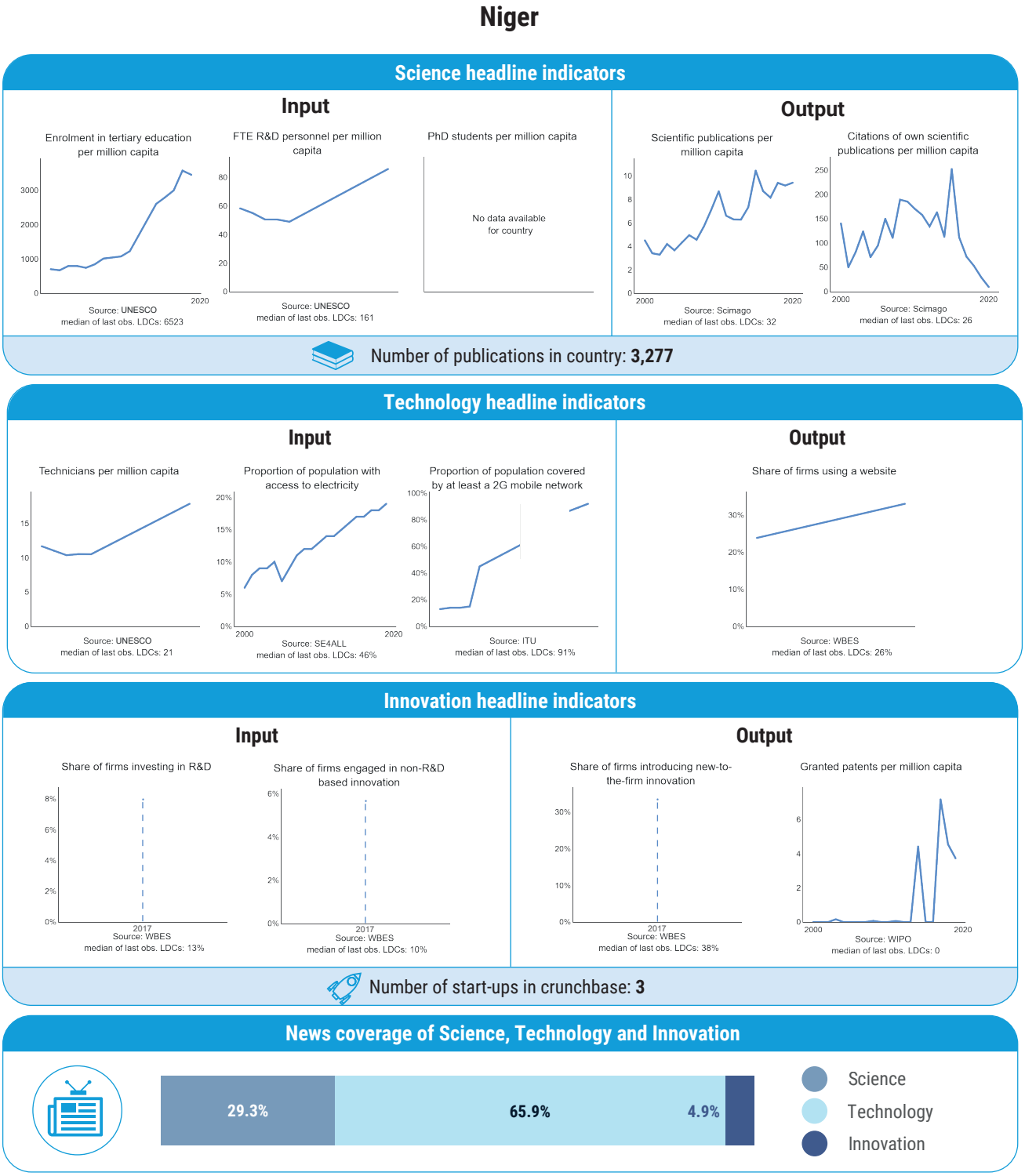
Table 10.1. Strengths, weaknesses, opportunities, and threats of the national STI system in Niger

Strengths	Weaknesses
• Several effective initiatives in progress: implementation of the national STI policy, the Academy of Science and the Centre National de la Recherche Scientifique (National Centre for Scientific Research). • In 2014, the Government of Niger created four new public universities in response to the increased number of youths and to the need to build expertise in a number of priority sectors. • In 2017, ANSI – the public agency responsible for overseeing information technology development in Niger – was created by the Office of the President. • In 2018, the Niger 2.0 Smart Villages project was launched with the goal of expanding Internet access to digitally enabled education, health, agriculture and commerce services for rural populations. • In 2021, the Niger Academy of Sciences was created to mobilize knowledge to facilitate progress, science and technological innovation. • ANSI is involved in Giga, a global initiative to connect every school to the Internet and every young person to information, opportunity and choice. • Good relationships with traditional partners, including China, France, Germany, the Gulf countries and the United States of America, which can facilitate funding and technical expertise, and partnerships to leverage STI. • Growing capacity to develop indigenous solutions.	• The national STI policy has been adopted but not yet published for subsequent implementation. • Most STI institutions and frameworks lack synergies and are working in silos. • Research institutes have constrained financial means, are not part of the entrepreneurial community and do not contribute to innovation. • The education system is facing an infrastructure deficit: unfinished schools, the absence of water points, a lack of sanitation equipment, an unstable electric supply, the lack of fencing; as well as insecurity and working conditions limiting the appeal of working in the teaching profession, leading to the displacement of the population. • Gaps in coverage between urban and rural areas with half of the population not covered by mobile broadband: 76 per cent of Nigeriens have no mobile Internet and 17 per cent face affordability challenges (they have 3G or 4G network coverage but do not use it for many reasons including affordability or lack of digital literacy or electricity). Only 6.4 per cent of Nigeriens are connected to the Internet and are active mobile Internet users.[366] • Out of the 19,435 schools in Niger (of which 15.70 per cent are secondary schools and 84.30 per cent are primary schools), only 80 schools are connected to the Internet. Most primary schools (89 per cent) are in rural areas, and 92 per cent of primary schools have no electricity.
Opportunities	**Threats**
• Productive use of renewable energy potential combined with the pool of international partners can be used to accelerate a low-carbon economy. • Wealth of natural resources (uranium, oil, gold mining), extracted and exported as raw material: an opportunity to add value by leveraging technologies. • Leverage CSA technologies to address adverse climate change effects. • Build refineries and take advantage of technologies to add value. • If properly connected to the higher education ecosystem, the variety of natural resources is an opportunity for smart specialization with a spillover effect on R&D investments as a percentage of GDP. • Important reserves of natural resources attract foreign investments that can support the development of the much needed physical and digital infrastructure.	• Political instability and growing insecurity in the region prevent or delay foreign investments and discourage innovators from piloting their solutions in the country. • Strong dependence on international cooperation to guarantee peace and security in the country, which is a pre-requisite for innovative ecosystems being able to flourish. • Jobs creation must keep up with the increase in the population to avoid a social and political crisis with consequences such as brain drain. • Institutions and policies are in their infancy. • The global trend of limiting carbon footprints is not favourable to investments in fossil resources and investments in oil resources will delay investments in innovative value chains based on renewable energies. • Recurring droughts that are leading to land and soil productivity degradation negatively impact agro-silvopastoral production.

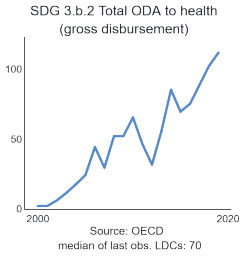
366 Giga, "Country analyses and plans: Niger", presentation, 2021. Available at https://gigaconnect.org/wp-content/uploads/2021/03/Niger-Opportunity-Brief.pdf (accessed on 29 December 2021).

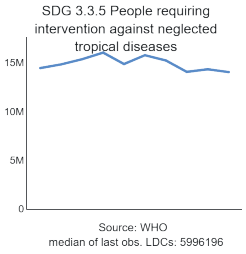
10.3.2 Key features of the STI system

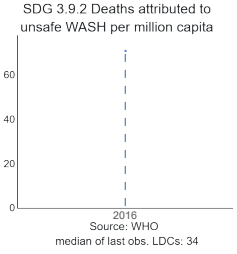
Figure 10.3. Key features of the STI system in Niger

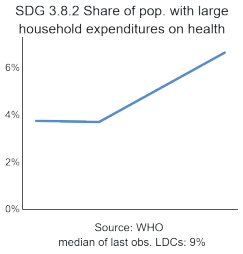


STI & COVID-19 & Health



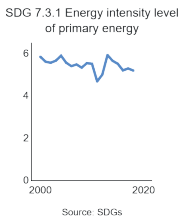


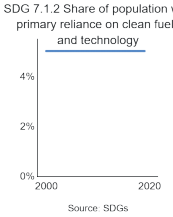


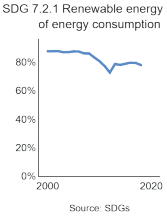


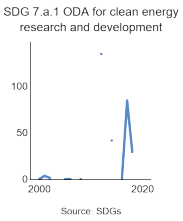
Publications 105: 3% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Clean Energy









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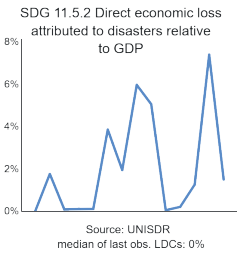
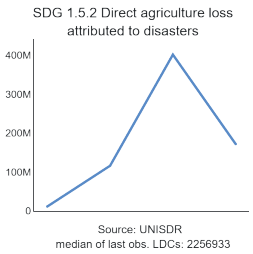
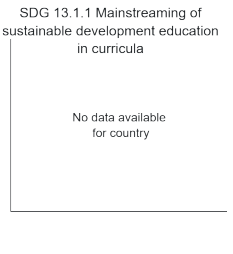
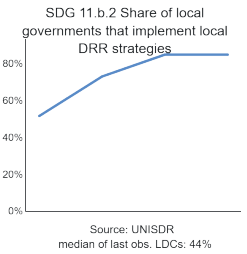
STI & Climate Adaptation



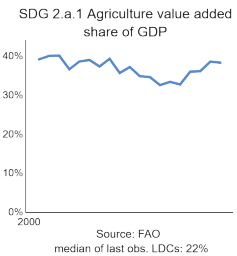


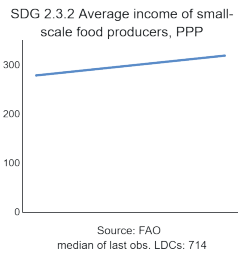


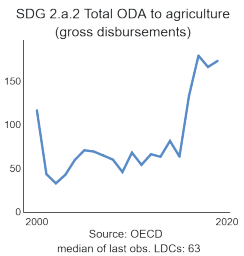


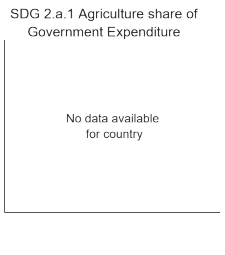
Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Agriculture









Publications 17: 0.5% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas

The STI system in Niger is still under construction. While the government adopted a national STI policy in 2018, the document is not yet available for the public to consult and as such is not yet embedded in Vision 2035. In 2021, the Council of Ministers decided to create the Niger Academy of Sciences to mobilize knowledge to facilitate progress, science and technological innovation. The aim is to bring together highly qualified scientific personalities, to serve as a framework for consultation, for the development of knowledge, and for promoting the culture of scientific excellence.

The government has also adopted several sectoral strategic frameworks, which is indicative of how the country is addressing its more pressing development challenges. For example, Niger has adopted a strategic framework for food and nutrition security and sustainable agricultural development called the 3N Initiative (Nigeriens Nourish Nigeriens), a policy to improve the quality of education (Education and Training Sector Program 2014–2024), the National Health Policy and a Health Development Plan and an ambitious programme to strengthen access to water and sanitation and improve water management. The National Strategic Framework for the Promotion of Youth Entrepreneurship in Niger (2020–2029) was also adopted in 2019 to strengthen the institutional and regulatory system for youth entrepreneurship, skills and capacities, and to improve funding mechanisms.

- **Capacity to develop new indigenous solutions**

The innovation ecosystem in Niger is in its infancy. It is showing signs of having the capacity to develop new indigenous solutions, but the number of use cases remains limited. A conducive ecosystem, which enables replicability and scaling up, is yet to be developed. Nevertheless, some interesting innovations have emerged over the last decade.

Tele-irrigation allows a farmer to remotely control the farm irrigation system using a mobile phone. Tech Innov, created in 2013, is an environmentally friendly digital farm providing smart and remotely controllable irrigation systems allowing farmers to remotely trigger land irrigation and fertilization using their mobile phones, solar panels and sensors. The application can also be voice-activated to make its use easier for those who are not digitally literate. Collected meteorological and hydrological data are further compiled and synchronized to provide a reliable and accurate advisory support service. The company has also developed an R&D programme to create innovative solutions for other sectors including agriculture, breeding, fishing and poultry farming, such as a smart automatic animal watering system that was recently launched.

> **Since 2013, Tech Innov has equipped more than 200 individual or collective farms.**

Since it was awarded Best Social Entrepreneur in Africa by Orange and AfricaCom in November 2011, this innovation is convincing the Heads of State of Smart Africa member countries and is now being adopted regionally. Note that irrigation kits remain relatively expensive for farmers because the kits' components are manufactured in Europe. Therefore, encouraging the local manufacturing of the kits will significantly decrease the costs. Drone Africa Service (DAS), founded in 2017, is another illustrative example of the capacity of local entrepreneurs to develop indigenous solutions. DAS designs civilian drones capable of operating in Sahelian environments under harsh weather conditions and offers its services throughout West Africa (Benin, Burkina Faso and Mali). The company is also aiming to train more designers and to create a Drone Academy in Niger. The drones carry out aerial mapping for precision agriculture, risk and disaster management, anti-poaching activities and environmental preservation, as well as inspecting works and delivering medicines. The African Development University, a private university, just opened a bachelor's degree in AI tailored to local needs while CodeLoccol is a school that teaches programming to Nigerien students, with students learning how to use technologies to address local problems and issues.

- **Governance**

The government has established several institutions that are supporting education, R&D as well as innovation in information and communications technology, agricultural research or entrepreneurial activities.

The National Centre for Scientific Research is a public institution under the Ministry of Secondary and Higher Education and Research and Technology of Niger. ANSI was created in 2017 as a public establishment under the Office of the President. Its mission is to design, supervise, coordinate and evaluate all actions in the development of computing and new information technologies in the public and parastatal sectors at both the national and regional levels. Currently, ANSI is operationalizing the implementation of the national strategy to provide universal access to information and communications technology.

In 2014, the government created four new public universities in response to the increased number

of youths in the population and to the need to build expertise in a number of priority sectors. The University of Dosso is a technology hub for the development of the digital economy. The University of Agadez, located in a region rich in minerals, hosts a Higher Institute of Fossil and Renewable Energy. The University of Diffa, in the Lake Chad Basin, is home to a Higher Institute of Environment and Ecology and a Faculty of Agronomy. The University of Tillabéri has a Faculty of Agronomy. The Faculty of Science and Technology, in Niamey, trains high-level specialists in technological fields. The Abdou Moumouni University carries out agronomy research through several faculties, institutes and laboratories.

The National Council for Agronomic Research (CNRA) created in 2007 has led to the emergence of a national agronomic research system. CNRA assists the government in the development of the national agricultural research policy. The Epicentre research centre in Maradi, registered in 2009, was created in the aftermath of the 2005 food crisis. The National Institute of Agricultural Research (INRAN), created in 1975, has been a public scientific, cultural and technical establishment since 2010. Institutions outside the national agronomic research system include the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the AGRHYMET Regional Center, the International Livestock Research Institute (ILRI) and the Institute for Research for Development.

There is no published national STI agenda. From the previous analysis, it appears that the main research axes include digital transformation, agriculture and food security, natural resources including renewable energies and entrepreneurship as cross-cutting themes. In the absence of a published national STI policy, research and innovation appear to be coordinated at a more decentralized level. For instance, ANSI is organizing the annual national information and communications technology competition "e-TAKARA" to democratize information and communications technology and has been leading the Smart Villages project to connect the administrative areas of 15,000 villages in Niger to digital tools. ANSI is also leading the work to establish a high-technology cluster of key sectors (agriculture, energy, health and education). The fields of research of Epicentre include medical care, epidemic investigation and response, laboratory, data management, quality control, logistics and administrative activities, among others. The staff come mainly from Niger and the countries of the subregion. INRAN designs and executes agricultural research programmes in all areas of rural development and coordinates any agricultural research undertaken in Niger. The Faculty of Agronomy at the Abdou Moumouni University has 11 hectares of experimental land with stables and a henhouse as well as two irrigated plots in Niamey totalling 11 hectares.

> **In general, the national STI policy and regulatory framework in Niger – including financial instruments – is not yet ready or mature enough for the country to fully benefit from STI to address its development challenges. While critical vehicles are conceptualized, their contents are yet to be finalized for actors to be able to use them as guiding tools moving forward.**

The Nigerien STI policy was adopted in 2018 with the support of the African Development Bank (AfDB) and UNESCO. Despite it having been adopted three years ago, the document is not yet publicly available. It is, however, reported that the policy is inspired by the Economic Community of West African States (ECOWAS) Policy on Science and Technology and is intended to help make Niger an emerging economy through the development and use of STI in socioeconomic sectors. This underscores the urgent need to align policy with the needs of the economy and to improve coordination and financing of policy implementation. There are several funding instruments available: the Support Fund for Scientific Research and Technological Innovation (FARSIT, 2010); the Fonds d'Appui à la Propriété Intellectuelle [Support Fund for Intellectual Property] (2010); and the Vocational Training and Apprenticeship Support Fund (2007).

In response to the various development challenges associated with the growing population of Niger, the government has published a national strategy framework to promote youth entrepreneurship. Incubators are key components of this strategy and in recent years four of them have evolved to support business promoters, particularly young people at the various stages of development of their businesses including the SME Incubator Center (CIPMEN), the Abdou Moumouni University incubator centre, Oasis (an incubator for entrepreneurs) and DLCoworking Niger. Since 2014, CIPMEN has incubated 14 start-ups.

- **Instruments**

CIPMEN supports the development of innovative and sustainable entrepreneurship and helps structure the entrepreneurial ecosystem with its pre-incubation, incubation and acceleration programmes focusing on companies in information and communications technology; renewable energies; the environment and agribusiness. CIPMEN initiated the SahelInnov consortium with the objective of improving cooperation

between incubators in the subregion and structuring the Sahelian market.

Initiatives for the Development of Enterprise (IDEE) is a three-year project funded by Italian Agency for Cooperation and Development and carried out by International Organization for Migration (IOM) Niger that aims to increase employment opportunities for young people in Niger by strengthening their technical skills and supporting local businesses, as well as sensitization of the target population to local employment and the creation of entrepreneurial activities as an alternative to irregular migration.

Finally, as part of the implementation of the Niger Renaissance Program, Act 3, the government plans to "integrate 500,000 young people into the labour force". In practical terms, this policy will be implemented through a programme to encourage young people to enter into entrepreneurship, particularly in agriculture, the continuation and intensification of the programme for the promotion of young people in the digital technology space, and the formalization of promising activities initiated by young people, according to the President of Niger.

Funding can be accessed in four ways: subsidies, competitions, microfinance and honorary loans. Subsidies are awarded by projects such as the Sogea-Satom Initiatives for Africa (ISSA), SNV's Youth, Advocacy, Women, Work and Alliances (YAWWA) project for social entrepreneurs, the French Development Agency's Innovative Projects from Civil Societies and Coalition of Actors (PISCCA) programme for entrepreneurs in the field of agriculture and the environment, and IOM's IDEE project for young entrepreneurs. Several projects and programmes financed by the World Bank intervene in the field of entrepreneurship and provide grants to project leaders and entrepreneurs. Examples include the West Africa Agricultural Productivity Programme (WAAPP) that subsidizes entrepreneurs in the agricultural sector, the Climate-Sensitive Agriculture Support Program (PAASEC), the Competitiveness and Growth Support Project (PRACC) and the Skills Development for Growth Project (PRODEC). The Office of Restructuring and Upgrading is also an option for entrepreneurs to obtain grants, investments in equipment and support for capacity-building.

Entrepreneurs can access funds through corporate social responsibility (CSR) initiatives from certain major structures in the market, such as the Orange Social Entrepreneur Prize in Africa, organized each year, the national e-TAKARA competition for project leaders and entrepreneurs in the field of information and communications technology, organized by ANSI, or the Pitch competition for the most innovative companies, established within the framework of the SahelInnov forum. Honorary loans are in their infancy in Niger. The French Development Agency (AFD) is supporting several funds, including two honorary loan options: the Solidarity Fund for Innovative Projects and the PAI fund. Microfinancing is available through certain financial institutions that specialize in granting funds to SMEs. Examples include Asusu, with its MATASSA project, ACEP Niger and mutual societies such as Yarda in Zinder and N'Gada in Diffa.

The Niger STI ecosystem is in its infancy. Several effective initiatives are in place but face operationalizational challenges. Specific examples include the national STI policy – announced but not yet publicly available – the Academy of Science and the Centre for Scientific Research. Governance of this ecosystem is still under construction, which raises some concerns: for example, ANSI is not under the auspices of the Ministry of Information and Culture. The development of robust financial instruments as well as the sustainability of solutions such as e-government are the main areas to work on going forward.

10.3.3 Resilience of the national innovation system of Niger

From the interviews carried out, the pandemic does not seem to have had a tangible impact on the STI system in Niger. There is a general belief and perception that COVID-19 only had a marginal impact on both the health-care system and the economy. It also appears that both the IVR campaign and the WhatsApp chatbot became obsolete as soon as the population became used to the pandemic.

> **The pandemic did not necessarily promote the importance of STI as a vehicle to address the country's development challenges, nor did it speed up its implementation.**

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Interviewees

Garba, Aminata. Senior (Technology) Coordinator at International Telecommunication Union Development Bureau, Telecommunications Network & Spectrum Management Division.

Hamadou, Daouda. CEO at Novatech.

Maina, Fadji Zaouna. Earth Scientist at NASA.

Labo, Mahamadou. Consultant at Labo Consulting.

Lawan, Sarah. Regional Co-operation Advisor, Organisation for Economic Co-operation and Development (OECD) Development Centre, Partnerships & Gender Division.

Sidi Zakari, Ibrahim. Assistant Professor at Abdou Moumouni University, Department of Mathematics and Computer Science.

Tahirou Assane Oumarou, Director of Operations at the Brightline Initiative.

11. Pacific Islands: Kiribati, Solomon Islands and Tuvalu

Figure 11.1. Least developed country status indicators for Kiribati

Pacific Island States
Kiribati

Population
0 million (2020)

LDC status
Recommended for graduation by the UNCDP; ECOSOC decision deferred to 2024

Well-being

Human Assets Index	Poverty level	Fragile States Index
(composed of six indicators)	*(population living on below US$1.90/day)*	*(composed of 12 conflict risk indicators, max score 120)*
81 (2021)	13% (2006)	No data
LDC median: 58	LDC median: 40%	
Source: UNCDP	*Source: World Bank*	

Economic conditions

GNI per capita	Growth of real GDP	Economic growth
(US$ national income over population)	*(% per employed person)*	*(% growth of GDP, projected)*
3,183 (2021)	No data	2% (2022)
LDC median: 854		LDC median: 5%
Source: UNCDP		*Source: IMF*

Economic vulnerability

Economic Vulnerability Index	Unemployment	Informal/vulnerable employment
(composed of eight indicators)	*(% of labour force)*	*(% of labour force)*
51 (2021)	9% (2019)	47% (2019)
LDC median: 39	LDC median: 5%	LDC median: 89%
Source: UNCDP	*Source: World Bank*	*Source: ILO*

Figure 11.2. Least developed country status indicators for Solomon Islands

Oceania + Haiti

Solomon Islands

Population
0 million (2020)

LDC status
Scheduled for graduation in 2024

Well-being

Human Assets Index	Poverty level	Fragile States Index
(composed of six indicators)	*(population living on below US$1.90/day)*	*(composed of 12 conflict risk indicators, max score 120)*
73 (2021)	25% (2012)	79 (2021)
LDC median: 58	LDC median: 40%	LDC median: 88
Source: UNCDP	*Source: World Bank*	*Source: Fund for Peace*

Economic conditions

GNI per capita	Growth of real GDP	Economic growth
(US$ national income over population)	*(% per employed person)*	*(% growth of GDP, projected)*
1,843 (2021)	-10% (2019)	4% (2022)
LDC median: 854	LDC median: 2%	LDC median: 5%
Source: UNCDP	*Source: ILO*	*Source: IMF*

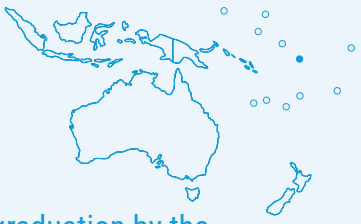
Economic vulnerability

Economic Vulnerability Index	Unemployment	Informal/vulnerable employment
(composed of eight indicators)	*(% of labour force)*	*(% of labour force)*
45 (2021)	1% (2013)	
LDC median: 39	LDC median: 5%	No data
Source: UNCDP	*Source: World Bank*	

Figure 11.3. Least developed country status indicators for Tuvalu

Oceania + Haiti

Tuvalu



Population
0 million (2020)

LDC status
Recommended for graduation by the UNCDP, under consideration by ECOSOC

Well-being

Human Assets Index	Poverty level	Fragile States Index
(composed of six indicators)	*(population living on below US$1.90/day)*	*(composed of 12 conflict risk indicators, max score 120)*
82 (2021) LDC median: 58 *Source: UNCDP*	3% (2010) LDC median: 40% *Source: World Bank*	No data

Economic conditions

GNI per capita	Growth of real GDP	Economic growth
(US$ national income over population)	*(% per employed person)*	*(% growth of GDP, projected)*
6,656 (2021) LDC median: 854 *Source: UNCDP*	No data	4% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability

Economic Vulnerability Index	Unemployment	Informal/vulnerable employment
(composed of eight indicators)	*(% of labour force)*	*(% of labour force)*
57 (2021) LDC median: 39 *Source: UNCDP*	8% (2016) LDC median: 5% *Source: World Bank*	No data

11.1 Country profiles

The economies of these three Pacific islands are characterized by resource-based industries and very few factories, resulting in a low proportion of private employment. Due to their small size and their spread-out nature, the three islands have large exclusive economic zones. The economies of Kiribati and Tuvalu are centred on fishing. Training centres available in this area of expertise include the Marine Training Centre in Betio. Those who work in fishing occasionally work abroad, and therefore occasionally provide remittances.[367] However, a lack of institutional and legal resources means the fishing sector is not fully controlled, and unlicenced fishing results in large revenue losses. All three islands have difficulty managing their natural resources, which are already very limited. A large proportion of incomes come from abroad, in the form of development assistance, worker remittances and tourism. The islands are also dependent on imported primary goods, which makes them highly vulnerable to external shocks such as financial crises or the COVID-19 pandemic.

Between 2011 and 2020, the three Pacific States implemented the International Plan of Action (IPOA). This resulted in increased economic growth and reduced income poverty in the region. However, of the three States, only Solomon Islands became eligible for graduation to the middle-income country group in 2024, since it reached the thresholds on GNI per capita, the HAI, and the Economic and Environmental Vulnerability Index (EVI). Kiribati and Tuvalu were nonetheless recommended for graduation by the UNCDP and are under consideration by ECOSOC.[368] They also both met the GNI threshold of US$1,222 at the 2021 triennial review. This delay in graduation is due to the major challenges these small States faced in the implementation of the IPOA that stem from their various vulnerabilities. Even after they graduate, these countries will have to consider their climate vulnerability to build resilient economies.

These three microstates have common constraints imposed by their land area, geographic dispersion across the ocean, remoteness from major markets, high vulnerability to climate change and sea level rise, and scarce natural resources. In 2014, the Government of Kiribati bought 5,500 acres of land in the Natoavatu Estate in Fiji[369] to prepare for future population displacement due to sea level rise. Today the land is being used for agriculture. The phenomenon is the same in Tuvalu: as early as 2001, the Government of Tuvalu announced that the islands, whose highest point is 5 m above sea level, would have to be evacuated in the event of a rise in the sea level, which is highly probable due to general global warming.[370] In Solomon Islands, five of the islands have already disappeared due to rising sea levels and coastal erosion, and six other islands are heavily affected. In addition, access to fresh water is particularly challenging, particularly jeopardized by population growth, saltwater intrusion and droughts.

11.2 Key development challenges

11.2.1 Priorities of the national development agendas

The three microstates have also developed parallel national strategies set out in Table 1. The respective priorities also correspond to parts of the United Nations Pacific Strategy (UNPS) 2018–2022,[371] which is a five-year strategic framework that outlines the collective response of the United Nations system to the development priorities in 14 Pacific Island States and territories and supports governments and peoples in the Pacific to advance a localized response to the global 2030 Agenda for Sustainable Development.

367 Asian Development Bank, *Tuvalu: Maritime Training Project*, Validation Report, PVR-251 (2013). Available at https://www.adb.org/documents/tuvalu-maritime-training-project.
368 United Nations Department of Economics and Social Affairs, *The LDC Category After the 2021 Triennial Review* (2021a). Available at https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/LDC-category-2021.pdf. United Nations Department of Economics and Social Affairs, The LDC Category After the 2021 Triennial Review (2021a). Available at https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/LDC-category-2021.pdf.
369 James Ellsmoor and Zachary Rosen, "Kiribati's land purchase in Fiji: does it make sense?" *Devpolicy Blog*, 11 January 2016.
370 Christopher Pala, "Kiribati and China to develop former climate refuge in Fiji", *The Guardian*, 23 February 2021.
371 United Nations in the Pacific, *United Nations Pacific Strategy 2018-2022. A Multi-country Sustainable Development Framework in the Pacific Region* (2017).

Table 11.1 Common priorities of national plans, and their link with the United Nations Pacific Strategy outcomes

Development plans	Kiribati Development Plan 2016-2019 (KDP)[372]	Solomon Islands National Development Strategy 2016-2035 (NDS)[373]	Tuvalu Te Kakeega III National Strategy for Sustainable Development 2016-2020[374]	United Nations Pacific Strategy outcome
New development plans since the United Nations Pacific Strategy report	Kiribati 20-year Vision 2016-2036 (KV20)		Te Kete 2021-2030	
Priorities	Key Priority Area 4: Environment Key Priority Area 5: Governance	NDS Objective 4: Resilient and environmentally sustainable development with effective disaster risk management, response and recovery	Strategic Area 1: Climate Change Strategic Area 8: Natural Resources Strategic Area 12: Oceans and Seas	Outcome 1: Climate Change, Disaster Resilience, and Environmental Protection
				Outcome 2: Gender Equality
	Key Priority Area 2: Economic Growth and Poverty Reduction	NDS Objective 1: Sustained and inclusive economic growth NDS Objective 2: Poverty alleviated across the whole of the Solomon Islands, basic needs addressed and food security improved; benefits of development more equitably distributed to Solomon Islanders	Strategic Area 3: The Economy – Growth and Stability Strategic Area 5: Falekaupule and Island Development Strategic Area 6: Private Sector, Employment and Trade Strategic Area 11: Migration and Urbanization	Outcome 3: Sustainable and Inclusive Economic Empowerment
	Key Priority Area 1: Human Resource Development Key Priority Area 3: Health	NDS Objective 3: All Solomon Islanders have access to quality health and education	Strategic Area 7: Education and Human Resources	Outcome 4: Equitable Basic Services
	Key Priority Area 5: Governance	NDS Objective 5: Unified nation with stable and effective governance and public order	Strategic Area 2: Good Governance	Outcome 5: Governance and Community Engagement
				Outcome 6: Human Rights

Source: United Nations in the Pacific (2017).

372 Kiribati, Ministry of Finance and Economic Development, *Kiribati Development Plan 2016-2019* (2016).
373 Solomon Islands, Ministry of Development, Planning and Coordination, *National Development Strategy 2016-2035. Improving the Social and Economic Livelihoods of all Solomon Islanders* (Honiara, 2016).
374 Tuvalu, *Te Kakeega III, National Strategy for Sustainable Development 2016 to 2020* (Funafuti, 2016).

However, the three States also have specific national development agendas. For example, Kiribati and Tuvalu also include sections on gender equality (outcome 2 of the UNPS 2018–2022) in their national plans: KPA 5 for Kiribatu and Strategic Area 3 for Tuvalu. Tuvalu also recently replaced its national strategic plan with a new one called Te Kete (2021–2030).

11.2.2 Level of achievement of SDGs

Despite common challenges and opportunities, for instance in the areas of SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 5 (gender equality), SDG 9 (industry, innovation and infrastructure), SDG 15 (life on land), the three States face some dissimilar trends in terms of progress towards the SDGs. Data on SDGs achievement is more complete for Solomon Islands.[375]

Figure 11.4. Progress on the SDG Index in Kiribati

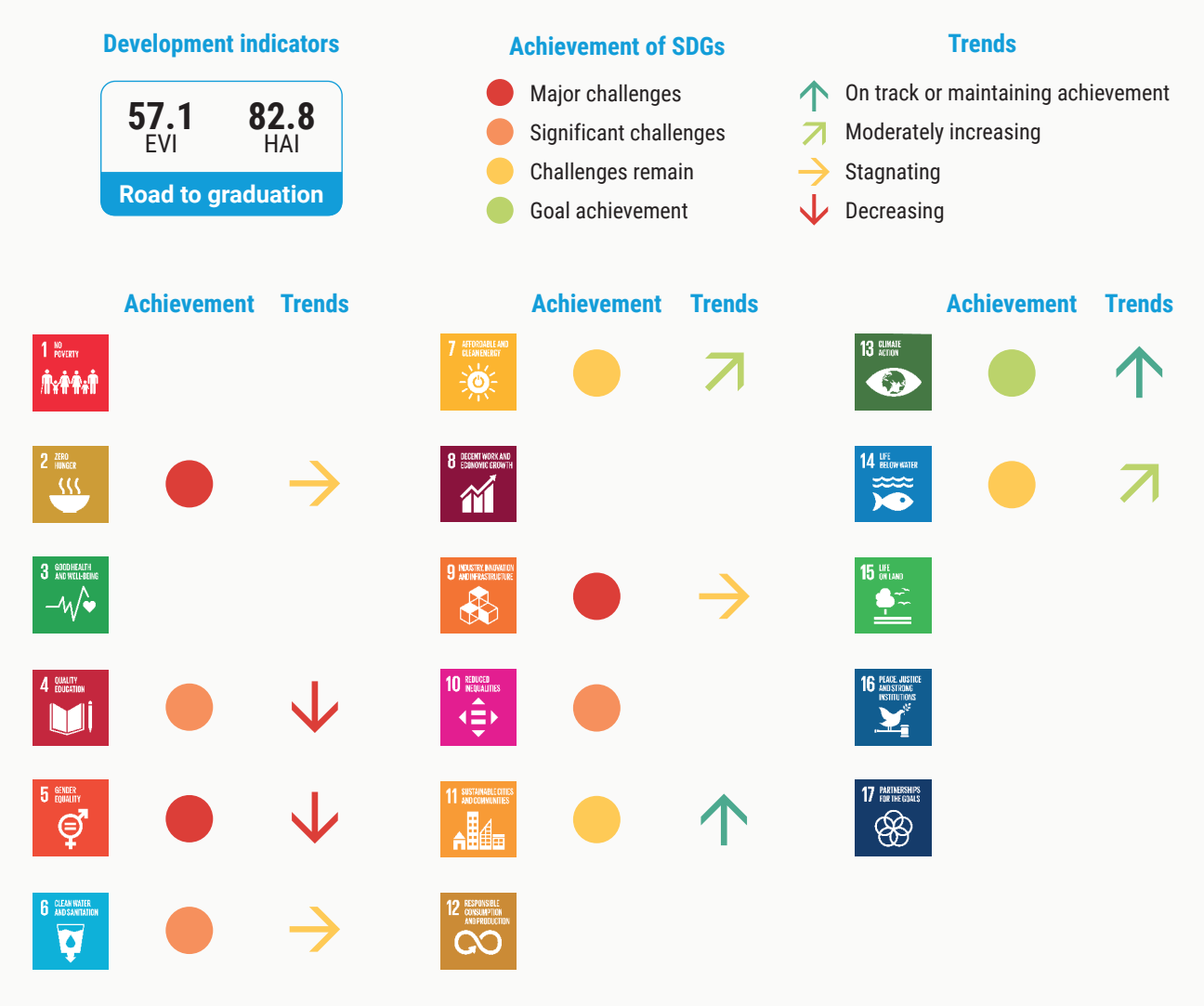
375 However, the structural challenges that the States studied face in gathering data prevent a complete overview of the trends.

Figure 11.5. Progress on the SDG Index in Solomon Islands

Progress on climate action is well under way in the region and in the three States, especially in terms of advocacy. Other upward trends include the affordability of and access to clean energy (SDG 7) and good health and well-being (SDG 3), despite starting from a low point. However, food security (SDG 2) remains a challenge in the three States, as well as industry, innovation, and infrastructure (SDG 9). Quality education is an ongoing challenge and has worsened in Solomon Islands and Tuvalu in recent years, coupled with a stagnation in gender equality in all three States. Solomon Islands faces difficulties with stagnating or downward trends in achievement of quality of life on land and below water and in water cleanliness and sanitation.

This shows common challenges that the three islands are facing, particularly in the field of climate change and the environment linked with natural resources and energy management, and in the field of productivity, jobs and a stable economy, as well as the development of an accessible and reliable health system.

Figure 11.6. Progress on the SDG Index in Tuvalu



- **Climate change and environment**

Kiribati, the Solomon Islands and Tuvalu face are at great risk of experiencing climate-related disasters in the coming years, due to their geographical position. Solomon Islands is currently the fifth most at- risk country in terms of forced displacement and migration due to extreme natural events according to the World Risk Index 2020[376] (Kiribati is eighteenth and Tuvalu is not ranked). The three States signed the Framework for Resilient Development in the Pacific 2017–2030, which identifies goals to enhance the resilience to climate change in the Pacific Island States. The action plan covers various stages of climate action, from disaster preparedness to response and recovery. It includes several aspects related to STI, such as:

- the provision of support through technology transfer from developed countries and partners tailored to the Pacific Island States' needs and priorities
- the strengthening of the effective use of science, technology and knowledge management (including risk assessment tools) to understand underlying drivers and to inform disaster risk reduction and climate change adaptation, loss and damage; and support the application of new technologies and innovative solutions
- strengthening effective multi-hazard early warning systems including for sudden and slow onset hazards and the use of science and technology

376 Benedikt Behlert, and others, *World Risk Report 2020, Focus: Forced Displacement and Migration* (Bündnis Entwicklung Hilft and Ruhr University Bochum – Institute for International Law of Peace and Armed Conflict (IFHV), 2020).

to inform risk management and hazard/disaster preparedness and policy development.

Other regional initiatives also emerged, such as the Pacific Climate Change Centre. The regional actions have started to show encouraging signs in some areas: the Pacific Island States have exceeded the target of the Convention on Biological Diversity for area-based protection of marine spaces.

However, despite growing advocacy on the subject and a regional approach to climate action, these States are still have limited institutional and financial capacity to implement and monitor the various plans put forward. The financial and technical means available to them are insufficient to act on and prepare the territories for the rapidly increasing effects of climate change. On some islands, climate change effects have already started to transform the land and the economies. According to the Intergovernmental Panel on Climate Change regional fact sheet, there is already a drying trend in the region, coupled with heavy rainfall events that inundate the territories.[377] Waste production in the rest of the world is also creating massive pollution in the Pacific Island States, which in turn must adopt innovative local legislation to confront the increasing environmental pollution. The water is becoming increasingly polluted with mercury, a toxic metal that is absorbed into the flesh of tuna fish, which in turn are eaten by the local populations that rely on the fishing economy.

377 Intergovernmental Panel on Climate Change, *Regional fact sheet – Small Islands* (2019).

- **Natural resources and energy**

A large proportion of public spending is directed towards energy consumption, with some Pacific islands spending as much as 10 per cent of their GDP on imported petroleum,[378] which remains the major source of energy for the inhabitants. Pacific Island States engaged in the definition of a regional but also national strategies to tackle the energy transition. The workplans provided under the Paris Agreement emphasize the need for the electrification of the region. However, as in other domains, financing the energy transition remains a challenge, given that building a new system for energy generation has significant start-up costs. Financing was the weakest point for Small Island Developing states (SIDS)[379] in terms of readiness for the energy transition.

- **Health inequalities and well-being**

Pacific Island States face a three-pronged challenge in the field of health:[380] communicable diseases, the non-communicable disease epidemic and the health impact of climate change.

The health of the population of Kiribati has improved over time, with life expectancy having risen in recent decades from 60 years in 1990 to 66 in 2015.

However, as Kiribati did not achieve any of the Millennium Development Goals, there is still an urgent need for action in the field of health on this island. Infant mortality in Kiribati is one of the highest in the region: hospital bed capacity in the country is very low, and the health system has deteriorated infrastructure. The Government of Kiribati entrenched its commitment to the SDGs in the Kiribati Development Plan 2016–2019, under Goal 3 which targets population health and health equity. Solomon Islands has made progress in the last decade, and the health system is transitioning following an ambitious development agenda called the Solomon Islands National Health Strategic Plan 2016–2020 (NHSP), which seeks to tackle four main challenges: service coverage, service quality, partnerships, and budling foundations for the future. The framework also identifies priority interventions in terms of fields of action.[381] In Tuvalu, the Ministry of Health built a plan called the National Health Reform Strategy 2016–2019 which specifically targets health management, as well as targeting both public health services and family planning. The health infrastructure of Tuvalu is limited to primary care, and is not suited to tackle the high rate of obesity among adults.[382]

11.2.3 Relevance of STI to solving these development challenges

Science and technology can play a decisive and pivotal role in achieving the national goals of the three islands. There are currently very few official sources or road maps in terms of STI development priorities and strategies. However, some STI priorities appear in the overall development agenda of Kiribati, such as in public health, secondary education, climate change, jobs and growth. It is likely that the same applies in Solomon Islands and Tuvalu.

- **Specific examples of how STI development was applied to challenges met**

There are several concrete examples in the three Pacific Islands of how STI have helped tackle development challenges. For instance, in Tuvalu, the digital economy has been instrumental in increasing the countries' revenues, particularly through its country code top-level domain. In 1998, the Government of Tuvalu opened the .tv domain to all companies from every country in the world. The domain is popular because "TV" is the abbreviation for "television" in several languages. In 2002, the Government of Tuvalu made a deal with Verisign Inc. renting it the right to manage the .tv domain, and the revenues represented 10–12 per cent of the country's GDP. In May 2019, there were approximately 430, 000 domains using the .tv domain.[383] Another example is the Pacific Centre for Renewable Energy and Energy Efficiency, which was created in Tonga in 2016 to tackle the issue of energy transition and financing. This centre, which is part of the Global Network of Regional Sustainable Energy Centres, set up a financial mechanism that offers funding for projects in this area.[384]

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378 Susan Schneegans, Jake Lewis, and Tiffany Straza, eds. *UNESCO Science Report 2021: The Race Against Time for Smarter Development* (Paris, United Nations Educational, Scientific and Cultural Organization, 2021).
379 International Renewable Energy Agency, *Renewable Energy Statistics 2017* (Abu Dhabi, 2017).
380 World Health Organization, Regional Office for the Western Pacific, *Pacific Island Countries and Areas – WHO Cooperation Strategy 2018–2022*, No. WPRO/2017/DPM/027 (2017).
381 Ibid.
382 Ibid.
383 United Nations Conference on Trade and Development, *Tuvalu, Rapid eTrade Readiness Assessment* (Geneva, 2019).
384 See https://www.pcreee.org/.

STI solutions are still underused to respond to development challenges in the three Pacific Islands. Tuvalu has profited from the digital economy but still faces hardship in working towards a reduction of the digital gap, with similar issues in Kiribati and Solomon Islands. To address SDG 10 (reduced inequalities) in the field of access to education, e-learning could be further developed, thus facilitating access to information and education for all, enabling progress on SDG 5 (gender equality) and SDG 4 (quality education). With regards to climate action, mitigation solutions such as smart construction and pollution limitation are critical to development. To address these challenges, action should be taken regarding SDG 1. The current lack of data hampers transparency and wealth redistribution, which in turn will affect the ability of the islands to translate GDP growth into poverty alleviation.

11.2.4 Impact of COVID-19 on the Pacific Islands

In addition to the aforementioned development challenges, these Pacific Islands have faced additional difficulties stemming from the pandemic. Due to limited testing capacities, the region was forced to close borders during the COVID-19 pandemic and this had a devastating impact on the tourism industry. The population of Kiribati, Solomon Islands and Tuvalu were particularly vulnerable to the pandemic's consequences because of the limited health facilities in place. However, their geographic isolation has been an advantage and helped to implement a quick border closure. Up to July 2021, their economy did not directly suffer from the effects of COVID-19. Unlike Solomon Islands, Kiribati and Tuvalu have less tourism-centred economies, which might help them recover from the global reduction of air traffic at a faster pace.[385]

The UNESCAP framework for analysing the impact of COVID-19 places Solomon Islands in the "Disruption and Uncertainty" group of Pacific countries. Its economy is partially reliant on tourism and also on timber exportation, which were heavily impacted by the lockdowns. COVID-19 cases have been recorded in Solomon Islands, with high death-risk levels. Kiribati and Tuvalu are part of the "Dependency on the Deep" group under the UNESCAP framework. Their economy heavily relies on tuna and fishing licence revenues, which were diminished by the lockdowns. However, it is noted that the COVID-19 crisis did not necessarily worsen the risks of this industry compared with the pre-COVID-19 situation.[386]

Overall, the COVID-19 crisis brought a decline in per-capita economic growth, partly due to a sharp decline in visit by tourists but also to market disruption in the significant area of fishing. School closures disrupted the education system, with a particular impact on girls as they were less likely to have access to online leaning options and more pressured to perform household duties. Reported job losses also increased, as did gender-based violence in a domestic setting.[387]

- **Concrete example of how STI have been successfully used to tackle COVID-19**

The Pacific Islands developed innovative tools to tackle the effects of the pandemic:

- Alternative access to education increased during the pandemic, with some communities sending learning materials to off-island communities in Tuvalu by post.[388] Indeed, due to their remoteness, these communities have increasingly relied on postal services and the Internet for distance learning.[389]

- To reduce physical contact during the pandemic, in March, Kiribati switched from paying government staffs' salaries in cash to using electronic payments. This increased the number of government staff that have a bank account.[390]

385 Asian Development Bank. *Pacific Economic Monitor, July 2021* (Mandaluyong City, 2021). Available at https://www.adb.org/sites/default/files/publication/719321/pem-july-2021.pdf.
386 United Nations Economic and Social Commission for Asia and the Pacific, *Addressing the impacts of COVID-19 on Pacific Island Countries Rapid Policy Appraisal* (2020).
387 Pacific Community, *Pacific Community Transition Plan 2021: Foundations for a Resilient Future: Responses to Recovery* (Noumea, 2020). Available at https://bit.ly/3hA3hEQ.
388 United Nations Economic and Social Commission for Asia and the Pacific, *Addressing the impacts of COVID-19 on Pacific Island Countries Rapid Policy Appraisal* (2020).
389 Susan Schneegans, Jake Lewis, and Tiffany Straza, eds. *UNESCO Science Report 2021: The Race Against Time for Smarter Development* (Paris, United Nations Educational, Scientific and Cultural Organization, 2021).
390 United Nations Conference on Trade and Development, "Kiribati sets sights on overcoming hurdles to e-commerce", 20 May 2020.

11.3 STI snapshot

The use of STI as a development tool is still relatively limited in Kiribati, Solomon Islands and Tuvalu. Their national agendas offer very little insight on the coordinated development of an STI system at the State level. This section highlights and explains the challenges these islands face in the definition and development of a systemic approach to STI in a SWOT analysis.

11.3.1 STI system SWOT analysis

Table 11.2 Strengths, weaknesses, opportunities, and threats of the national STI system in Kiribati

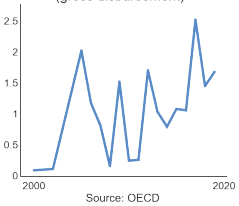
Strengths	Weaknesses
• Common development issues that allow the international scientific community acting on climate change issues to capitalize on reflections and share the associated resources. • Strong advocacy on climate change issues which makes the international scientific community aware of the issues the States face. • Numerous development plans drawn up at national and Pacific region levels (for example, the United Nations Pacific Strategy 2018-2022, the Kiribati Development Plan 2016–2019, the Solomon Islands National Development Strategy 2016–2035 and the Tuvalu Te Kakeega III National Strategy for Sustainable Development 2016–2020). • Collaborative initiatives such as the Pacific Islands Universities Research Network (PIURN) put in place since 2015 provide a shared network and open data/open research processes. Academic research benefits from this Pacific-wide network.	• No STI-dedicated institutions, no STI governance, no STI-dedicated policies and no STI-specific policy instruments. • Weak public infrastructure (research facilities, collaborative spaces, etc.) that prevent States from meeting contemporary challenges (pandemics, the energy transition, climate change adaptation and mitigation, etc.) • Lack of data and data sharing for use by the international research community. • Limited amount of technical and soft skills to develop and implement STI, due to the size and remoteness of the studied territories.
Opportunities	**Threats**
• A consciousness since 2014 that taking a regional approach to science and technology offers greater opportunities for economic and institutional development. • Various regional cooperation initiatives in the Pacific area (projects, networks…): The Pacific–Europe Network for Science, Technology and Innovation (PACE-Net Plus), the Pacific Climate Change Centre, the FALAH' project (Family Agriculture, Lifestyle and Health). • The Pacific Islands Neighbour Network for the Access to Local E-databases project to promote data access, structure its use, and disseminate results to the scientific community (PINNACLE project) in order to structure the community of researchers.	• The COVID-19 shock may exert long-lasting effects in terms of poverty and inequalities (in access to health care and education). • No indigenous or local STI tools to face current climate challenges (rising waters, pollution...) which threatens the existence of the three microstates.

11.3.2 Key features of the STI systems

Figure 11.7. Key features of the STI system in Kiribati

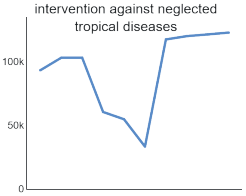
STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)



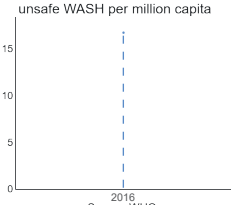
Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita



Source: WHO
median of last obs. LDCs: 34

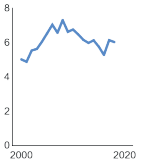
SDG 3.8.2 Share of pop. with large household expenditures on health

No data available for country

Publications 52: 1% of publications **Start-ups in crunchbase** No data

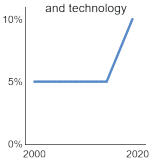
STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy



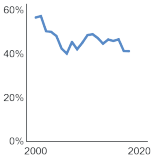
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



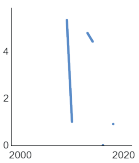
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development

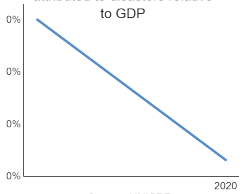


Source: SDGs

Publications 1: 0.03% of publications **Start-ups in crunchbase** No data

STI & Climate Adaptation

SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP



Source: UNISDR
median of last obs. LDCs: 0%

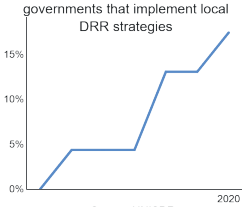
SDG 1.5.2 Direct agriculture loss attributed to disasters

No data available for country

SDG 13.1.1 Mainstreaming of sustainable development education in curricula

No data available for country

SDG 11.b.2 Share of local governments that implement local DRR strategies

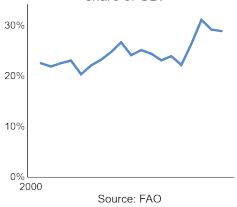


Source: UNISDR
median of last obs. LDCs: 44%

Publications 2: 0.06% of publications **Start-ups in crunchbase** No data

STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP

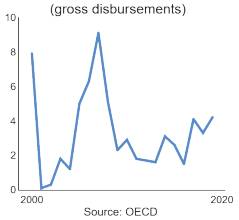


Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP

No data available for country

SDG 2.a.2 Total ODA to agriculture (gross disbursements)



Source: OECD
median of last obs. LDCs: 63

SDG 2.a.1 Agriculture share of Government Expenditure

No data available for country

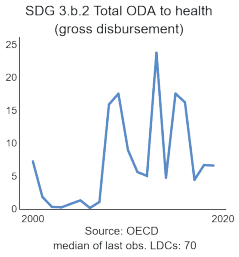
Publications 0: 0% of publications **Start-ups in crunchbase** No data

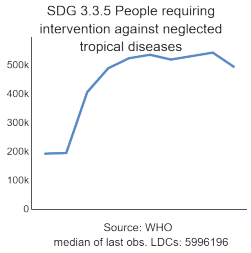
News coverage of thematic areas

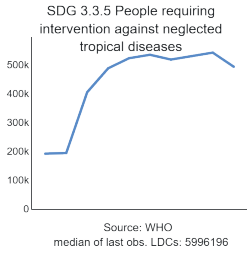
No data

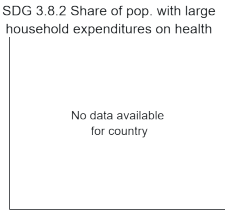
Figure 11.8. Key features of the STI system in Solomon Islands

STI & COVID-19 & Health



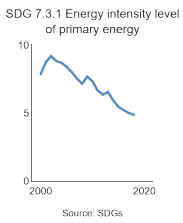


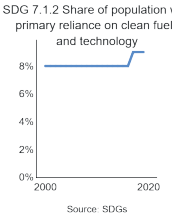


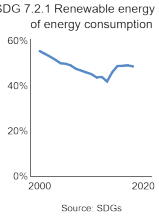


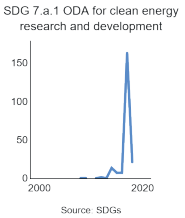
Publications 33: 4% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Clean Energy



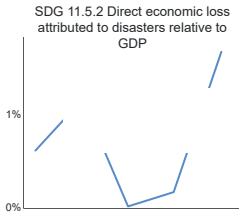


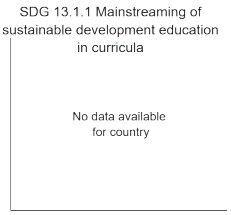


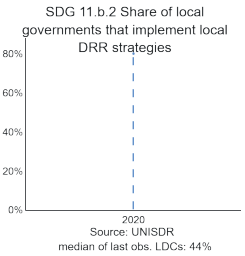


Publications 2: 0.2% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Climate Adaptation

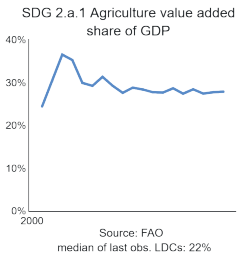


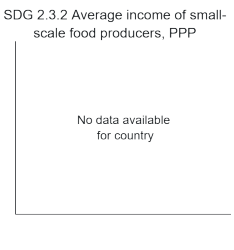


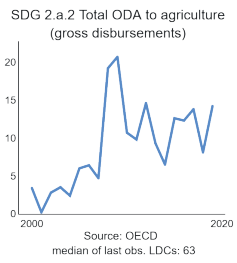


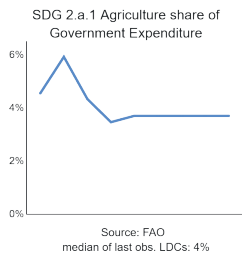
Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

STI & Agriculture









Publications 2: 0.2% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas

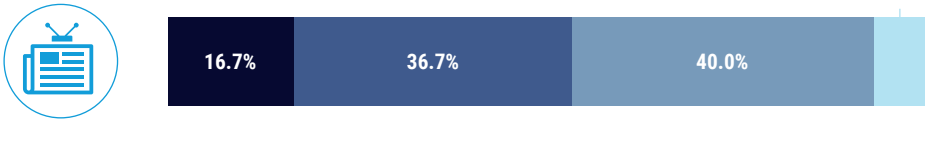
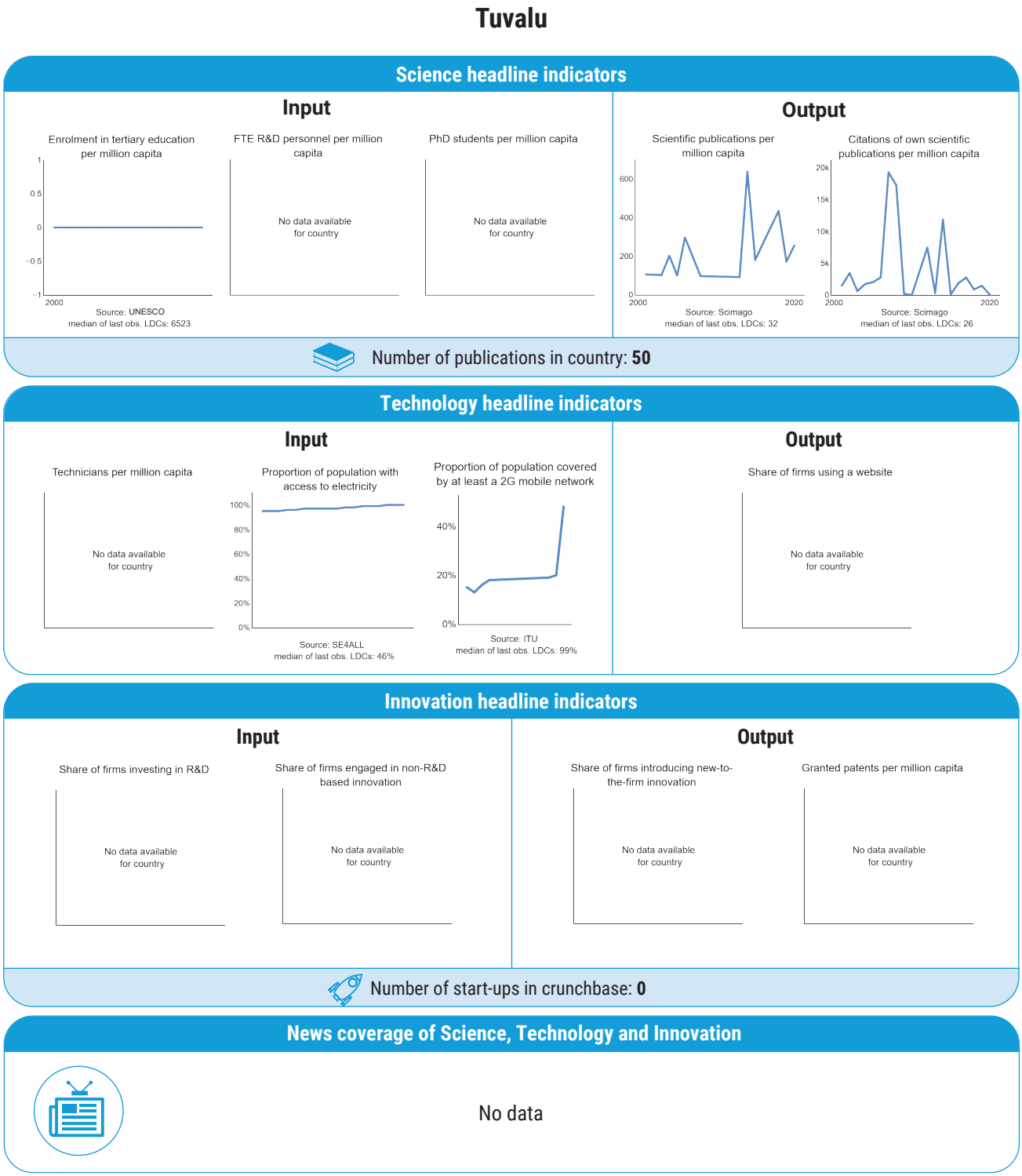
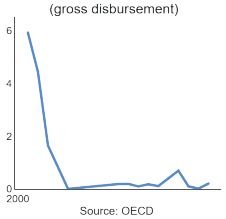


Figure 11.9. Key features of the STI system in Tuvalu



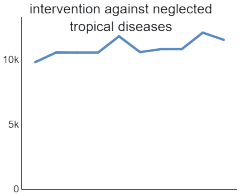
STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)



Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita

No data available for country

SDG 3.8.2 Share of pop. with large household expenditures on health

No data available for country

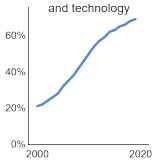
Publications **0: 0% of publications** **Start-ups in crunchbase** **No data**

STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy

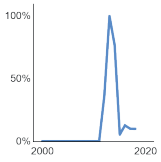
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



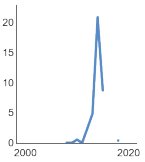
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development



Source: SDGs

Publications **0: 0% of publications** **Start-ups in crunchbase** **No data**

STI & Climate Adaptation

SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP

No data available for country

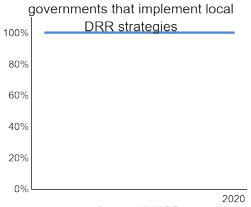
SDG 1.5.2 Direct agriculture loss attributed to disasters

No data available for country

SDG 13.1.1 Mainstreaming of sustainable development education in curricula

No data available for country

SDG 11.b.2 Share of local governments that implement local DRR strategies

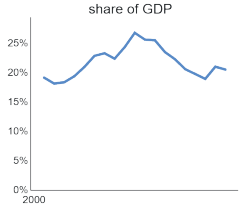


Source: UNISDR
median of last obs. LDCs: 44%

Publications **0: 0% of publications** **Start-ups in crunchbase** **No data**

STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP

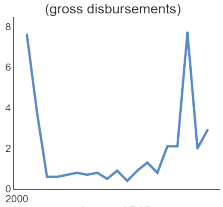


Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP

No data available for country

SDG 2.a.2 Total ODA to agriculture (gross disbursements)



Source: OECD
median of last obs. LDCs: 63

SDG 2.a.1 Agriculture share of Government Expenditure

No data available for country

Publications **0: 0% of publications** **Start-ups in crunchbase** **No data**

News coverage of thematic areas

No data

The infographics describe the key STI indicators in the three islands. These highlight the lack of data in the three islands when it comes to STI. Tuvalu has a particularly low volume of data available. Less than 50 per cent of its population has access to a 2G network, with a large increase in recent years. This proportion is slightly larger in Kiribati, with more than 60 per cent of the population having access to a 2G network. There has been a steady increase in Internet coverage in Solomon Islands in recent years, reaching an Internet coverage rate of above 90 per cent.

This section contains a deep dive into the key features and challenges faced by these three Pacific islands in their respective innovation systems, focusing on the issues of governance, digitization, lack of data and regional and subregional cooperation.

- **Governance**

Both the largest and smallest Pacific nations acknowledge that taking a regional approach to science and technology offers them greater opportunities for institutional development. In 2014, the Heads of State and governments of the SIDS committed to the Accelerated Modalities of Action (SAMOA Pathway), which acknowledges the utmost importance of STI for sustainable development in SIDS.[391] The framework was developed by the Council of Regional Organisations of the Pacific (CROP), which plays a similar role to that which science councils do in other regions. However, they do not have a specific mandate for science and technology in the region. In 2017, the ministries of education of the 14 Pacific States signed a Ministerial Communiqué on Pacific, Science, Technology and Innovation. In this framework they engaged their countries to develop both regional and national STI road maps. However, no further progress has been made since then.[392] Despite being recognized as useful for the region, the STI framework is not at the top of the agenda.

Consequently, an STI policy is yet to be developed by the governments of the region,[393] and little spending in this field. However, in Kiribati, some actors include STI in their missions: the Ministry of Information Communication, Transport and Tourism Development, the Ministry of Infrastructure and Sustainable Energy, the Ministry of Health and Medical Services, the Kiribati Meteorological Service, the Ministry of Education and the Communications Commission.

Currently, most Pacific Island States do not have guidelines for research.[394] It appears that none of the three States studied has a dedicated ministry in charge of STI policies. However, the European Commission funded a research programme through its Seventh Framework Programme for Research and Innovation (2007–2013) that was extended to 2016. The programme is called PACE-Net and focuses on health, demographic change and well-being; food security and sustainability; climate action and resource efficiency. It appears that this initiative resulted in a small group of people continuing to work towards the development of STI policies for the islands of the South Pacific.[395]

The need for research is increasingly emphasized at the regional level. A regional centre for ocean sciences called the Pacific Community Centre for Ocean Science. was established in 2015 in New Caledonia.

- **Digitization**

Digitization is one of the main future challenges for this region of the world, and for the three SIDS. Indeed, the mobile Internet penetration rate in this region was the lowest in the world in 2018 (18 per cent).[396] However, Solomon Islands has a higher rate of mobile Internet penetration, with a 49 per cent mobile Internet subscription rate. This will go hand in hand with the closure of the technology gap, to catch up with other countries. Digitization of payment is limited due to low-quality mobile network operators and a lack of possibilities offered by local banks. The amount of mobile phone subscription owners in Solomon Islands (71 per cent) and Tuvalu (70 per cent) is higher than in the other SIDS that are around 60 per cent. [397] Solomon Islands is using innovative solutions such as drones to survey organic farms, assess disasters and collect

391 United Nations, *Small Island Developing States Accelerated Modalities of Action* (Samoa Pathway) (Apia, 2014). Available at https://sustainabledevelopment.un.org/samoapathway.html.
392 Susan Schneegans, Jake Lewis, and Tiffany Straza, eds. *UNESCO Science Report 2021: The Race Against Time for Smarter Development* (Paris, United Nations Educational, Scientific and Cultural Organization, 2021).
393 Ibid.
394 Ibid.
395 See https://pacenet.plus/.
396 GSMA, *The Mobile Economy Pacific Islands 2019* (London, 2020).
397 Food and Agriculture Organization of the United Nations, *SIDS Solution Forum 2021: Overview of the Challenges and Opportunities Associated with Innovation and Digitalization in Pacific Small Islands Developing States* (Bangkok, 2021).

data, among other tasks. However, this use remains very limited.[398]

- **Lack of data**

As at 2015, only Fiji had recent data on expenditure on R&D and there were no recent data on researchers and technicians for any of the developing Pacific Island States. The lack of data for these States remains a critical barrier to the region's development of a STI system. As we can see in the infographics relating to the STI systems, Tuvalu and Kiribati present a very limited amount of available data. The World Bank is currently working on pilot projects with Kiribati to help improve the monitoring systems and boost the country improvement in this field in the coming years.

- **Regional and subregional cooperation**

Regional and subregional initiative and cooperation projects have been developed in recent years in the Pacific region and contribute to STI development efforts to overcome the issues of critical mass and the lack of national policies in this area:

- The Pacific–Europe Network for Science, Technology, and Innovation (PACE-NETPlus), goes some way towards filling the void in science policy, at least temporarily. Funded by the European Commission (EU funds 2007/2013), the objectives of PACE-Net Plus are to strengthen the dialogue between the Pacific region and Europe on STI; to support cross-regional research and innovation through calls for research proposals; and to promote scientific excellence and industrial and economic competition.

- The Pacific Islands University Research Network (PIURN) is a consortium of 14 universities in the Pacific Island countries and territories. It was established in 2012 under the strong impulse of the University of New Caledonia and the University of the South Pacific to enable closer and meaningful collaboration among researchers in the consortium to identify and address social priorities, economic growth, and environmental challenges for the Pacific Island countries and territories via research, development and innovation. Kiribati, Solomon Islands and Tuvalu are all part of this network.

- The Pacific Climate Change Centre – a centre for climate change studies and actions – was established in 2019 in Samoa. The goal of this centre is to function as a regional asset in several areas: knowledge brokering, applied research, capacity-building and innovation. The aim is to improve climate change adaptation and mitigation both in the region and worldwide. Kiribati, Solomon Islands and Tuvalu are members of this centre.

- FALAH[399] (Family Farming, Lifestyle and Health in the Pacific) is a multidisciplinary research project of the European Union's H2020-EU.1.3.3 programme, with a budget of €1.2 million over a period of four years (April 2020 to March 2024).[400] It focuses on the family farming, food, lifestyle, and health of the populations of the South Pacific islands: Fiji, New Caledonia, Solomon Islands and Vanuatu. It is a network of scientific teams composed of 14 institutions from Australia, Europe and the Pacific Islands that brings together researchers and professionals to share their research results, knowledge and innovations for the sustainability of South Pacific Island societies.

  Comprising researchers, teacher-researchers and PhD students with a common interest in food security and its direct or indirect links with the environment, nutrition and health sector, the aim of FALAH is to create and animate a network of research teams operating in the Pacific region and The ultimate goal is to promote and revitalize family farming in order to improve the health of populations in the Pacific and to ensure food security in a context of climate change and social and economic transformations. The project facilitates linkages and networks combining scientific proximities and disciplinary complementarities at several levels, from local to regional and from national to international.

398 See https://falah.unc.nc/en.
399 Ibid.
400 Three teams from the University of New Caledonia – the Institute of Exact and Applied Sciences (ISEA-EA7484), the Interdisciplinary Laboratory for Educational Research (LIRE-EA7483) and the Research Centre for Law and Economics (LARJE-EA3329) – form the basic framework of the FALAH project. At the local level, the three teams and some of the partners of the Consortium for Research, Higher Education and Innovation in New Caledonia (CRESICA), namely the New Caledonian Institute of Agronomy (IAC) and the Research Institute for Development (IRD), constitute the New Caledonian network of the FALAH project. The project also involves two PIURN partner universities located in Fiji and Solomon Islands, the South Pacific Community in Fiji and Noumea, the Ministry of Education and Training of Vanuatu as well as the Vanuatu Agricultural Research and Technical Centre.

11.3.3 Resilience of the national innovation system of the Pacific Islands

The elements detailed in the previous subsection outline the interesting structural features of the STI system. However, it is also important to consider the robustness of an STI system in response to conjunctural shocks.

The impact of the COVID-19 pandemic exposes the fragility of the health system in the three Pacific Islands. This shock had a paradoxical impact on the STI system, as it accelerated the adoption of digital technologies. On the one hand, in Kiribati, the COVID-19 pandemic limited the development of STI because the border closure prevented international actors and experts in public health from entering the country. On the other hand, it accelerated the adoption of digital technologies, with, for example, increased use of videoconference tools to facilitate online meetings, trainings, and workshops. However, there was no real use of data during the pandemic, at a time where it could have been very useful. Presumably, these reported impacts could have been the same for Solomon Islands and Tuvalu.

The use of STI in the three islands during the crisis has been mostly conjunctural and highlights the weakness of these systems in terms of response to potential future shocks. The lack of data also limits the systemic capacity to learn from previous shocks to address future challenges.

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Interviewees

Rouault, Anne. Director at Office of Research and International Affairs – Pacific Islands Universities Research Network and Director of Research and PhD Studies – University of New Caledonia.

Burtet-Sarramegna, Valérie. Lecturer at the University of New Caledonia.and member of the Pacific Islands Universities Research Network.

12. Rwanda

Figure 12.1. Least developed country status indicators for Rwanda

Africa
Rwanda

Population
12 million (2020)

LDC status
Member since 1971

Well-being		
Human Assets Index *(composed of six indicators)* 67 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 56% (2016) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(index of various State-level risks)* 84 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 783 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 6% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 7% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 32 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 15% (2019) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* 80% (2019) LDC median: 89% *Source: ILO*

12.1 Country profile

Rwanda, the "land of thousand hills," is a landlocked country in central Africa. The country shares borders with the United Republic of Tanzania, an economically strong country providing access to the sea via the central corridor departing from the port of Dar Es Salaam; Uganda, providing access to the sea via the northern corridor departing from the port of Mombasa in Kenya; Burundi and the Democratic Republic of the Congo, two countries going through political transition. Water occupies 5 per cent of the land and Lake Kivu in particular stores exceptionally large quantities of methane gas, which is extracted to produce electricity. Rwanda has been a member of the World Trade Organization (WTO) since 1996 and included in the least developed country group since 1971.

Rwanda is going through several phases: post-genocide recovery; Vision 2020 (2000–2020) that lays the foundation for sustained growth by investing in human capital, developing basic infrastructure and expanding access to various services; and Vision 2050 (2020–2050)

that aims to transform the entire economy and society into "the Rwanda we want".

Since the 1994 genocide, Rwanda has been politically stable with fair representation of women and youth in key leadership functions at national, regional and international levels within both private and public sectors.

> **Vision 2020 had the ambition to transform Rwanda into a middle-income country (MIC) and an East African hub with modernized agriculture, knowledge-based industry and services.**

During this period, the country made important economic and structural reforms and sustained its growth rates at an average of 7.2 per cent until 2019 with its per-capita gross domestic product (GDP) growing at 5 per cent annually. Prior to the pandemic, economic growth exceeded 10 per cent in 2019, driven by large public investments to implement the National Strategy of Transformation(2017–2024), a medium-term development plan to bridge Vision 2020 and the Vision 2050 transition. The strong growth was expected to continue in 2020: it is projected to be 8 per cent. The COVID-19 pandemic, with its related lockdown and social distancing measures, led to a GDP drop of 0.6 per cent in the fourth quarter of 2020 following a 3.6-per cent contraction in the previous period.[401, 402, 403]

In 2019, the main contributor to GDP was the service industry (49 per cent), followed by agriculture at 24 per cent and industry at 18 per cent. This has been the general trend since 2009. Food crops and export crops (tea and coffee) drove the growth in agriculture. For industry, drivers included construction and manufacturing. Within mining, the export of cassiterite and tungsten decreased while exports of coltan increased. For services: wholesale and retail trade of locally made and imported products, transport services boosted by air transport activities, financial services and hotel and restaurant services were the drivers. Remarkably, in the decade through 2018, information and communications technology was the fastest growing services subsector and has rejuvenated other sectors.[404, 405] Vision 2050 with a revised goal to reach middle-income country status by 2035 and high-income country (HIC) status by 2050 is now guiding the national economy long-term strategy.

Rwanda will retain its least developed country status until 2025.[406] Encouragingly, Rwanda has met the graduation threshold on the HAI, with the latest value standing at 67.6. The Economic and Environmental Vulnerability Index of Rwanda (32.3) meets the graduation threshold of 32 but the GNI (US$ 784) per capita remains below the graduation threshold of US$ 1.025.

12.2 Key development challenges

12.2.1 Priorities of the national development agenda

Vision 2050 describes the pathways for Rwanda to become an upper-middle-income country by 2035 and a high-income country by 2050. To reach these goals, the GDP growth rates must at least be 12 per cent from 2018 to 2035 and 10 per cent from 2036 to 2050. Within the business-as-usual scenario (i.e. a growth rate of 7 per cent), Rwanda would only become a high-income country by 2075. Strictly speaking, Vision 2050 corresponds to a 40-year acceleration of the country's economic development. National priorities include human development, economic competitiveness and integration, agriculture for wealth creation, urbanization and agglomeration, accountable and capable State institutions, and an overall strategy in line with a structural transformation of the entire society and geared towards a sustainable graduation from the least developed country status.

12.2.2 Level of achievement of SDGs

Overall, Rwanda is showing good progress on achievement of the SDGs. The country is on track for SDG 8 (decent work and economic growth) and SDG 13 (climate action). A moderate increase is recorded for SDGs 3, 5, 7, 9 and 16 and stagnation was observed for SDGs 1, 2, 4, 11, 15 and 17. For all other SDGs, information is not available. Overall, the country's capacity to monitor statistics on SDGs has improved due to the adoption of the National Strategy for the Development of Statistics and the Data Revolution and to Rwanda hosting the SDG Center for Africa.

401 Rwanda, Ministry of Finance and Economic Planning, *7 Years Government Programme: National Strategy for Transformation (NST1) 2017 – 2024* (2017).
402 Rwanda, Ministry of Finance and Economic Planning, *Vision 2050* (Kigali, 2015).
403 Ibid.
404 Rwanda, Ministry of Finance and Economic Planning, *Budget Execution Report*, July– March 2021 (2021).
405 Rwanda, National Institute of Statistics, "Statistical publications", n.d. Available at https://www.statistics.gov.rw/statistical-publications/subjects (accessed on 13 December 2021).
406 United Nations Department of Economic and Social Affairs, *Least Developed Country Category: Rwanda Profile* (2021).

Figure 12.2. Progress on the SDG Index in Rwanda

The drivers for progress on SDG 13 (climate action) are the combination of a clearly set vision for the country to become a green, climate-resilient and low-carbon economy by 2050 combined with the presence of a comprehensive portfolio of both governmental and non-governmental institutions (Global Green Growth Initiative), together with key development partners (for example, UK Aid, Swedish International Development Cooperation Agency, UNDP and GIZ). They have been working on strengthening national financial and institutional frameworks, green growth planning, increasing green investment flows and supporting green project development. For SDG 3, Rwanda has significantly advanced universal health coverage with its community-based health insurance scheme "*Mutuelle de Santé*". Coverage has expanded from less than 7 per cent of the scheme's target in 2003 to 74 per cent in 2013. Since July 2015, the scheme has been managed by the Rwanda Social Security Board (RSSB). Subscribers to the scheme are reimbursed by RSSB if the health facility they visited has signed an agreement with RSSB. The Ministry of Health and RSSB jointly decide which medical procedures and drugs are eligible for reimbursement.[407]

The next subsection discusses some of the development challenges faced by Rwanda, which are cross-cutting to the SDGs mentioned in this subsection. Addressing these development challenges will support progress in achieving the SDGs.

- **Demographic trends**

With the expected population increase, reaching 17.6 million by 2035 and about 22.1 million by 2050, the

407 See https://www.rssb.rw/index.php?id=17.

working-age population is expected to grow from 61 per cent of the population today to 65.7 per cent in 2050. By 2032, the rural population is projected to increase by 2.5–3.5 million people, adding pressure on land resources and farm incomes in the absence of alternative employment opportunities.

- **Geographical context**

The lack of access to the sea hinders trade and, in turn, economic development due to the high dependency on access to the sea and as such to regional transport links. This is particularly relevant in a region at risk of political instability, where the extent of good governance in the region has an impact on both the reliability and the cost of transit. Rwanda is also a transit route to Burundi and the Democratic Republic of the Congo, which posed further challenges in the pandemic response due to a lack of uniformity in preventive measures within the region. However, Rwanda is successfully taking advantage of its central position in the region, which the government is exploiting to make the country a hub for infrastructure, services, information and communications technology innovation and health care, among other areas of expertise. For instance, the government has already attracted several investors who have set up assembly plants for cars, computers and mobile phones. One way in which Rwanda is becoming a central hub for information and communications technology innovation in Africa is its hosting of the Smart Africa initiative, a commitment from African Heads of State and Government to accelerate sustainable development on the continent through affordable access to broadband and usage of information and communications technology. The country's centrality is also seen as an opportunity to become an airline transportation hub, with key airline partnerships planned that will allow passengers to fly from Rwanda to 160 cities around the world.

- **Trade**

All East African Community (EAC) countries have comparable production capabilities, which constrain direct intraregional trade. Vegetables are either first- or second-ranked, with food products in their top five products except for the United Republic of Tanzania, which specializes in hides and skin products such as leather.

The mining sector is an important sector in terms of export revenue. However, the benefits of exporting goods are highly dependent on the market pricing dynamics. Since 2011, with the stagnation or decrease

of international prices, the export of commodities has no longer been beneficial, despite the continued increase in export volumes. The relative impact of pricing dynamics is now being reduced as Rwanda is adopting reforms and building an ecosystem around value addition through local mineral processing. The country is home to two refineries of gold and tin capable of processing large amounts of minerals from within the country and the region. Rwanda has a mineral tagging and sealing scheme, internationally recognized as a member of the International Tin Association Tin Supply Chain Initiative (iTSCi) to ensure the origins of the minerals can be traced. In 2020, despite the pandemic, the revenue of the sector grew to US$730 million, against a target of US$600 million.

The export sector lacks diversity (actors and products) compared with regional peers (Ethiopia, Kenya, Uganda and the United Republic of Tanzania). Data for the 2009–2016 period indicate that 1 per cent of exporters accounted for more than 40 per cent of the total value of exports and 5 per cent of exporters accounted for more than 80 per cent of the total value of exports. On average, these Rwandan firms export only two products to 1.5 destinations. Similarly, about 59 per cent of all exporting companies in 2016 sold only a single product to a single destination (accounting for about one third of the total value of exports). Exporter survival rates in Rwanda are low with only 30 per cent of new exporters expected to be exporting products in the following year. Many Rwandan exporters are small traders moving goods across the border with neighbouring countries, particularly the Democratic Republic of the Congo.

Private finance mostly goes to construction and real estate, and to microfinance. Given the broader aspirations of the government for private-led transformation, more needs to be done to attract additional foreign direct investment (FDI) and domestic private capital into tradable sectors.

- **Geographic and climatic constrains**

> **There are exceptionally large quantities of methane gas stored in Lake Kivu. This may constitute a natural risk for the surrounding population.**

Even if the government is extracting methane to produce electricity, the true potential of this solution remains limited due to insufficient demand for electricity. Besides being landlocked, the “land of thousand hills” is also mountainous, which is a challenge for transport and therefore a delivery challenge for goods in general and emergency health supplies in particular in some parts of the country. More than 70 per cent of farming in Rwanda is carried out on slopes ranging from a 5 to 55-per cent inclination, which leads to erosion, soil degradation, and soil loss. Agriculture in Rwanda suffers from a range of soil fertility problems such as acidic soil, which occupies more than 50 per cent of its land and negatively influences the availability and uptake of several essential nutrients and access to water and nutrients, as well as restricting root growth, leading to low productivity. The sector is dominated by small-scale, subsistence, rain-fed farming, relying on traditional technologies.

12.2.3 Relevance of STI to solving these development challenges

Rwanda is already using STI to address several of its development challenges. In some cases, innovative solutions that have been piloted in the Rwanda have later been exported to other areas in Africa and beyond, which is the case for AI-enabled drones used to deliver medical supplies to more remote areas of the country. Rwanda aims to remain a proof-of-concept destination and a living laboratory for current and future innovations, and also to become a data-driven economy powered by technologies. As Rwanda aims to transition to a knowledge-based economy by leveraging information and communications technology and green technologies, there are many concrete opportunities to be seized while at the same time resolving development challenges: AI and emerging technologies in health care and education, moving from “landlocked” to “land-linked” by establishing an e-commerce platform and facilitating medical tourism, among other solutions. The following paragraphs provide some examples.

- **Digital health**

Since August 2020, the Government of Rwanda, in partnership with GIZ, has been working on developing a national AI policy to accelerate AI adoption by enabling the rapid growth of the country’s AI ecosystem, fostering the adoption of AI, and scaling public- and private-sector investment in AI. In March 2020, the Government of Rwanda and a health company entered into a 10-year partnership to provide with mobile phone-operated remote access to quality health-care services for the population, throughout the country. The delivery model is an AI-powered triage and symptoms checker, the country’s first digital-first universal health-care system. Another Rwandan e-health start-up, established in March 2021, is launching a platform for the early detection and prevention of non-communicable diseases. The screening platform connects various stakeholders in the health-care system such as doctors, nurses, pharmacists

and patients. It delivers quality preventive health care through the scientific, smart and evidence-based exchange, control and analysis of patient information. The technology endeavours to detect and prevent most non-communicable diseases in the early stages through AI-supported care models. It provides an overview of risk factors, describes care models, suggests relevant examinations and diagnoses and presents the final synopsis of all examinations, diagnoses and treatments. The company released its minimum viable product in November 2021 and is planning to start accepting patients in January 2022.

- **Educational technology**

Both the Education Sector Strategic Plan and the 2016 ICT in Education Policy emphasize the use of educational technology tools and methodologies to improve learning outcomes. There are already several public-led and private-led educational technology initiatives in Rwanda:

- The One Laptop per Child (OLPC) initiative, which launched in 2007, aims to enhance education by introducing technology in primary schools. Since its launch, the initiative has expanded its reach to cover 407 schools across Rwanda, and according to the Rwanda Education Board, it has distributed 274,073 laptops to learners.

- The Rwanda Education Commons (REC), which was in place between 2008 and 2012, promoted the effective use of information and communications technology in education.

- The Mentorship Community of Practice initiative, which was in place between 2013 and 2017, was a best-practice sharing platform for school-based mentors.

- Another initiative, which has been operating since 2018, is developing e-learning courses.

There are fewer initiatives in the private educational technology ecosystem. BAG Innovation is a virtual internship system that bridges the gap between the academic and business environment to tackle issues that contribute to youth unemployment such as the lack of preparedness of students upon completion of university. To strengthen the capacities of university students and higher learning institutions in Rwanda, BAG Innovation has developed an online system to complement theoretical learning with practical experience before they graduate. The approach involves integrating augmented reality and machine learning into the platform with gamification capabilities. Students are introduced to real-life business challenges in the form of cases, built on real challenges encountered by private businesses.[408]

- **E-commerce platform**

The Government of Rwanda is supporting the development of e-commerce with the launch of a business-to-business (B2B) and business-to-customer (B2C) e-commerce platform in partnership with a company owned by the Government of Dubai in the United Arab Emirates. Through this partnership, Rwanda will become an e-commerce hub for East Africa and beyond. The service was first made available in Rwanda and plans to expand its coverage across Africa and around the world. In practice, the service adds digital trading corridors to existing physical corridors and has facilitated progress across the continent by investing in ports, terminals and logistics operations. The portfolio of solutions (physical logistics infrastructure, data-driven logistics solutions) help resolve some of the key challenges for e-commerce, including reliable fulfilment, secure financial transactions, and the movement of goods.

- **Medical tourism**

Rwanda is aiming to become a medical tourism destination.[409] According to studies, medical tourism is a market growing at 15–25 per cent per annum globally. It has had great economic benefits for several countries such as India, South Africa and Tunisia. Latest statistics indicate that Africans spend US$6 billion on medical tourism, seeking treatment beyond the continent. Rwandans are travelling abroad, mainly to India and Kenya, to seek affordable and state-of-the art treatments. Rwanda is therefore positioning itself as a centre for medical tourism, biomedical research and pharmaceutical industries. World-class health facilities are being developed to offer specialized health care with quality services that are competitive on the continent. For instance, in 2018, the Government of Rwanda formed a partnership with a global institution dedicated to advancing and teaching minimally invasive surgery in order to establish a centre in Kigali. The goal is to improve and advance surgery by closing the technology and knowledge gap in the field of research and training on minimally invasive surgery. King Faisal Hospital is

408 Eric Kimenyi, Rachel Chuang and Abeba Taddese, "EdTech in Rwanda: a rapid scan", *EdTech Hub*, Country Scan No. 11 (2020).
409 Rwanda Development Board, *Consultancy Service for Development of a Health Care Services Strategy for Medical Tourism in Rwanda: Paving the Way for Medical Tourism in Rwanda* (2014).

another pillar of the medical tourism strategy of Rwanda with a mandate to provide a range of specialized health care in East and Central Africa. Although this strategy is nascent, it is hoped that this will deliver positive results in the medium to long term.

- **Converting methane gas into electricity**

The Government of Rwanda plans to reach an electrification rate of 100 per cent by 2024 and the extraction of methane gas from Lake Kivu could significantly contribute to the country's electrification objectives while at the same time reducing the natural risks affecting its population. Several initiatives took place over the last decades, including the development of the KivuWatt Power Station, commissioned in December 2015. In its first phase, the power plant has generated 26 MW and is now aiming for 100 MW of electricity, provided that there is sufficient demand. Another public-private partnership is planning to build a plant to provide 56 MW of electricity. Finally, another company is building a gas extraction facility with the goal of generating and selling compressed natural gas in bottles.

12.2.4 The impact of COVID-19 on Rwanda

The first confirmed case of COVID-19 was declared on 14 March 2020. Since then, the country has recorded 89,768 cases, 1124 deaths, and 45,359 recovered cases as at 6 September 2021.[410]

> **The school closures have impacted more than 3.5 million students, from kindergarten to higher education, with lower household income likely to reduce school enrolment.**

The Rwandan economy has fallen into its first recession and could potentially compromise years of gains in poverty reduction, with the poverty headcount expected to increase by 5.1 percentage points in 2021. The COVID-19-related restrictions have severely impacted the travel and hospitality services sector, in which the country has invested massively in recent years through its Meetings, Incentives, Conferences and Events (MICE) strategy. The pandemic has negatively impacted the tourism industry and the agricultural sector, compounding the decline already expected due to adverse weather. In the medium term, the economy is expected to recover, with growth reaching 6.3 per cent in 2021 and returning to its average growth of 8 per cent in 2022.

- **Concrete example of how STI have been successfully used to tackle COVID-19**

The government leveraged the country's high financial inclusion rate (93 per cent, including both formal and informal financial products/services)[411] and took measures to limit the spread of COVID-19. The use of cash was limited by waiving peer-to-peer mobile money transfer fees, merchant payment fees, and transfers from bank accounts to mobile wallets or vice versa for three months. These measures led to an increase in peer-to-peer transfers from US$11 million in the week of 15 March 2020, to nearly US$73 million in the last week of May 2020. Ultimately, the pandemic boosted the Rwandan cashless economy and the elimination of fees on cashless payments had benefits for Rwanda. The e-payment to GDP rate increased from 34.6 per cent in June 2019 to 54 per cent in June 2020.

Digital health has been a key enabler for the COVID-19 response in Rwanda, particularly in terms of access to information and health care. The government has set up an Unstructured Supplementary Service Data (USSD) platform for self-triage. Information from WHO was disseminated via SMS, and AI-enabled drones have been used to deliver medical supplies to more remote areas of the country. Data modelling helps governments predict the evolution of the pandemic against the prescribed confinement and de-confinement measures. To counter the limited availability of diagnostic test kits, Rwanda adopted mathematical modelling to implement a pool testing method that reduces the number of tests required for an accurate infection count.

410 Rwanda Biomedical Centre, "COVID-19 confirmed cases map by district". Available at https://www.rbc.gov.rw/index.php?id=707 (accessed on 6 September 2021).
411 National Bank of Rwanda, *FinScope, Financial Inclusion* (Rwanda, 2019).

More specifically, a range of digital solutions have helped the government respond effectively to the COVID-19 outbreak: contact tracing; COVID-19 surveillance – a digital reporting surveillance system for health facilities; infection prevention using robots; and data visualization using Geographic Information System (GIS) software.[412] A chatbot providing information about the pandemic in English, French and Kinyarwanda was also launched in September 2021 through a collaborative effort.

12.3 STI snapshot

12.3.1 STI system SWOT analysis

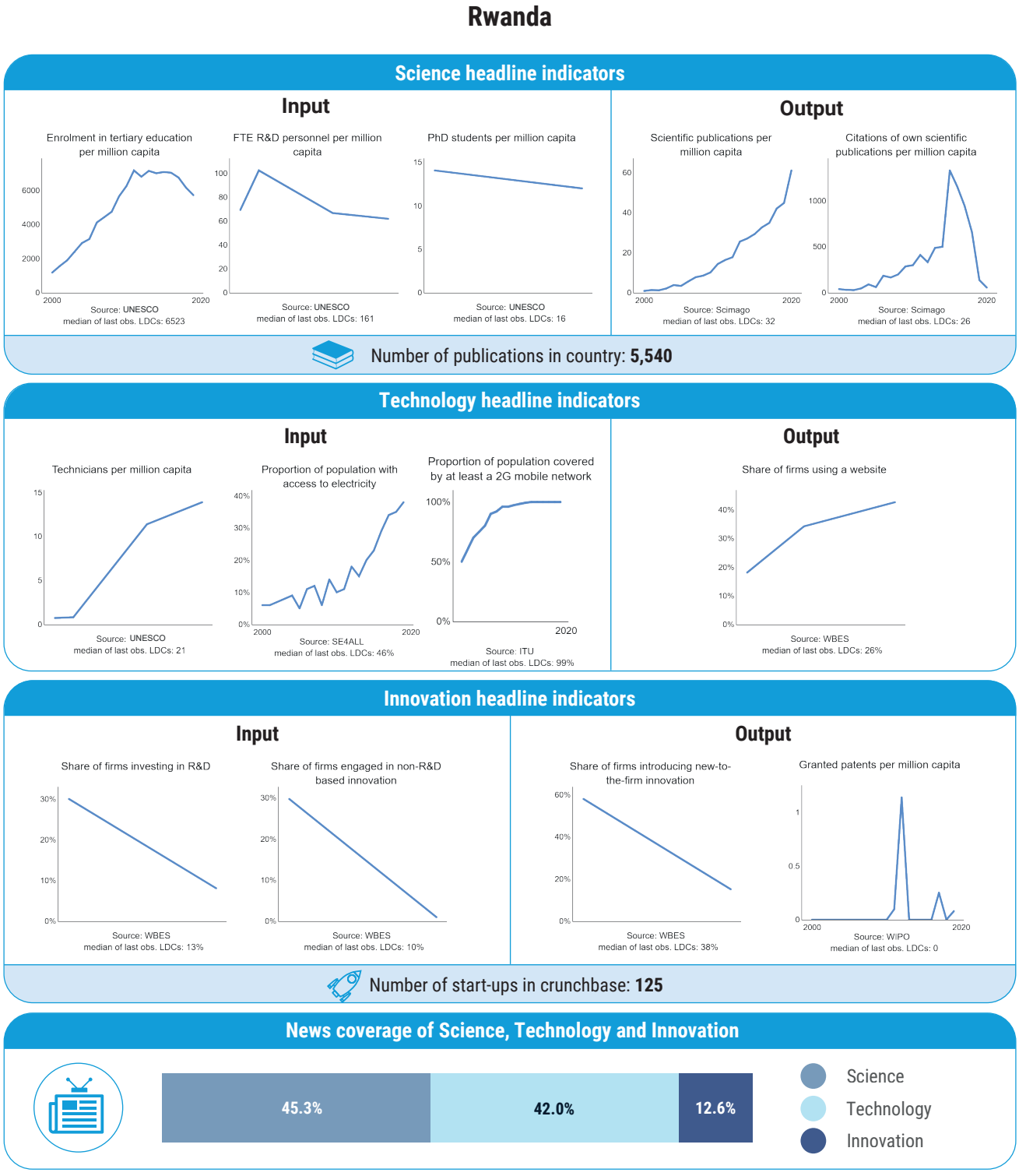
Table 12.1. Strengths, weaknesses, opportunities, and threats of the national STI system in Rwanda

Strengths	Weaknesses
• Pathways to graduation from least developed country status are clear and the role of STI in this process is very clear • Leadership and governmental institutions are supportive of STI as a development vehicle • Well articulated Visions (2020, 2050) are in place with stakeholders aligned on Vision 2050 • The STI policy framework is constantly being improved and development partners are funding relevant studies (white papers, market studies, solutions mapping) to further develop and support the innovation ecosystem • Chief Digital Officers have been deployed in all ministries to support economic sectors in leveraging digital solutions • There is a business-friendly environment in Rwanda, including hubs and innovation centres for start-ups, supporting STI-led development • There is a very diverse STI funding landscape in Rwanda, covering the entire research and innovation pipeline • Digital infrastructure: broadband, fibre-optic, 4G LTE coverage, high mobile penetration under constant improvement • The knowledge ecosystem is becoming increasingly comprehensive with all the building blocks coming together	• The export sector lacks diversity, both in terms of actors and products, impacting the country's resilience • Digital divide: skills and literacy, access to high-speed Internet, hardware affordability to slow down the adoption of digital solutions • The lack of access to substantial venture capital in early stages and the small size of the market raise challenges in scaling up innovation • The lack of highly qualified nationals in STEM makes the country rely on other African nationals and international experts
Opportunities	**Threats**
• Rwanda is going to build better transport links and leverage its central position to boost solutions such as e-commerce and manufacturing of technology products • An attractive environment positioning Rwanda as a role model and a proof-of-concept and value addition economy (there is an opportunity to develop multiple innovative value chains) • Diversification of the methane gas value chain including the reuse of carbon dioxide (as a by-product of methane gas extraction)	• Political stability within the region may impact trade and logistics • Resilience challenges exist due to comparable agriculture production within the East African countries and mineral products, which still depend on the global pricing dynamics • Insufficient electricity demand slows down the scaling up of the conversion of methane gas to electricity

412 Sam Ajadi and Peter Drury, *Health Systems, Digital Health and COVID-19: Insights from Bangladesh, Myanmar, Pakistan, Benin, Nigeria and Rwanda* (GSM Association, 2021).

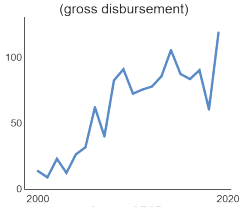
12.3.2 Key features of the STI system

Figure 12.3. Key features of the STI system in Rwanda



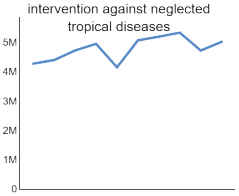
STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)



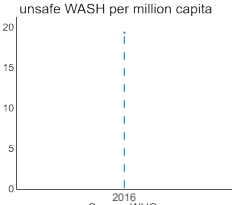
Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita



Source: WHO
median of last obs. LDCs: 34

SDG 3.8.2 Share of pop. with large household expenditures on health

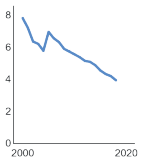
No data available for country

Publications 319: 5% of publications

Start-ups in crunchbase 8: 6% of start-ups

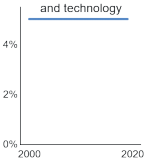
STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy



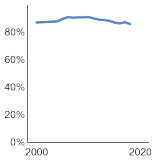
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



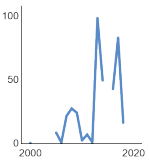
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development



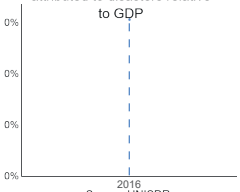
Source: SDGs

Publications 33: 0.6% of publications

Start-ups in crunchbase 8: 6% of start-ups

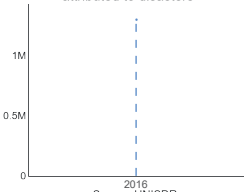
STI & Climate Adaptation

SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP



Source: UNISDR
median of last obs. LDCs: 0%

SDG 1.5.2 Direct agriculture loss attributed to disasters



Source: UNISDR
median of last obs. LDCs: 2256933

SDG 13.1.1 Mainstreaming of sustainable development education in curricula

No data available for country

SDG 11.b.2 Share of local governments that implement local DRR strategies

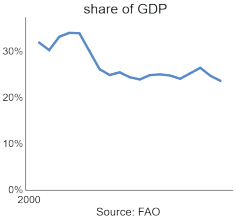
No data available for country

Publications 0: 0% of publications

Start-ups in crunchbase 0: 0% of start-ups

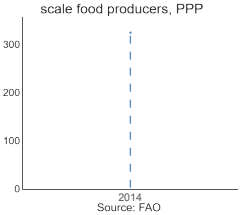
STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP



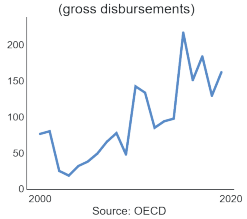
Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP



Source: FAO
median of last obs. LDCs: 714

SDG 2.a.2 Total ODA to agriculture (gross disbursements)



Source: OECD
median of last obs. LDCs: 63

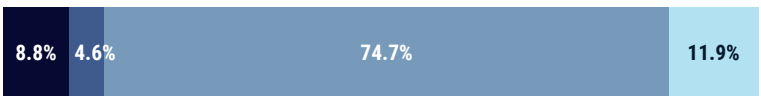
SDG 2.a.1 Agriculture share of Government Expenditure

No data available for country

Publications 32: 0.6% of publications

Start-ups in crunchbase 0: 0% of start-ups

News coverage of thematic areas



- Agriculture
- Climate adaptation
- Health
- Renewable energy

The Rwanda STI system is characterized by: i) a strong sense of directionality; ii) a deliberate strategy to foster absorptive capacity and regional cooperation, as well as closing the gender gap; iii) a comprehensive set of governmental bodies and instruments. These are discussed in further detail below.

- **Directionality**

Innovation is a central piece of the ambition for Rwanda to become a middle-income country by 2035 and a high-income country by 2050, a knowledge-intensive economy in which the production, distribution and use of knowledge are the main drivers of growth, wealth creation, and employment. Achieving this level of ambition will require Rwanda to focus on knowledge creation and use as well as on accelerating and strengthening the laboratory-to-market chain for innovations. In its Vision 2050, the Government of Rwanda has set out four directions that must be followed to increase its innovative capacity and leverage the use of technology for its transformation.

- **Foster excellence in research and development**

Under Vision 2020, Rwanda has attracted world-class universities and research institutions such as Carnegie Mellon University Africa, the Africa Leadership University, the African Institute for Mathematical Sciences which hosts the Master's degree in Machine Learning programme – the first of its kind in Africa – the University of Global Health Equity, the International Centre for Theoretical Physics, and the Rwanda Institute for Conservation Agriculture. Rwanda will continue to do so as well as continue to build the R&D capabilities of the University of Rwanda. In 2021, the law establishing the Rwanda Space Agency (RSA) was approved. In partnership with the Japan Aerospace Exploration Agency (JAXA), Rwanda will develop its space engineering capability. Rwanda will also continue to build its research infrastructure by increasing funding of R&D across fundamental research, applied research and market applications, attract top researchers through various mechanisms such as research Chairs (for example, in Climate Change or Data Science) and align its research with industry demand through strong collaborations with local and global industries (for example, through a science and innovation platform to boost medical research and innovation).

- **Remain a proof-of-concept destination for current and future innovations**

Over the last decade, Rwanda has not only been a proof-of-concept destination and living laboratory for drone technologies but also a laboratory for incremental innovation to improve products, processes and business models. The first integrated mobility concept has been designed in this eastern African country including local production, service, sales and new types of mobility offerings. The company expects to create about a thousand jobs through the integrated mobility concept. Several of the vehicles assembled in Rwanda will not be sold but will rather be used by mobility services such as car sharing and ride hailing. This is a strategy to counter the fact that, with the exception of South Africa, there is no official market for new cars on the continent. The company, which makes vehicles in South Africa as well as in Kenya and Nigeria, is considering expanding this model to other African countries. Rwanda will continue be a place where today and tomorrow's innovation can be tested, piloted and subsequently exported throughout Africa or beyond.

- **Becoming a data-driven economy**

The economy, government, private sector, civil society and population of Rwanda will be more data-driven and powered by current and emerging technologies such the Internet of Things (IoT), robotics, AI and big data. In line with this, the government passed a new law in October 2021 protecting personal data. A national AI policy has been drafted and is currently under validation while several initiatives such as developing the fintech strategy and assessing the country's readiness for AI technologies are in progress.

- **Future-proof the education system**

Rwanda will require a sufficiently large pool of people with qualifications in the science, technology, engineering, arts and mathematics fields to develop its innovative strength. The Rwanda Coding Academy is an example of such a sustainable approach to produce a pool of top-end experts in software engineering to strengthen a framework of information and communications technology training and qualifications with an emphasis on hands-on and market-oriented information and communications technology skills. This academy opened in 2019 with 60 students – 30 girls and 30 boys; it now has 118 students.

The previously mentioned framework, outlined in Vision 2050, is an important strength of the Rwandan innovation ecosystem. It helps both the government and entrepreneurs to ensure proper alignment when establishing new initiatives with a series of lasting impacts as described in the following paragraphs.

- **Regional and subregional cooperation**

The Government of Rwanda is driving regional and subregional cooperation on STI in many ways. The Fourth Industrial Revolution (4IR) presents a unique opportunity for the African continent to catch up with other world regions in terms of socioeconomic prosperity. Rwanda is home to the thirteenth Centre for the Fourth Industrial Revolution (C4IR), thanks to the collaboration between the government and the World Economic Forum. The centre promotes emerging technologies such as AI, machine learning, blockchain and the IoT with the aim of developing and implementing technology governance and policy protocols that will accelerate the benefits of adopting these technologies. The C4IR brings together government, industry, civil society and academia to co-design, test and refine policy frameworks and governance protocols that maximize the benefits of new technologies. The C4IR focuses primarily on AI and data policy and seeks to develop multi-stakeholder partnerships to drive innovation and adoption at scale. Another example of cooperation is Smart Africa, a commitment made by African Heads of State and Government to accelerate affordable access to broadband and usage of information and communications technologies. The partnership works with the Government of Rwanda on its national AI policy framework, on cybersecurity and on smart cities. Lastly, the Sustainable Development Goals Center for Africa (SDGC/A), based in Rwanda, supports governments, civil society, businesses and academic institutions in achieving the SDGs in Africa.

- **Gender gap in STI and the diaspora**

Closing the gender gap in STI and leveraging the African diaspora to strengthen its R&D system are two avenues being encouraged and supported by the Government of Rwanda. Upstream of the education pipeline, the Gashora Girls Academy of Science and Technology is an upper-secondary boarding school for girls, located an hour south of the capital city of Kigali. Over the past year, the school has seen promising and talented girls all the way through to graduation. These girls then managed to secure places at top universities worldwide. The African Institute for Mathematical Sciences's Next Einstein Initiative (AIMS-NEI) Fellowship Program for Women in Climate Change Science (WiCCS) is attracting African women researchers working on climate change with the aim of increasing women's contribution to the climate change response, and also foster regional collaboration.

Another important feature of the STI ecosystem is governance and instruments that are developed and under continuous improvement.

- **Governance**

In 2016, the gross domestic expenditure on R&D (GERD) amounted to US$44,024,141 representing 0.66 per cent of GDP. The government expenditure on R&D (GOVERD) was 77.76 per cent, higher learning institutions' expenditure on R&D (HERD) was 7.88 per cent, private not-for-profit institutions' expenditure on R&D (PnPERD) amounted to 7.52 per cent and businesses' expenditure on R&D (BERD) amounted to 6.83 per cent. For each of the four categories, funding originated from their own finances, foreign funding or other national funds. The GERD breakdown was 19.31 per cent from their own finances, 26.25 per cent from foreign funds and 54.44 per cent from other national funds.[413]

The GOVERD breakdown was 15.52 per cent from their own funds, 8 per cent from foreign funds and 76.49 per cent from other national funds. The HERD breakdown was 21.69 per cent from their own funds, 1.84 per cent from foreign funds and 76.46 per cent from other national funds. The BERD breakdown was 35.71 per cent from their own funds, 17.07 per cent from foreign funds and 47.23 per cent from other national funds. Finally, PnPERD breakdown was 35.41 per cent from their own funds, 9.24 per cent from foreign funds and 55.35 per cent from other national funds.

The establishment of a knowledge-based economy requires an STI governance framework covering policy, regulations, standards and a coordination mechanism to create an enabling environment. The Rwandan STI governance framework has gone through many changes between 2005 and 2018 including the establishment of the Ministry of ICT and Innovation, the National Council for Science and Technology, the National Industrial and Research Development Agency, the Rwanda Information Society Authority, the Rwanda Agriculture and Animal Resources Development Board, the Rwanda Biomedical

413 Rwanda, National Council for Science and Technology, *Analysis Report 2015/2016, Rwanda National Survey of Research and Experimental Development* (2015).

Centre and the Rwanda Standards Board. The current institutional framework encompasses ministries and institutions in charge of science, technology, research and innovation, ministries and institutions in charge of education, science granting councils, STI-sector institutions, institutions in charge of standards and the private sector.

Rwanda has the ambition of leveraging STI for its socioeconomic transformation. The research and innovation agendas are prioritized according to the economic sector's priorities.

> **More specifically, the focus areas of the national STI agendas include sustainable energy, food security and agriculture modernization, life and health science, local production and value addition, digital services, products and lifestyle, a resilient environment and climate change.**

The country's STI policy[414] has five objectives. The first objective is to establish an enabling policy environment and coordination mechanisms to strengthen linkages between science, economy and society to encourage research and innovation. The second objective is to increase scientific and technological output: to boost national capability in terms of adopting, inventing and innovating technologies and services towards sustainable socioeconomic development; and to provide technology innovation support mechanisms for a seamless laboratory-to-market process. The last three objectives include increasing R&D and innovation financing, developing human capital and knowledge networks and fostering international cooperation in science and innovation.

On 5 February 2021, Rwanda published the new Law on Investment Promotion and Facilitation to enhance the country's competitiveness and attract cross-border investment, new business, and financial institutions. This is expected to attract investors to support projects of strategic importance. The law introduces a new investor category for strategic projects of national importance that will have an impact on the country's development. It also introduces a five-year validity period for investment certificates from the date of issuance, subject to a maximum renewal period of five years.

The legislative process for establishing a national start-up act is at an advanced stage of planning and the procedure should be finalized in 2021. It seeks to support entrepreneurship and business ecosystems in the country. Start-up acts are an emerging legislative instrument to package strategic incentives and interventions to accelerate the formation and sustained scale-up of innovative and high-growth firms.

- **Instruments**

Financial instruments are in place to foster an STI-conducive environment. In 2018, two complementary funding avenues for research and innovation value chains across specific areas including the Rwanda Innovation Fund and the National Research and Innovation Fund were launched. The purpose of these funding instruments is to support fundamental, applied and experimental development forms of research from laboratory to market. The national STI funding landscape also comprises other specialized funding streams. The previously discussed Rwanda Green Fund, the Business Development Fund, which provides support to SMEs via credit guarantees, credit lines, matching grants, quasi-equity and advisory services. The Fund for African Private Sector Assistance, an AfDB fund, provides untied grants for technical assistance and capacity-building. It also provides direct funding to research performing institutions such as the Rwanda Agriculture Board and the Rwanda Biomedical Centre. A number of research Chairs are funded by International Development Research Centre and the Carnegie Foundation in very specific sectors or disciplines. The Ministry of Education manages the Rwanda Innovation Endowment Fund to support R&D for the country's innovation priority, economic and social areas. The Workforce Development Authority is the implementing agency for the Skills Development Facility fund targeting workforce development to expand the number of individuals with the relevant skills in critical sectors. The Development Bank of Rwanda manages the Export Growth Facility fund, an investment catalyst, matching grants for market entry costs and export guarantee. The Skills, Employability and Entrepreneurship Programme III (SEEP III) fund is managed by the Workforce Development Authority. The Ministry of ICT and Innovation and the Development Bank of Rwanda are the implementing structures for a small- and medium-sized enterprise information and communications technology fund, a public-private fund for job creation under the national STI agendas.

Over the last decade, Rwanda has managed to connect its STI ecosystem to society and business. The country has successfully managed to address its development and societal challenges through STI solutions while at the same time enabling wealth creation. Interestingly,

414 Rwanda, National Council for Science and Technology, *Science, Technology and Innovation Policy* (2020).

the most successful solutions deployed in the country have been north-south collaborations involving the identification of innovative solutions from research that was carried out in the United States of America and subsequently piloted and deployed first in Rwanda and later across Africa (for example, Zipline on-demand deliveries and Babyl digital health services). Going forward, it is important that local solutions are enabled and fostered. For this to happen and to lead to the same level of impact as Zipline, Irembo, Mara Phones or KivuWatt, enhancing the size of local financial instruments is of paramount importance.

12.3.3 Resilience of the national innovation system of Rwanda

> **The pandemic has boosted major initiatives in Rwanda such as mobilizing decision makers around the urgent need to localize vaccine manufacturing on the African continent and raising citizens' awareness of the need to move towards a cashless economy and for policymakers to design mechanisms to facilitate the process.**

The pandemic has therefore reinforced the strong conviction that leveraging STI to achieve the country's ambitions is essential.

The Government of Rwanda has advocated for localizing vaccine manufacturing in the African region and in Rwanda. This has led to the signing of an agreement with the European Union to support local manufacturing of health products. The goal of this agreement is to strengthen the capacity of the Rwanda Food and Drugs Authority by upgrading the country's regulatory capabilities to meet the required international standards for vaccine manufacturing. A second agreement was signed with the International Finance Corporation to support the technical and policy frameworks that are in place to establish a world-class vaccine manufacturing supply chain for the production of vaccines intended for local and continental use. In the process of establishing vaccine manufacturing in Rwanda, one of the leading manufacturers of the COVID-19 vaccines will build mRNA manufacturing sites in Rwanda and Senegal for future production of not only COVID-19 vaccines but also vaccines against malaria and tuberculosis.

The cashless economy initially received resistance[415] from consumers and merchants because of the transaction fees involved in using mobile money on cashless systems. To limit the spread of the COVID-19, the government has promoted cashless transactions by removing transaction fees for mobile payments. Following this measure, mobile money transactions increased by 450 per cent from January to May 2020. The government then introduced mobile motor taxi meters and enforced cashless payments. The elimination of fees on cashless payments benefited the country. The National Bank of Rwanda's *2019/20 Annual Report*[416] shows that despite the economic slowdown during the pandemic, the country's financial system remained sound and prices remained stable. Bank-sector profitability and liquidity rates improved for both microfinance institutions and banks. The e-payment to GDP rate increased from 34.6 per cent in June 2019 to 54 per cent in June 2020. Additionally, the percentage of counterfeit banknotes dropped significantly.

Even if the Rwanda STI ecosystem is still under construction, some tangible results have been observed over the last decade in developing and strengthening capacity in both knowledge development and knowledge use. A very comprehensive ecosystem is being developed around: i) STI-related skills; ii) building a policy framework for innovation combining sectoral strategies and national strategies to harness emerging technologies; iii) infrastructure development; iv) building strategic partnerships. Efforts that have been made in building a cashless economy as well as in developing capacity in big data have paid off during the pandemic. Going forward, the government is aiming to leverage AI in sectors such health, banking and finance, agriculture, and transport.

415 Collins Mwai, "Cashless economy: is mobile money too expensive?", *The New Times Rwanda*, 1 November 2019.
416 Daniel Sabiiti, "COVID-19 drove Rwanda's cashless economy, drop in counterfeits – BNR report", *KT Press*, 10 November 2020.

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Interviewees

Bimpe, Israel. Director at Africa Go-To-Market – Zipline.

Gasigwa, Benoit. Acting Director of Planning and M&E Unit at Ministry of ICT and Innovation.

Gueye, Assane. Assistant Professor at Carnegie Mellon University Africa.

Kamatari, Chantal. Corporate Social Responsibility at BNP Paribas Fortis.

Kamili, Diana. ICT SWG Coordinator at Ministry of ICT and Innovation.

Kunda, Esther. Director General, Innovation & Emerging Technologies at Ministry of ICT and Innovation.

Mutangana, Aphrodice. Deputy Chief Executive Officer at Digital Africa.

Munyaneza, Francine. Founder and CEO at Munyax Eco.

Muvunyi, Kevin. Artificial Intelligence Skills and Ecosystem Advisor at Fair Forward Project (GIZ).

Muvunyi, Victor. Emerging Technologies Senior Technologist at Ministry of ICT and Innovation.

Yala, Sam. President at African Institute for Mathematical Sciences.

13. Sierra Leone

Figure 13.1. Least developed country status indicators for Sierra Leone

Africa
Sierra Leone

Population
7 million (2020)

LDC status
Member since 1982

Well-being		
Human Assets Index *(composed of six indicators)* 41 (2021) LDC median: 58 *Source: UNCDP*	**Poverty level** *(population living on below US$1.90/day)* 43% (2018) LDC median: 40% *Source: World Bank*	**Fragile States Index** *(composed of 12 conflict risk indicators, max score 120)* 83 (2021) LDC median: 88 *Source: Fund for Peace*

Economic conditions		
GNI per capita *(US$ national income over population)* 532 (2021) LDC median: 854 *Source: UNCDP*	**Growth of real GDP** *(% per employed person)* 3% (2019) LDC median: 2% *Source: ILO*	**Economic growth** *(% growth of GDP, projected)* 4% (2022) LDC median: 5% *Source: IMF*

Economic vulnerability		
Economic Vulnerability Index *(composed of eight indicators)* 40 (2021) LDC median: 39 *Source: UNCDP*	**Unemployment** *(% of labour force)* 5% (2014) LDC median: 5% *Source: World Bank*	**Informal/vulnerable employment** *(% of labour force)* No data

13.1 Country profile

Sierra Leone gained independence from Great Britain in 1961. However, multiparty democracy was short-lived, and the resulting instability and spillover of the conflict in neighbouring Liberia led to civil war. Following the 1998 intervention of the Nigeria-led West African multilateral armed force, the ECOWAS Monitoring Group, peace was secured in 2001.[417] By then some 50,000 people had died in the conflict, and a third of the population was displaced. Since 1998, Sierra Leone has enjoyed constitutional democracy and regular elections. Many professionals had sought better economic prospects abroad or had fled, with long-term consequences for national development. The new political order in Sierra Leone, with its openness, coupled with rising nationalist sentiment abroad, is persuading swathes of the diaspora to return home.

417 The Economic Community of West African States Monitoring Group was formed by the Economic Community of West African States (ECOWAS) to intervene in the Liberian conflict in 1990.

The population, standing at 6,807,277 in July 2021, comprises 10 distinct groups, with the Krio language serving as the lingua franca, with limited use of English. The population is widely dispersed, with urbanization at 40 per cent. While 60 per cent of the population is under 25 years of age, youth unemployment is estimated at 60 per cent. Little is known of the informal economy and the way this contributes to household resilience.

Sierra Leone placed twenty-fourth in the world for social capital in the *Global Competitiveness Report 2018*. Given the trauma of the civil war period, this high score is perhaps surprising, most likely reflecting the new optimism and government commitment to building fairness and stabilizing the economy. Early measures include free schooling and permitting pregnant schoolgirls to continue their education. It is worth noting that Sierra Leone ranked 117th on the Transparency International Corruption Index in 2020, an improvement from its rank of 130th in 2018.[418]

Agriculture, including fisheries, contributes 60.7 per cent of the country's GDP, industry (beverages, textiles and footwear) contributes 6.5 per cent, and services 32.9 per cent. Some 50 per cent of the population engage in subsistence agriculture. Sierra Leone trade openness (imports plus exports to GDP) stood at 53.52 per cent in 2019 (the world average is 91.6 per cent) with imports to GDP at 37.5 per cent (the world average is 48.6 per cent). Labour remittances stood at 1.29 per cent (the world average is 4.7 per cent).[419]

Natural resources include diamonds, titanium ore (rutile), bauxite, iron ore, gold, and chromite. In addition to mineral extraction and primary processing, the country produces a range of agricultural crops including cassava, rice, vegetables, oil palm fruit, sweet potatoes, milk, citrus, groundnuts, rice, pulses, coffee and cocoa beans.

Photo credit: Annie Spratt on Unsplash

418 Transparency International, "Sierra Leone overview". Available at https://www.transparency.org/en/countries/sierra-leone (accessed on 23 August 2021).
419 The Global Economy, "Sierra Leone: remittances as share of GDP", Global Economy database. Available at https://www.theglobaleconomy.com/Sierra-Leone/remittances_percent_GDP/ (accessed on 23 August 2021).

Sierra Leone is a member of ECOWAS and the Mano River Union that comprises Côte d'Ivoire, Guinea, Liberia and Sierra Leone. The Mano River Union has enabled the improvement of surface transport links. ECOWAS is a very powerful unifier for military cooperation, health, communications, electricity pooling, harmonization of protocols, and visa-free travel. In 2019, ECOWAS announced the introduction of a single currency named the ECO that is to be launched in 2027. Redenomination of the Leone was announced in August 2021, with its face value to be reduced by the removal of three zeros. Inflation is presently 15.7 per cent and bank interest rates are correspondingly high. The impact that the redenomination will have remains moot.

Sierra Leone entered the least developed country group in 1982 as a deeply impoverished agriculture-based economy. The Gini index (World Bank estimate) was reported to be 35.7 in 2018, slightly below the world median level. The United Nations 2021 triennial review of the list of LDCs recorded the country's GNI per capita as US$522, well below the graduation threshold of US$1,222, and far short of the income GNI per capita graduation threshold of US$2,444.[420] GDP stood at nominal US$4.132 billion in 2020.

> **Sierra Leone was one of the main centres of the Ebola epidemic in 2014 and was further destabilized by the 2015 monsoon rains and extreme flooding.**

Risks that limit progress include being a price taker for non-beneficiated mineral exports and the high burden of waterborne and insect vector infectious diseases. Arable land covers 23.4 per cent of the country, with 37.5 per cent being densely forested. Rainfall is plentiful; along the coast it is very heavy, with up to 4,900 mm a year being recorded. Flooding is therefore a perpetual threat.

13.2 Key development challenges

13.2.1 Priorities of the national development agenda

Sierra Leone has adopted the Medium-Term National Development Plan (NDP) 2019–2023, Education for Development: A New Direction for Improving People's Lives through Education, Inclusive Growth, and Building a Resilient Economy. The NDP seeks to achieve middle-income status by 2039 through inclusive growth. Positioning itself in the developmental state paradigm, four major goals were proposed: i) a diversified, resilient green economy; ii) a nation with educated, empowered, and healthy citizens capable of realizing their fullest potential; iii) a society that is peaceful, cohesive, secure, and just; iv) a competitive economy with a well-developed infrastructure.

To enable well-considered prioritization and adjustments, the government intends to lay out a long-term NDP. Sierra Leone seeks to align its NDP with the Mano River Union Strategy, the African Union's Agenda 2063, the SDGs, and the New Deal's Peacebuilding and Statebuilding Goals.

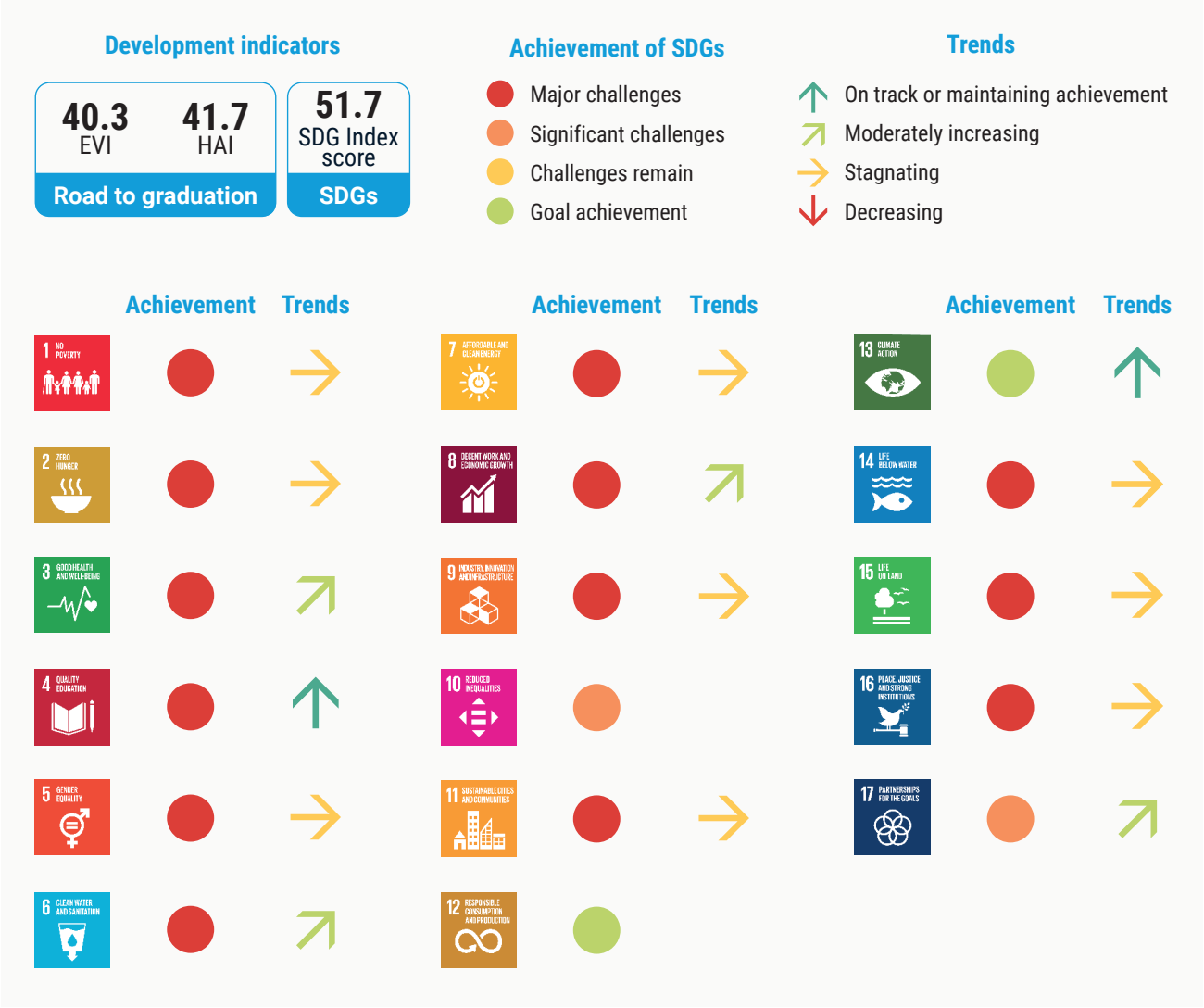
13.2.2 Level of achievement of SDGs

Sierra Leone has now conducted three Voluntary National Assessments of progress towards attainment of the SDGs, with the third focusing on two accelerators: SDG 4 (quality education) and SDG 16 (peace, justice and strong institutions) and nine priority goals for 2021, namely: SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 5 (gender equality), SDG 8 (decent work and economic growth), SDG 10 (reduced inequalities), SDG 12 (responsible consumption and production), 13 (climate action) and SDG 17 (partnerships for the goals).[421, 422]

A near doubling of education expenditure since 2016 drives the gains towards SDG 4, whereas political instability has left SDG 16 unchanged.[423] SDGs 1 and 2 witnessed stagnation as the pandemic pushed food prices higher across West Africa.[424] Delayed progress on SDG 5 is disappointing, given the relatively low gender bias in schooling. However, women's experience under lockdown has been more difficult than for men. Progress on SDGs 9, 11, 14 and 15 stagnated as a result of budget re-prioritization towards education. The gain in SDG 13 may be attributed to the contribution of the UNDP intervention.

420 Paolo Di Lorenzo, Clarence Tsimpo Nkengne, and Thierry Urbain Yogo, *Niger Economic Update: Maximizing Public Expenditure Efficiency for Rebuilding Better* (Washington, D.C., International Bank for Reconstruction and Development and World Bank, 2021).
421 Sierra Leone, Ministry of Planning and Economic Development, *2021 VNR Report on SDGs in Sierra Leone* (2021).
422 Jeffrey D. Sachs and others, *Sustainable Development Report 2021: The Decade of Action for the Sustainable Development Goals* (Cambridge, New York, NY, Port Melbourne, New Delhi and Singapore, Cambridge University Press, 2021).
423 United Nations Educational, Scientific and Cultural Organization, "Homepage". Available at https://en.unesco.org/ (accessed on 13 December 2021).
424 World Food Programme, *State of Food Security in Sierra Leone 2020: Comprehensive Food Security and Vulnerability Analysis* (2020).

Figure 13.2. Progress on the SDG Index in Sierra Leone



Sectors that require concerted action to address the shortcomings noted in the National Voluntary Assessment, the above priority goals and the uneven attainment noted in the *Sustainable Development Report* are as follows. These relate strongly to SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 5 (gender equality), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production), and 13 (climate action).

- **Agriculture, food, water and energy**

Agriculture is the backbone of the economy and rural livelihoods. However, it is estimated that 31 per cent of children aged 6–59 months endure chronic malnutrition with stunting at 27.7 per cent.[425] Under the NDP, the poverty headcount ratio is 57 per cent, recording those living in absolute poverty at 10.8 per cent. Arable land is under-utilized, as are the rich coastal waters. Increasing yields from these is a task for STI, to ensure responsible usage, and sustainable management under the pressure to mechanize.[426]

Health security is jeopardized by inadequate access to potable water and improved sanitation: 55.7 per cent of the rural population in Sierra Leone still collects their drinking water from unprotected sources, with 31.9 per cent of the rural population lacking access to improved sanitation facilities. The provision of affordable potable

425 World Food Programme, *WFP Sierra Leone Country Brief, June 2021* (2021). Available at https://reliefweb.int/report/sierra-leone/wfp-sierra-leone-country-brief-june-2021.
426 Arable land is under-utilized.

water and sanitation systems present immediate challenges for STI-led intervention.

Half of the electricity generated in Sierra Leone is hydropower, another quarter is from renewables and the remainder is from other sources. Access is provided to 26 per cent of households.

> **Two thirds of urban households are connected to the grid, but only 6 per cent of rural households are connected.**

Supply is unreliable, with lengthy outages. This jeopardizes the telecommunications backbone and associated management systems.

- **Climate change and the environment**

Sierra Leone experiences very heavy summer rains, especially along the coast. Climate change will render the coastal zone increasingly vulnerable to erosion, flooding and storm surges that will affect well-being, livelihoods, fishing, tourism and agriculture. Coastal communities are already experiencing considerable repercussions of these impacts, notably on their livelihoods with reduced fishing productivity, ecosystem degradation and low farming outputs.[427] UNDP is supporting the Adapting to Climate Change Induced Coastal Risks Management in Sierra Leone project that will provide high-quality climate risk information, mitigate current and long-term coastal challenges, and design climate-resilient alternatives to sand mining. The outcomes of this initiative will only manifest in the medium term.

Logging activities in rainforest areas are also a cause for concern, due to loss of natural habitat and the effect that this has on drainage patterns.

- **Economy and employment**

Due to a downturn in diamond sales, and declines in mining, transport, trade, and tourism, the economy entered a recession in 2020.[428] Inflation rose to 17 per cent in 2020 and the budget deficit was expected to widen to 5.7 per cent of GDP from 2.9 per cent in 2019. Exports are dominated in value by the contribution of mining, which was as much as 90 per cent in value and was last recorded at 64 per cent for 2018. The recent commodities boom has pulled this figure upward once again.

In Sierra Leone, industrial diversification is constrained by this structural imbalance, as mining companies effectively operate in enclaves so that its Mano River Union neighbours' mining results in "growth without development." Local grievances continue, revolving around ineffectually mitigated land and compensation claims, environmental and social impacts, exclusion from expected employment opportunities, and elite capture of local benefit-sharing.

Sierra Leone displays slightly higher employment vulnerability and lower economic resilience than its African peers and was already facing difficulties pre-COVID-19 as it attempted to absorb its economic shock. As the African Economic Outlook 2021 notes, the size of the government, as well as its well-developed financial services and its export concentration appear to be crucial factors for recovery. Sierra Leone is thereby constrained. Sixty per cent of the population is under 24 years of age, and youth unemployment is estimated at 60 per cent. The vast informal sector provides survival opportunities. The official unemployment rate of 17 per cent must be interpreted in this context.

13.2.3 Relevance of STI to solving these development challenges

The following five priority areas for STI development have been identified:[429] enhanced service delivery, especially in health and education, using smart digitization; enhanced export competitiveness; skills development; improved communications infrastructure; green economy – renewables, especially solar power.

Addressing the priority areas requires funding from local and international sources, the development, transfer, adaptation and adoption of new technologies, and the management skills to implement these in accordance with the goals of inclusion and sustainability.

The most visible application of STI to these challenges will most likely arise from the work of the government. The National Innovation and Digitization strategy (NIDS)

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427 United Nations Development Programme, "Adapting to climate change induced coastal risks management in Sierra Leone". Available at www.adaptation-undp.org/projects/adapting-climate-change-induced-coastal-risks-management-sierra-leone (accessed on 13 December 2021).

428 African Development Bank Group, *African Economic Outlook 2021: From Debt Resolution to Growth: The Road Ahead for Africa* (2021).

429 A single interview was conducted and provided a measure of triangulation for these choices.

sets out to use information and communications technology and emerging Fourth Industrial Revolution applications to build social justice, fairness and equity through responsible management of data, thereby reducing corruption and building trust. Informed by the limited communication bandwidth and the prevalence of entry-level handsets, rather than high-end smartphones, in Sierra Leone, the design and implementation of interoperable multiplatform applications are a priority. The availability of timely, complete, quality data is essential to the above. The goal of open, smart government using best-of-breed technical solutions may go some way towards improving governance, but the human factor will remain pivotal. Addressing the priority areas requires funding from local and international sources; the development, transfer, adaptation and adoption of new technologies; and the management skills to implement these in accordance with the goals of inclusion and sustainability.

- **Specific examples of how STI was applied to challenges**

The eboVAC project that successfully trialled an Ebola vaccine serves as an example of building networks of trust among STI stakeholders and brought together the Janssen Pharmaceutical Companies of Johnson & Johnson, the College of Medicine and Allied Health Sciences, the London School of Hygiene and Tropical Medicine, and the Ministry of Health. Other international collaborators include WHO, Harvard University, the Centers for Disease Control and Prevention (CDC), Kings College, and University College London.

The Directorate of Science, Technology and Innovation (DSTI) has deployed the Government of Sierra Leone Integrated GIS platform, the Free Quality Education Data Hub, and the Electronic Public Expenditure Tracking System (ePETS) a free-of-charge system that is part of the national financial data services mapping platform, used to integrate and track government spending. ePETS replaces the paper-based public financial management system, Public Expenditure Tracking System (PETS) and the Payment Voucher and Commitment Control Forms with a new Electronic Expenditure Management System (EEMS) developed by technologists at the DSTI.

13.2.4 Impact of COVID-19 in Sierra Leone

Sierra Leone remains vulnerable to the COVID-19 pandemic and has progressed through a third wave. The government launched a timely national response when the first cases of COVID-19 were identified in April 2020, and as at 20 August 2021, had recorded 6,347 confirmed cases and 121 deaths as a result of COVID-19. The significant improvement in post-Ebola surveillance suggests that these figures may be reliable, with responsibility for tracking laying with the Directorate of Health Security and Emergencies (DHSE) of the Ministry of Health and Sanitation. As such, DHSE is the national focal point for health security that is provided in accordance with WHO International Health Regulations. Radio remains the leading media channel in Sierra Leone, with 81 per cent of the population having access to it – this was capitalized on through the Radio Teaching Programme that has enabled schooling to continue during lockdowns. Given the vulnerability of the general population, lockdowns have been restricted to short periods of three days. This action seems to have been effective in slowing the spread of the disease so that health facilities have been able to cope.

The United Nations Committee for Development Policy has assessed the impact of COVID-19 on least developed countries and this assessment shows that Sierra Leone has been unable to obtain the necessary fiscal stimulus to mitigate the loss of livelihoods and the downturn in trade and services. There was a fiscal shortfall of 7 per cent in 2020, and limited savings on debt service suspension. GDP has contracted by nearly 8 per cent compared with the expansion of 2.5 per cent that was expected before the pandemic. Food insecurity has risen sharply from 53.4 per cent in August 2019 to 63 per cent in June 2020. The country is expected to experience an extended financial crisis that will affect its domestic and global prospects. However, despite the hardships, the Sierra Leone Human Capital Index remained steady, at 0.37 in 2017 and 0.38 in 2020. National-level safety nets are, so far, limited to a World Bank-supported project that targets 35,000 of the poorest households, a measure that falls short of the reality of 70 per cent of its population living in poverty.

- **Concrete examples of how STI have been successfully used to tackle COVID-19**

The Ebola shock of 2014–2016 drew in worldwide experience, that together with the government and the College of Medicine and Allied Health Sciences, form the basis for the present surveillance, diagnosis and control systems that have been applied to COVID-19 mitigation. Reference and diagnostic laboratories, including PCR technology, were put in place, and staff were trained up to best-practice standards. These mitigations are science-led, and include barrier management, treatment and social mitigation.

13.3 STI snapshot

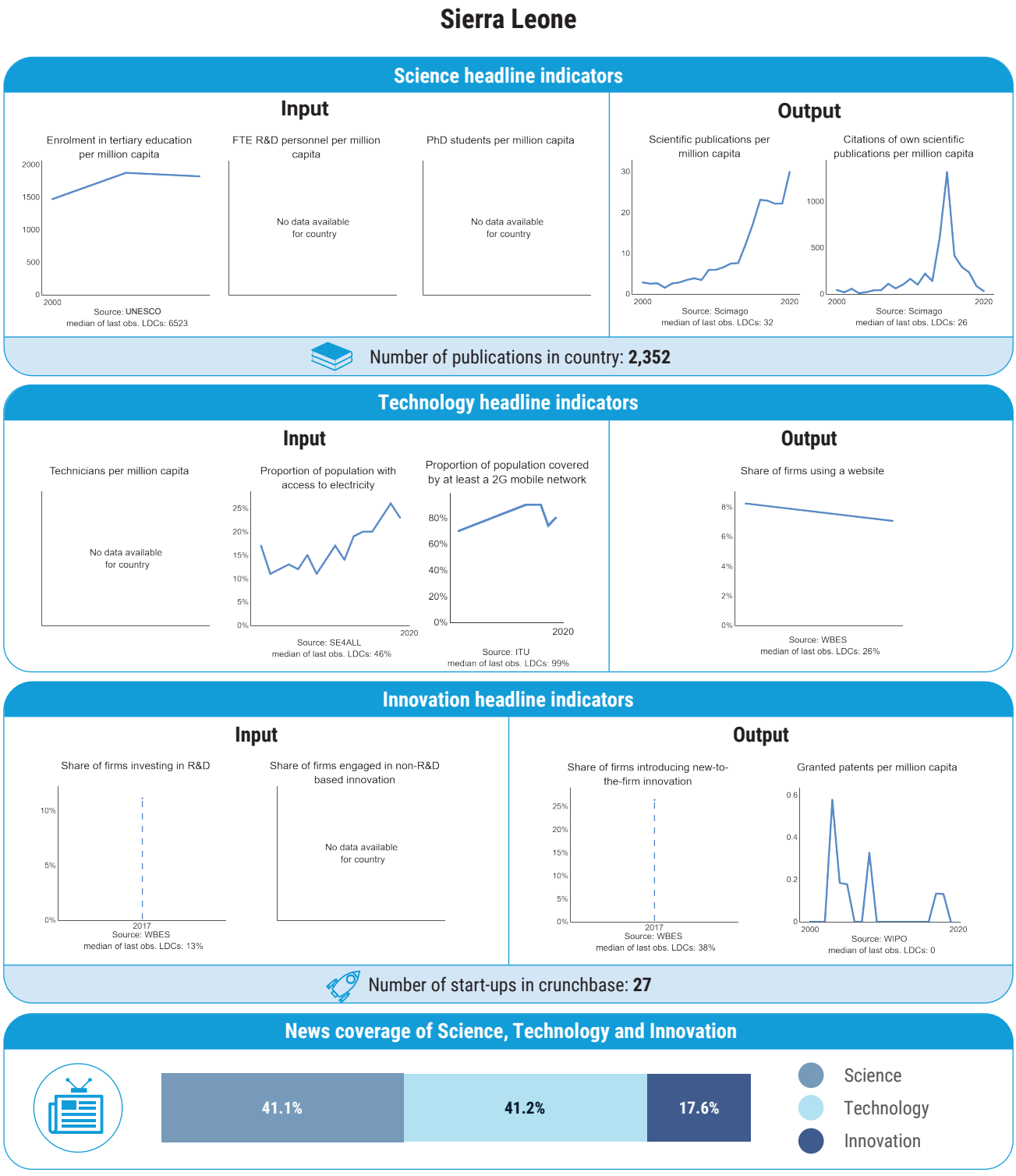
13.3.1 STI system SWOT analysis

Table 13.1. Strengths, weaknesses, opportunities, and threats of the national STI system in Sierra Leone

Strengths	Weaknesses
• Presidential-level champion of STI • STI policy coordination through the DSTI and NIDS • Long university tradition with pockets of world-class health research • World-class biosafety regime provides leadership in research on neglected tropical diseases • Free schooling • Girl-positive policies that reduce gender-based violence • Relative ease to start a business (ranking of 58 of 191)	• Unreliable energy supply and limited telecommunications • Underdeveloped private sector with low demand for R&D • Small stock of researchers • Teachers and lecturers lack adequate training and qualifications • Shortage of funds for innovation and R&D
Opportunities	**Threats**
• Further roll-out of the NIDS under the leadership of the DSTI • Entry into multinational corporation value chains such as food processing, mineral refining and precious metals value chains • Demographic dividend via youthful population, provided education and employment are addressed • Development of scientific and technical services as an adjunct to industrial diversification • Linkages with diaspora and integration of returnees into the innovation system and industry • Networking with the diaspora, the “invisible college” of science, international donors and foundations • Protection of indigenous knowledge and sensitive incorporation into health, agriculture and pharmaceuticals • Establishment of an innovation fund as a bridge for start-ups and entry into value chains	• Environmental depletion, poaching and smuggling • Climate change (long-term) • Brain drain

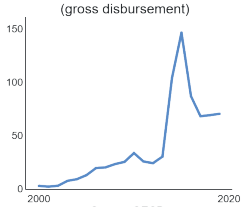
13.3.2 Key features of the STI system in Sierra Leone

Figure 13.3. Key features of the STI system in Sierra Leone



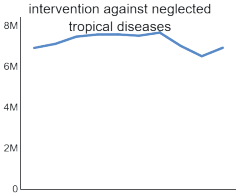
STI & COVID-19 & Health

SDG 3.b.2 Total ODA to health (gross disbursement)



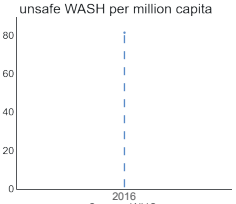
Source: OECD
median of last obs. LDCs: 70

SDG 3.3.5 People requiring intervention against neglected tropical diseases



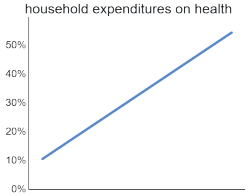
Source: WHO
median of last obs. LDCs: 5996196

SDG 3.9.2 Deaths attributed to unsafe WASH per million capita



Source: WHO
median of last obs. LDCs: 34

SDG 3.8.2 Share of pop. with large household expenditures on health

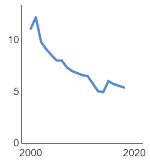


Source: WHO
median of last obs. LDCs: 9%

Publications 129: 5% of publications **Start-ups in crunchbase** 2: 7% of start-ups

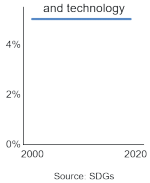
STI & Clean Energy

SDG 7.3.1 Energy intensity level of primary energy



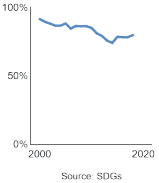
Source: SDGs

SDG 7.1.2 Share of population with primary reliance on clean fuels and technology



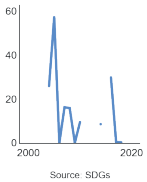
Source: SDGs

SDG 7.2.1 Renewable energy share of energy consumption



Source: SDGs

SDG 7.a.1 ODA for clean energy research and development

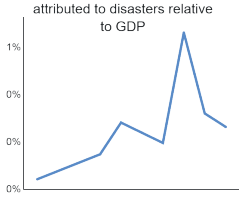


Source: SDGs

Publications 6: 0.3% of publications **Start-ups in crunchbase** 1: 3% of start-ups

STI & Climate Adaptation

SDG 11.5.2 Direct economic loss attributed to disasters relative to GDP



Source: UNISDR
median of last obs. LDCs: 0%

SDG 1.5.2 Direct agriculture loss attributed to disasters

No data available for country

SDG 13.1.1 Mainstreaming of sustainable development education in curricula

No data available for country

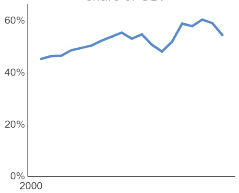
SDG 11.b.2 Share of local governments that implement local DRR strategies

No data available for country

Publications 0: 0% of publications **Start-ups in crunchbase** 0: 0% of start-ups

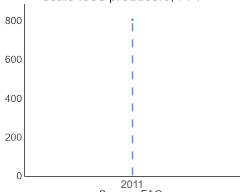
STI & Agriculture

SDG 2.a.1 Agriculture value added share of GDP



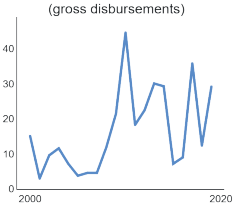
Source: FAO
median of last obs. LDCs: 22%

SDG 2.3.2 Average income of small-scale food producers, PPP



Source: FAO
median of last obs. LDCs: 714

SDG 2.a.2 Total ODA to agriculture (gross disbursements)



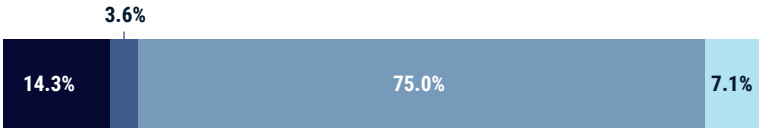
Source: OECD
median of last obs. LDCs: 63

SDG 2.a.1 Agriculture share of Government Expenditure

No data available for country

Publications 3: 0.1% of publications **Start-ups in crunchbase** 0: 0% of start-ups

News coverage of thematic areas



- Agriculture
- Climate adaptation
- Health
- Renewable energy

- **The innovation system, knowledge development and diffusion**

Linkages are central to the very concept of an innovation system. In Sierra Leone, linkage takes the form of knowledge exchange, whereby graduates are equipped with up-to-date skills in engineering, medicine, accounting, logistics, business management and so on. Academics in the country are also in a position to offer consultancy advice to the public and private sectors. Given the small size of the research system, basic research will be unlikely to inform business activity. However, there may be user-driven applied research on a limited scale.

As for other least developed countries, frontier basic research is rare in Sierra Leone. R&D and knowledge development are important innovation activities for firms that are operating at the knowledge frontier, and for public research organizations that engage in applied research, technology transfer and improvement. These activities are characterized by indicators that include R&D expenditure, scientific publications, the rate of introduction of innovations, the entry of firms into new markets and value chains, and the registration of intellectual property in the form of patents, copyright, designs, plant cultivars and animal breeds. Regarding intellectual property, the WIPO Patent Statistics recorded two patent applications in Sierra Leone in 2019, and 205 trademark registrations, putting the country into 112th place.[430] The Global Competitiveness Index for 2018 ranks the country in 101st place out of the 140 countries in the rankings for patenting per million. R&D expenditure in Sierra Leone is currently undetermined; the data gap of the inputs to R&D – namely expenditure and labour, distribution by field, and sources of funds – presents a challenge to informed STI policy formulation.

The Sierra Leone research system is weighted towards the public sector. The leading higher education institution is the University of Sierra Leone, the successor to Fourah Bay College that was founded in 1827 and became the leading English-medium university in West Africa, attracting students from across the region. The College of Medicine and Allied Health Sciences was added to the University of Sierra Leone in 1987. Njala University was established as the Njala Agricultural Experimental Station in 1910 and became a full university in 2005. Universities are the main producers of scientific publications in the country, with a strong orientation towards public health. However, few university staff hold doctoral degrees, which consequentially limits the universities' role as sites for doctoral study. They are also severely understaffed, with lecturer–student ratios of up to 100:1. Sierra Leoneans therefore seek postgraduate study opportunities abroad, especially in the United Kingdom and the United States of America.

Research production in Sierra Leone is lacking: in the 2016–2020 period, a total of 1,061 publications were indexed on the Web of Science for authors citing an address in Sierra Leone. The top 10 science categories were all in the area of health sciences, with 25.6 per cent in public, environmental and occupational health, followed by 18.4 per cent in infectious diseases and 10.9 per cent in tropical medicine. Scientists from Sierra Leone collaborate with their peers in the United States of America, England, China, the Netherlands and South Africa, and are often highly cited.

The new Directorate of Science, Technology and Innovation (DSTI) in Sierra Leone[431] is a hybrid government research institute that develops policy and performs research into information and communications technology. Its website describes the 20 active researchers on its staff as "a diverse group of thinkers, strategists, coders, analysts, artists and problem solvers. All units work closely together to ensure the vision of DSTI is achieved." The Head of DSTI holds the office of Chief Innovation Officer and is active in networking with the development banks, multilateral agencies, major donors, trusts and foundations. This empowers DSTI to be a forward-thinking knowledge hub that supports evidence-based policymaking alongside its educative function. Its activities include modelling the factors of education attainment and strengthening database integrity and database interoperability.

No up-to-date data on gross national expenditure on R&D are available. It is, however, possible to make some estimates based on reported R&D activities. As an important R&D node, DSTI provides a starting point. At a total cost of employment of US$50,000 per annum per researcher, DSTI could account for US$2 million of annual government expenditure on R&D.[432]

A second important activity is that of official clinical trials research as authorized by the Sierra Leone Pharmacy

430 World Intellectual Property Organization, "Statistical country profiles, Sierra Leone" (2019). Available at https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=SL (accessed on 29 December 2021).
431 See www.dsti.gov.sl/team/.
432 Average salary in Freetown. See www.averagesalarysurvey.com/freetown-sierra-leone.

Board, for example those working towards Ebola vaccines in the 2015–2018 period that involved the United States Centers for Disease Control and Prevention, the University of Sierra Leone, and the U.S. Department of Health and Human Services. Clinical trials in phases 1 to 3 are considered as R&D as defined in the Frascati Manual. The large-scale EBOVAC investigation entailed expenditures of at least €4.78 million.[433] This figure excludes the costs of local facilities and local staff. Scrutiny of the US resource www.clinicaltrials.org reveals nine active clinical trials that might account for US$10 to 20 million of annual expenditure. Given the nature of the industrial system, for which purpose-ready extraction plant is imported, it is likely that little R&D is taking place in the business sector, though there may be some R&D in services, especially software and applications.

Based on these activities, a conservative estimate puts annual gross expenditure on R&D (GERD) at ±US$10 million, representing 0.25 per cent of GDP. It must be emphasized that the bulk of the expenditure is on the fieldwork associated with clinical trials, and it cannot therefore impact on industrial development.

- **Infrastructure**

Functional innovation systems require the necessary knowledge, communication and utilities infrastructure to be productive. This infrastructure includes knowledge institutions (which were addressed earlier) and regulatory bodies. Typical regulatory bodies are in place in the country and the Sierra Leone Standards Bureau is the focal point for standards, certification and metrology.

The Sierra Leone Intellectual Property Office manages intellectual property rights for the country, which is a member of the Paris, Berne and Rome Conventions, the PCT, the African Regional Intellectual Property Organization via the Banjul Protocol, and the Madrid Agreement and Protocol. Sierra Leone also subscribes to the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement).

Shortcomings in electricity supply are a major problem. Regarding telecommunication systems, the World Factbook notes that the country's "telecom sector is recovering from the decades of war, yet (is) still constrained by inadequate power and pervasive corruption; recently installed terrestrial fibre backbone infrastructure; telephone service improving with the rapid growth of mobile sector; operators increased investment to provide national coverage; LTE available in some parts of the country; construction of 600 km ECOWAS Wide Area Network completed; fibre link to Guinea completed; importer of broadcasting equipment from China (2020)".[434]

Overall, the necessary knowledge infrastructure is weak, some pockets of excellence aside.

- **Framework conditions**

The framework conditions of Sierra Leone are shaped by a commitment to macroeconomic stability and inflation tracking. Western legal systems apply, with protection of property rights and the rule of law. Starting in August 2018, free education was introduced for primary and secondary school students in public schools throughout Sierra Leone. Application fees for students in government-run public universities were set aside, and a US$400 million loan from China for a new international airport was cancelled.

Sierra Leone's National Bank Corporation and the Bank of Sierra Leone (BSL) seed fintech and financial services have established a regulatory sandbox to enable small-scale testing and deployment of innovative fintech products, services and solutions in a live controlled environment. The Sierra Leone Investment and Export Promotion Agency provides extensive financial incentives, including accelerated depreciation, reduced taxation, and exemption of duties.[435] A special economic zone was established outside Freetown in 2011. It offers three-year tax holidays and is structured as a public-private partnership.

The Ministry of Trade and Industry oversees the regulation of anti-competitive practices. The Cabinet has approved a Competition Policy and a Consumer Protection Policy, but no enabling legislation is yet in place.

There have been efforts towards creating an investor-friendly operating environment, but this is yet to produce results.

433 Thomas Mooney and others, "Lessons learned from implementing an Ebola vaccine trial in an Ebola-affected country", *Clinical Trials*, vol. 15, No. 5 (October 2018).
434 Central Intelligence Agency, The world factbook: Sierra Leone (2021). Available at https://www.cia.gov/the-world-factbook/countries/sierra-leone/ (accessed on 29 December 2021).
435 Sierra Leone Investment & Export Promotion Agency, "Fiscal and financial incentive and special zones" (n.d.).

- **Governance**

The governance of the innovation system is vested in DSTI, established by the presidency in 2018 and headed by the Chief Innovation Officer. The previous Ministry of Higher Education, Science and Technology became the Ministry of Technical and Higher Education.

DSTI drives the Sierra Leone National Innovation and Digital Strategy (NIDS) 2019–2029, which expresses the country's goal of becoming a global leader in digital agile governance "by focusing on effective service delivery, citizen engagement, and the digital economy driven by innovation and entrepreneurship. Such a transformation will reduce the cost of governance and reduce corruption while increasing national productivity".[436] The NIDS strapline Digitization for All: digital identity; digital economy; and digital governance "embodies the realization that technology and scientific advances will fail to deliver national development and good governance for every citizen if digitization is not inclusive and available for all: the literate and illiterate, urban and rural dwellers, young and old, men and women, companies and individuals, public and private sector."[437]

The NIDS is a visionary statement that seeks to build on Fourah Bay College's nearly 200-year history of educational provision. "Today, [Sierra Leone] dreams of being a centre of excellence for the development, application and use of state-of-the-art technology and innovation for the benefit of all Sierra Leoneans and mankind through the Philosophy of Digitization for all."

The NIDS seeks to expand the use of mobile devices and platforms. Present estimates put mobile penetration at 104 per cent. While on the low side by international standards, this should be seen in the context of fixed-line availability, for which Sierra Leone ranks 210th in the world. The intention is to exploit digital data and applied AI to work towards social and economic goals, for which the necessary regulatory framework is being developed. This will include personal data protection.

13.3.3 Resilience of the national innovation system in Sierra Leone

A number of the least developed countries have experienced recent civil disorder, epidemics or natural disasters. Sierra Leone has experienced and survived all three, and has achieved major learnings in public health. The College of Medicine and Allied Health Sciences is now a respected research partner of leading international research organizations.

Prior experience in dealing with the Ebola epidemic, coupled with new leadership and access to international funding, have translated into a host of innovative actions driven by the COVID-19 pandemic. When resources are limited, it is sensible to concentrate efforts where benefits have been assessed to be feasible.

The decision made in 2018 to centralize research and innovation policy, strategy and information and communications technology interventions at the presidential level within DSTI has proved to be inspired, and may serve as an exemplar to other least developed countries and emerging and industrialized economies.

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Interviewee

Prof Moses Bockarie, Njala University

Appendix A: Interview guides

Government

1. Background

1. What is your role within this organization?

2. Did you receive our survey? Have you responded yet? Did you experience difficulties?

(There are many questions in the survey to map the national innovation system. If survey responses have not been submitted yet, please briefly describe whether there is a national science, technology and innovation (STI) policy, how governance is structured, and the main instruments for implementing this policy.)

3. What are the key documents that our researchers should have access to? Could you share documents/links?

2. SWOT of the STI system

4. To your knowledge, what are the priority areas in enhancing STI systems? (e.g. planning, budgeting and programming STI; financing STI; gender equality; advocacy; science, technology, engineering and mathematics (STEM) education). Why?

5. What are the strengths, weaknesses, opportunities and threats regarding your current STI system? (e.g. research infrastructure; industrial tech/training bodies; clusters and companies in niche fields; regulatory framework; and collaboration between all these e.g. between researchers and the Government or between academia, industry and the Government, known as the triple helix).

6. What do you think are the most important enabling factors for STI development in your country (or in general)? (e.g. the Fourth Industrial Revolution, regional and subregional cooperations, absorptive capacities, indigenous knowledge, civil society, role of diaspora). How can these enabling factors be boosted in your country? Is the Government already doing something to this effect?

7. What do you think are the most important factors hindering STI development in your country (or in general)? How can these factors be reduced, or dealt with, in your country? Is the Government already doing something to this effect?

3. Development challenges

8. In general, what are some of the main economic and human strengths in your country? On the other hand, what are some of the main challenges/areas of fragility faced by your country right now?

9. How close is your country to graduating (as an MIC)? What appear to be key drivers for country development and achievement of graduation?

10. In your opinion, could STI development go some way towards addressing challenges and graduation goals? How? Please give examples of STI being successfully used to address key challenges in your country.

11. How has your country been impacted by COVID-19? Has the COVID-19 pandemic undermined gains that had been made in STI development in your country? Has the COVID-19 pandemic energized STI development in any way?

12. Did the Government provide any incentives for STI solutions to tackle the COVID-19 pandemic?

13. Do you think the development of STI in the least developed countries could help or hinder areas of fragility and how? What about gender equality? Climate change? What are the risks linked to STI development?

4. Best practices and replicability

14. Can you identify any best practices in your country regarding government initiatives for STI development? What are the drivers for the success of these initiatives/practices?

15. Can you identify any grass-roots innovation initiatives in your country? If so, who set them up, what is their purpose (what need do they address?), which resources do they use and how does knowledge transfer occur? Which factors encouraged this particular innovation to take place?

16. Are there any indigenous knowledge systems that are unique to your country? Are these knowledge systems being maintained? How? Are they effectively integrated into more mainstream knowledge systems? (e.g. academic research to assess the effectiveness of traditional medicine practices).

17. Which initiatives – whether government, grass-roots or other – have been less successful in your country at developing STI? Why do you think they were not successful?

5. Future outlook

18. What do you consider to be the most important current and future trends in STI development in your country? (e.g. digital transformation, the Fourth Industrial Revolution, closing the technology gap, producing cutting-edge technology, gender equality in STI, STEM education, open innovation/open science, increased economic competitiveness)

19. How do you support these trends?

Think tanks

5. Background

1. What is your role within this organization?

2. Can you briefly describe the key features of the national innovation system? (e.g. national STI policy, how governance is structured, and the main instruments for implementing this policy)

3. What are the key documents that our researchers should have access to? Could you share documents/links?

6. SWOT of the STI system

4. To your knowledge, what are the priority areas in enhancing STI systems? (e.g. planning, budgeting and programming STI; financing STI; gender equality; advocacy; STEM education) Why?

5. What are the strengths, weaknesses, opportunities and threats regarding your current STI system? (e.g. research infrastructure; industrial tech/training bodies; clusters and companies in niche fields; regulatory framework; and collaboration between all these e.g. between researchers and the Government or between academia, industry and the Government, known as the triple helix) What role can think tanks play in encouraging STI development in your country?

6. What do you think are the most important enabling factors for STI development in your country (or in general)? (e.g. the Fourth Industrial Revolution, regional and subregional cooperations, absorptive capacities, indigenous knowledge, civil society, role of diaspora). How can these enabling factors be boosted in your country? Is the Government already doing something to this effect?

7. What do you think are the most important factors hindering STI development in your country (or in general)? How can these factors be reduced, or dealt with, in your country? Is the Government already doing something to this effect?

7. Development challenges

8. In general, what are some of the main economic and human strengths in your country? On the other hand, what are some of the main challenges/areas of fragility faced by your country right now?

9. How close is your country to graduating (as an MIC)? What appear to be key drivers for country development and achievement of graduation?

10. In your opinion, could STI development go some way towards addressing challenges and graduation goals? How? Please give examples of STI being successfully used to address key challenges in your country.

11. How has your country been impacted by COVID-19? Did the COVID-19 pandemic undermine gains that had been made in STI development in your country? Did the COVID-19 pandemic energize STI development in any way?

12. Did the Government provide any incentives for STI solutions to tackle the COVID-19 pandemic?

13. Do you think the development of STI in the least developed countries could help or hinder gender equality in your country/stakeholder group? Why? Do you think the development of STI in the least developed countries could help or hinder climate change issues in your country/stakeholder group? Why?

8. Best practices and replicability

14. Can you identify any best practices in your country regarding government initiatives for STI development? What are the drivers for the success of these initiatives/practices?

15. Can you identify any grass-roots innovation initiatives in your country? If so, who set them up, what is their purpose (what need do they address?), which resources do they use and how does knowledge transfer occur? Which factors encouraged this particular innovation to take place?

16. Are there any indigenous knowledge systems that are unique to your country? Are these knowledge systems being maintained? How? Are they effectively integrated into more mainstream knowledge systems? (e.g. academic research to assess the effectiveness of traditional medicine practices).

17. Which initiatives – whether government, grass-roots or other – have been less successful in your country at developing STI? Why do you think they were not successful?

9. Future outlook

18. What do you consider to be the most important current and future trends in STI development in your country? (e.g. digital transformation, the Fourth Industrial Revolution, closing the technology gap, producing cutting-edge technology, gender equality in STI, STEM education, open innovation/open science, increased economic competitiveness)

19. How do you support these trends?

Higher education/research institutions

10. Background

1. What is your role within this organization?

2. Can you briefly describe the key features of the higher education/research system in your country?

3. What are the key documents that our researchers should access? Could you share documents/links?

11. SWOT of the STI system

4. To your knowledge, what are the priority areas in enhancing STI systems? (e.g. planning, budgeting and programming STI; financing STI; gender equality; advocacy; STEM education) Why?

5. What are the strengths, weaknesses, opportunities and threats regarding your current STI system? (e.g. research infrastructure; industrial tech/training bodies; clusters and companies in niche fields; regulatory framework; and collaboration between all these e.g. between researchers and the Government or between academia, industry and the Government, known as the triple helix).

6. What do you think are the most important enabling factors for STI development in your country (or in general)? (e.g. the Fourth Industrial Revolution, regional and subregional cooperations, absorptive capacities, indigenous knowledge, civil society, role of diaspora). How can these enabling factors be boosted in your country? Is the Government already doing something to this effect?

7. What do you think are the most important factors hindering STI development in your country (or in general)? How can these factors be reduced, or dealt with, in your country? Is the Government already doing something to this effect?

12. Development challenges

8. In general, what are some of the main economic and human strengths in your country? On the other hand, what are some of the main challenges/areas of fragility faced by your country right now?

9. How close is your country to graduating (as an MIC)? What appear to be key drivers for country development and achievement of graduation?

10. In your opinion, could STI development go some way towards addressing challenges and graduation goals? How? Please give examples of STI being successfully used to address key challenges in your country.

11. How has your country been impacted by COVID-19? Did the COVID-19 pandemic undermine gains that had been made in STI development in your country? Did the COVID-19 pandemic energize STI development in any way?

12. Did the Government provide any incentives for STI solutions to tackle the COVID-19 pandemic?

13. Do you think the development of STI in the least developed countries could help or hinder gender equality in your country/stakeholder group? Why? Do you think the development of STI in the least developed countries could help or hinder climate change issues in your country/stakeholder group? Why?

13. Best practices and replicability

14. Can you identify any best practices in your country regarding government initiatives for STI development? What are the drivers for the success of these initiatives/practices?

15. Can you identify any grass-roots innovation initiatives in your country? If so, who set them up, what is their purpose (what need do they address?), which resources do they use and how does knowledge transfer occur? Which factors encouraged this particular innovation to take place?

16. Are there any indigenous knowledge systems that are unique to your country? Are these knowledge systems being maintained? How? Are they effectively integrated into more mainstream knowledge systems? (e.g. academic research to assess the effectiveness of traditional medicine practices).

17. Which initiatives – whether government, grass-roots or other – have been less successful in your country at developing STI? Why do you think they were not successful?

14. Future outlook

18. What do you consider to be the most important current and future trends in STI development in your country? (e.g. digital transformation, the Fourth Industrial Revolution, closing the technology gap, producing cutting-edge technology, gender equality in STI, STEM education, open innovation/open science, increased economic competitiveness)

19. How do you support these trends?

Incubators/accelerators

15. Background

1. What is your role within this organization?

2. Can you briefly describe the key features of incubation/acceleration in your country?

3. What are the key documents that our researchers should access? Could you share documents/links?

16. SWOT of the STI system

4. To your knowledge, what are the priority areas in enhancing STI systems? (e.g. planning, budgeting and programming STI; financing STI; gender equality; advocacy; STEM education) Why?

5. What are the strengths, weaknesses, opportunities and threats regarding your current STI system? (e.g. research infrastructure; industrial tech/training bodies; clusters and companies in niche fields; regulatory framework; and collaboration between all these e.g. between researchers and the Government or between academia, industry and the Government, known as the triple helix).

6. What do you think are the most important enabling factors for STI development in your country (or in general)? (e.g. the Fourth Industrial Revolution, regional and subregional cooperations, absorptive capacities, indigenous knowledge, civil society, role of diaspora). How can these enabling factors be boosted in your country? Is the Government already doing something to this effect?

7. What do you think are the most important factors hindering STI development in your country (or in general)? How can these factors be reduced, or dealt with, in your country? Is the Government already doing something to this effect?

17. Development challenges

8. How has your country been impacted by COVID-19? Did the COVID-19 pandemic undermine gains that had been made in STI development in your country? Did the COVID-19 pandemic energize STI development in any way?

9. Did the Government provide any incentives for STI solutions to tackle the COVID-19 pandemic?

10. Do you think the development of STI in the least developed countries could help or hinder gender equality in your country/stakeholder group? Why? Do you think the development of STI in the least developed countries could help or hinder climate change issues in your country/stakeholder group? Why?

18. Best practices and replicability

11. Can you identify any best practices in your country regarding government initiatives for STI development? What are the drivers for the success of these initiatives/practices?

12. Can you identify any grass-roots innovation initiatives in your country? If so, who set them up, what is their purpose (what need do they address?), which resources do they use and how does knowledge transfer occur? Which factors encouraged this particular innovation to take place?

13. Are there any indigenous knowledge systems that are unique to your country? Are these knowledge systems being maintained? How? Are they effectively integrated into more mainstream knowledge systems? (e.g. academic research to assess the effectiveness of traditional medicine practices).

14. Which initiatives – whether government, grass-roots or other – have been less successful in your country at developing STI? Why do you think they were not successful?

19. Future outlook

15. What do you consider to be the most important current and future trends in STI development in your country? (e.g. digital transformation, the Fourth Industrial Revolution, closing the technology gap, producing cutting-edge technology, gender equality in STI, STEM education, open innovation/open science, increased economic competitiveness)

16. How do you support these trends?

Interview guidelines: financers/civil society/private sector

20. Background

1. What is your role within this organization?

2. Can you briefly describe the key features of the financing system/civil society/private sector in your country?

3. What are the key documents that our researchers should access? Could you share documents/links?

21. SWOT of the STI system

4. To your knowledge, what are the priority areas in enhancing STI systems? (e.g. planning, budgeting and programming STI; financing STI; gender equality; advocacy; STEM education) Why?

5. What are the strengths, weaknesses, opportunities and threats regarding your current STI system? (e.g. research infrastructure; industrial tech/training bodies; clusters and companies in niche fields; regulatory framework; and collaboration between all these e.g. between researchers and the Government or between academia, industry and the Government, known as the triple helix).

6. What do you think are the most important enabling factors for STI development in your country (or in general)? (e.g. the Fourth Industrial Revolution, regional and subregional cooperations, absorptive capacities,

indigenous knowledge, civil society, role of diaspora). How can these enabling factors be boosted in your country? Is the Government already doing something to this effect?

7. What do you think are the most important factors hindering STI development in your country (or in general)? How can these factors be reduced, or dealt with, in your country? Is the Government already doing something to this effect?

22. Development challenges

8. How has your country been impacted by COVID-19? Did the COVID-19 pandemic undermine gains that had been made in STI development in your country? Did the COVID-19 pandemic energize STI development in any way?

9. Did the Government provide any incentives for STI solutions to tackle the COVID-19 pandemic?

10. Do you think the development of STI in the least developed countries could help or hinder gender equality in your country/stakeholder group? Why? Do you think the development of STI in the least developed countries could help or hinder climate change issues in your country/stakeholder group? Why?

23. Best practices and replicability

11. Can you identify any best practices in your country regarding government initiatives for STI development? What are the drivers for the success of these initiatives/practices?

12. Can you identify any grass-roots innovation initiatives in your country? If so, who set them up, what is their purpose (what need do they address?), which resources do they use and how does knowledge transfer occur? Which factors encouraged this particular innovation to take place?

13. Are there any indigenous knowledge systems that are unique to your country? Are these knowledge systems being maintained? How? Are they effectively integrated into more mainstream knowledge systems? (e.g. academic research to assess the effectiveness of traditional medicine practices).

14. Which initiatives – whether government, grass-roots or other – have been less successful in your country at developing STI? Why do you think they were not successful?

24. Future outlook

15. What do you consider to be the most important current and future trends in STI development in your country? (e.g. digital transformation, the Fourth Industrial Revolution, closing the technology gap, producing cutting-edge technology, gender equality in STI, STEM education, open innovation/open science, increased economic competitiveness).

16. How do you support these trends?

Appendix B: Stakeholder consultation by country

Table B1. Stakeholder consultation by country

Country	Government	Higher education and research centres	Think tanks	Incubators and accelerators	Private sector	Civil society	Financers	Development partners	Total
Bangladesh	6	3				2			11
Burkina Faso	1	2		1	3	1			8
Cambodia				1					1
Democratic Republic of the Congo	1	3		1	1	1			7
Lao People's Democratic Republic	2								3
Lesotho	1	4			2				7
Mauritania	2	1							3
Mozambique	2	1					1		4
Myanmar	1	1			2				4
Niger		2			3	1	1		7
Rwanda	4	2		1	2	1		1	11
Sierra Leone		1							1
Pacific Islands		2							2

Appendix C: Quantitative data collection

Data for traditional indicators

The data for traditional indicators are based on data provided by other United Nations organizations and international agencies. Table C1 provides an overview of the sources, metadata and overlap with SDG indicators for each of the included indicators.

Table C1. Overview of indicators, source, metadata and possible overlap with SDG indicators

Indicator	Short description of indicator	Source	Link to metadata	Overlap with SDG indicator
Indicators for introduction infographic				
Human Assets Index	Index of education and health indicators	UN Capital Development Fund (UNCDP)	https://ferdi.fr/dl/df-8Xb3gamq6g2dPcnuf4NdnAE/ferdi-p179-human-assets-index-retrospective-series-2016-update.pdf	
Poverty level	Percentage of the population living on less than US$1.90 a day	World Bank	https://databank.worldbank.org/source/world-development-indicators	
Fragile States Index	Index of various State-level risks and vulnerabilities	Fund for Peace	https://fundforpeace.org/wp-content/uploads/2020/05/fsi2020-report.pdf	
Gross national income (GNI) per capita	GNI over midyear population	UNCDP	http://data.un.org/Data.aspx?d=SNAAMA&f=grID:103;currID:USD;pcFlag:1	
Growth of real gross domestic product (GDP) per employed person	Percentage annual growth of real GDP per employed person	International Labour Organization (ILO)	https://ilostat.ilo.org/data/	SDG 8.2.1
Economic growth	Projected percentage change in GDP	International Monetary Fund (IMF)	https://www.imf.org/en/Publications/WEO/Issues/2021/10/12/world-economic-outlook-october-2021	
Economic and Environmental Vulnerability Index	Index of various economic risks	UNCDP	https://ferdi.fr/dl/df-cT7xN1CvmPnbwrmfA6gYL7hf/ferdi-i9-the-economic-vulnerability-index.pdf	
Unemployment	Unemployed people as a percentage of the labour force	World Bank / ILO	https://ilostat.ilo.org/data/; https://databank.worldbank.org/ reports.aspx?source=2&type=metadata&series=SL.UEM.TOTL.ZS	
Informal / vulnerable employment	Percentage of labour force belonging to International Classification of Status in Employment (ICSE-93) cate-gories 3) own-account workers, or 5) contributing family workers	ILO	https://ilostat.ilo.org/data/; https://ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/publication/wcms_631497.pdf	

Indicators for STI infographic				
Enrolment in tertiary education	Percentage of enrolment in post-secondary institutions	United Nations Educational, Scientific and Cultural Organization (UNESCO)	http://data.uis.unesco.org/#	
Full-time equivalent (FTE) research and development (R&D) personnel per million capita	FTE of R&D personnel (total working hours spent on R&D over a year) per million capita	UNESCO	http://data.uis.unesco.org/#	
PhD students per million capita	Number of PhD students per million capita	UNESCO	http://data.uis.unesco.org/#	
Scientific publications per million capita	Scientific publications by at least one author from the country, per million capita	SCImago	https://www.scimagojr.com/aboutus.php	
Citations of own scientific publications per million capita	Citations of publications by at least one author from the country, per million capita	SCImago	https://www.scimagojr.com/aboutus.php	
Technicians per million capita	Number of technicians per million capita	UNESCO	http://data.uis.unesco.org/#	
Proportion of population covered by at least 2G network	Proportion of population cov-ered by a mobile network of at least 2G	International Telecommunication Union (ITU)	https://www.itu.int/en/ITU-D/Statistics/Pages/datacollection/default.aspx	
Share of population using the Internet	Share of population actively using the Internet	ITU	https://www.itu.int/en/ITU-D/Statistics/Pages/datacollection/default.aspx	
Share of firms using a website	Percentage of firms using a website for business-related activities such as sales or product promotion	World Bank Enterprise Surveys (WBES)	https://www.enterprisesurveys.org/content/dam/enterprisesurveys/documents/Indicator-Descriptions.pdf	
Share of firms investing in R&D	Percentage of firms making investments in R&D	WBES	https://www.enterprisesurveys.org/content/dam/enterprisesurveys/documents/Indicator-Descriptions.pdf	
Share of firms engaged in non-R&D-based innovation	Percentage of firms engaged in innovation minus percentage of firms engaged in R&D-based innovation	WBES	https://www.enterprisesurveys.org/content/dam/enterprisesurveys/documents/Indicator-Descriptions.pdf	
Granted patents per million capita	Granted patents per million capita	World Intellectual Property Organization (WIPO)	https://www.wipo.int/ipstats/en/	
Total official development assistance (ODA) to health	Total net ODA provided to medical research and basic health sectors	Organisation for Economic Co-operation and Development (OECD)	https://www.oecd.org/sdd/managementofstatisticalmetadataattheoecd.htm; https://unstats.un.org/sdgs/metadata/files/Metadata-03-0b-02.pdf	SDG 3.b.2

People requiring intervention against neglected tropical diseases	Number of people requiring interventions against neglected tropical diseases	World Health Organization (WHO)	https://apps.who.int/gho/data/node.metadata; https://unstats.un.org/sdgs/metadata/files/Metadata-03-03-05.pdf	SDG 3.3.5
Share of population with large household expenditures on health	Proportion of population with large household expenditures on health as a share of total household expenditure or income	WHO	https://apps.who.int/gho/data/node.metadata; https://unstats.un.org/sdgs/metadata/files/Metadata-03-08-02.pdf	SDG 3.8.2
Energy intensity of primary energy	Energy intensity measured in terms of primary energy and GDP	International Energy Agency (IEA), Sustainable Energy for All (SE4ALL), World Bank	https://databank.worldbank.org/reports.aspx?source=2&type=metadata&series=EG.EGY.PRIM.PP.KD; https://unstats.un.org/sdgs/metadata/files/Metadata-07-03-01.pdf	SDG 7.3.1
Share of population with primary reliance on clean fuels and technology	Proportion of population with primary reliance on clean fuels and technology	WHO	https://apps.who.int/gho/data/node.metadata; https://unstats.un.org/sdgs/metadata/files/Metadata-07-01-02.pdf	SDG 7.1.2
Renewable energy share of energy consumption	Renewable energy share in the total final energy consumption	IEA, United Nations Statistics Division (UNSD), International Renewable Energy Agency (IRENA)	https://unstats.un.org/sdgs/metadata/files/Metadata-02-0a-01.pdf	SDG 7.2.1
ODA for clean energy R&D	International financial flows to developing countries in support of clean energy R&D and renewable energy production, including in hybrid systems	OECD, IRENA	https://unstats.un.org/sdgs/metadata/files/Metadata-07-0a-01.pdf	SDG 7.a.1
Direct economic loss attributed to disasters relative to GDP	Direct economic loss in rela-tion to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters	United Nations Office for Disaster Reduction (UNISDR)	https://unstats.un.org/sdgs/metadata/files/Metadata-11-05-02.pdf	SDG 11.5.2
Direct agriculture loss attributed to disasters	Direct economic loss attributed to disasters in relation to global GDP		https://unstats.un.org/sdgs/metadata/files/Metadata-01-05-02.pdf	SDG 1.5.2
Mainstreaming of sustainable development education in curricula	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population	UNISDR	https://unstats.un.org/sdgs/metadata/files/Metadata-13-01-01.pdf	SDG 13.1.1
Share of local governments that implement local disaster risk reduction strategies	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	UNISDR	https://unstats.un.org/sdgs/metadata/files/Metadata-11-0b-02.pdf	SDG 11.b.2
Agriculture value added share of GDP	The agriculture orientation index for government expenditures	Food and Agriculture Organization of the United Nations (FAO)	https://unstats.un.org/sdgs/metadata/files/Metadata-02-0a-01.pdf	SDG 2.a.1

Average income of small-scale food producers, purchasing power parity (PPP)	Average income of small-scale food producers, by sex and indigenous status	FAO	https://unstats.un.org/sdgs/metadata/files/Metadata-02-03-02.pdf	SDG 2.3.2
Total ODA to agriculture (gross disbursements)	Total official flows (ODA plus other official flows) to the agriculture sector	OECD	https://www.oecd.org/sdd/managementofstatisticalmetadataattheoecd.html	SDG 2.a.2
Agriculture share of government expenditure	The agriculture orientation index for government expenditures	FAO	https://unstats.un.org/sdgs/metadata/files/Metadata-02-0a-01.pdf	SDG 2.a.1

Data for innovative indicators

Data for innovative indicators were obtained from three software programs: Meltwater, Scopus and crunchbase.

Keywords

In order to search in each of these three software programs, sets of keywords needed to be chosen. These are provided in Table C2 and are based on (but differ slightly from) the keyword searches that Scopus uses and recommends as search strings for the SDGs.[438]

Meltwater search

Meltwater collects social media posts and news articles from countries around the globe. Users can search within this software by filtering by both the location where the article is published and keywords in the article's content. As soon as the search is activated, Meltwater starts collecting data. It is important to note that Meltwater cannot search news articles published in the past: only articles published on the day of the search are included in the results. To increase the relevancy of the search results, the initial English search string was translated into 22 languages (see Table C.3), although 62 local official languages were not included in the search. These 22 languages were chosen based on the availability of the languages in the Google Translate plugin, and such that for each least developed country, at least one official language was included.

Based on the Meltwater searches, a number of outputs were created:

- For the news articles that were found based on the STI keywords, the relative attention for science, technology and innovation was determined and reported on for each least developed country. The relative attention is expressed as the share of news articles that were found on the individual fields of science, technology and innovation, compared to all STI keywords.

- For the four thematic areas, the relative attention for each area was found in a similar way: it is expressed as the share of news articles that were found on the individual thematic areas, compared to all articles found for all thematic keywords.

- For each least developed country, the keywords for which news articles were found were collected, as well the frequency with which articles were found based on these keywords. Based on these keywords and their frequencies, wordclouds were made for each thematic area and each least developed country.

438 Scopus, "Sustainable Development Goals FAQs" (2021). Available at https://service.elsevier.com/app/answers/detail/a_id/31662/supporthub/scopuscontent/ (accessed on 7 December 2021).

Scopus search

In Scopus, the database with publications, a search similar to the Meltwater search was conducted. Here, the number of publications per thematic area was collected based on the appearance of keywords in the title and/or abstract, and whether an affiliation of one or more of the authors was based in the least developed country. Based on the number of publications from that country in a thematic area, and the total number of publications in that country, the percentage of publications in that least developed country for a specific thematic area was examined.

Crunchbase search

In crunchbase, the database with innovative companies, a similar search was conducted as for the Scopus search. In this case, the search was based on the keywords for the thematic areas, and whether the headquarter of the company is in a least developed country. Also, the total number of innovative companies was collected per least developed country. Based on the number of companies in a thematic area and the total number of companies, the relative attention for a thematic area among innovative companies was examined.

Table C2. Overview of keywords used for STI and four thematic areas for searches in various software programs

Science, technology and innovation	Health and COVID-19 *Related to SDG 3*	Renewable energy *Related to SDG 7*	Climate adaptation *Related to SDGs 1 and 11*	Agriculture *Related to SDG 2*
Science:	Health	energy efficiency	Disaster Risk Reduction	Agriculture
Science, Research	Human AND Disease	energy consumption	DRR	Agricultural
Technology:	Human AND Illness	energy transition	Green Climate Fund	food chain
Technology	Human AND medicine	clean energy	clean development mechanism	food chains
Innovation:	Corona	energy policy	Climate AND	nitrogen cycle
Innovation	Covid	Renewable	adaptive	nitrogen cycles
	sars-cov-2	Renewables	climate adaptation	land tenure rights
	Biontech*	smart grid	Climate AND	smallholder farm
	Pfizer*	smart grids	adapt	Smallholder AND
	Johnson*	electricity consumption	climate resilience	fishery
	Janssen*	clean fuel	Climate AND	Smallholder AND
	Moderna*	clean cooking fuel	resilient	forestry
	AstraZeneca*	Photovoltaic	Innovation	Smallholder AND
	Sputnik*	hydrogen production	climate risk	Food
	Sinovac*	lithium-ion batteries	climate risks	Smallholder AND
	Sinopharm*	lithium-ion battery	Climate AND	pastoral
	CanSino Biologics*	rural electrification	education	food security
	working from home	energy access	climate hazard	food insecurity
		low-carbon	climate hazards	food production
		energy governance	Climate AND	land right
		climate action	island	land rights
		climate equity	Climate AND	land reform
		climate finance	islands	resilient agricultural practices
		climate investment	Climate AND	Agroforestry

		climate mitigation	small island developing states	agricultural innovation
		climate policy	Climate AND	land use
		climate policies	sea level	land uses
		greenhouse gas	Climate AND	land degradation
		greenhouse gases	sea levels	soil degradation
		UNFCCC		LULUCF
		Climate AND		land conservation
		Emission		sustainable land management
		Climate AND		
		emissions		

Keywords indicated with * were not included in the searches in crunchbase, since they are companies themselves, and the crunchbase database collects companies. For searches in Meltwater, the keywords were translated into various languages.

Table C3. Languages spoken in the least developed countries and languages used for Meltwater search

Least developed country	Language(s) spoken	Languages included in Meltwater search	Languages not included in Meltwater search
Afghanistan	Dari / Farsi	Dari / Farsi	
Angola	Portuguese	Portuguese	
Bangladesh	Bengali, English	Bengali, English	
Benin	French	French	
Bhutan	English	English	
Burkina Faso	French	French	
Burundi	Kirundi, French, English, Swahili	French, English, Swahili	Kirundi
Cambodia	Khmer	Khmer	
Central African Republic	French, Sangho	French	Sangho
Chad	French, Arabic	French, Arabic	
Comoros (the)	Comorian, Arabic, French	Arabic, French	Comorian
Democratic Republic of the Congo	French, Kituba, Swahili, Lingala, Tshiluba	French, Swahili	Kituba, Lingala, Tshiluba
Djibouti	French, Arabic	French, Arabic	
Eritrea	Amharic, Arabic, English, Tigrinya	Amharic, Arabic, English	Tigrinya
Ethiopia	Amharic, Oromo	Amharic	Oromo
Gambia	English, Mandinka, Wolof	English	Mandinka, Wolof
Guinea	French, Pular, Mandinka, Susu, Kissi, Kpelle, Toma	French	Pular, Mandinka, Susu, Kissi, Kpelle, Toma
Guinea-Bissau	Portuguese, French, Portuguese Creole	Portuguese, French, Portuguese Creole	
Haiti	Haitian Creole, French	French	Haitian Creole
Kiribati	Kiribati (/ Gilbertese / Taetae), English	English	Kiribati (/ Gilbertese / Taetae)
Lao People's Democratic Republic	Lao	Lao	
Lesotho	Southern Sotho, English	Southern Sotho, English	

Liberia	English, Kpelle, Bassa, Grebo, Dan, Kru, Mano, Loma, Mandingo	English	Kpelle, Bassa, Grebo, Dan, Kru, Mano, Loma, Mandingo
Madagascar	Malagasy, French	Malagasy, French	
Malawi	Chichewa / Nyanja, English	Chichewa / Nyanja, English	
Mali	French, Arabic, English, Fulani, Mandinka	French, Arabic, English	Fulani, Mandinka
Mauritania	Arabic, Fula, Soninke, Wolof	Arabic	Fula, Soninke, Wolof
Mozambique	Portuguese, Swahili, Mwani, Chewa, Tsonga	Portuguese, Swahili	Mwani, Chewa, Tsonga
Myanmar	Burmese	Burmese	
Nepal	Nepali	Nepali	
Niger	French, Arabic, Buduma, Fulfulde, Gou-manchéma, Hausa, Kanuri, Zarma, Songhai, Tamasheq, Tassawaq, Tebu	French, Arabic	Buduma, Fulfulde, Goumanchéma, Hausa, Kanuri, Zarma, Songhai, Ta-masheq, Tassawaq, Tebu
Rwanda	Kinyarwanda, English, French, Swahili	Kinyarwanda, English, French, Swahili	
Sao Tome and Principe	Portuguese, Portuguese Creole	Portuguese, Portuguese Creole	
Senegal	Arabic, Balanta, Jola-Fonyi, Mandinka, Mandjak, Mankanya, Noon, Pulaar, Serer, Soninke	Arabic	Balanta, Jola-Fonyi, Mandinka, Mandjak, Mankanya, Noon, Pulaar, Serer, Soninke
Sierra Leone	English, Portuguese Creole	English, Portuguese Creole	
Solomon Islands	English	English	
Somalia	Somali, Arabic, English, Italian	Somali, Arabic, English, Italian	
South Sudan	Arabic, English, Nuer, Murle, Luo, Dinka, Ma'di, Otuho, Zande	Arabic, English	Nuer, Murle, Luo, Dinka, Ma'di, Otuho, Zande
Timor-Leste	English, Indonesian, Portuguese, Tetum	English, Indonesian, Portuguese	Tetum
Togo	French, Ewe, Kabiye	French	Ewe, Kabiye
Tuvalu	Tuvaluan, English	English	Tuvaluan
Uganda	English, Swahili	English, Swahili	
United Republic of Tanzania	English, Swahili	English, Swahili	
Yemen	Arabic	Arabic	
Zambia	English, Bemba, Nyanja (/ Chichewa), Tonga	English, Nyanja (/ Chichewa)	Bemba, Tonga
All countries		Dari / Farsi, Portuguese, Bengali, English, French, Arabic, Khmer, Swahili, Amharic, Portuguese Creole, Lao, Southern Sotho, Malagasy, Chichewa / Nyanja, Burmese, Nepali, Kinyarwanda, Somali, Italian, Indonesian	Kirundi, Sangho, Comorian, Kituba, Lingala, Tshiluba, Tigrinya, Oromo, Mandinka, Wolof, Pular, Mandinka, Susu, Kissi, Kpelle, Toma, Haitian Creole, Kiribati (/ Gilbertese / Taetae), Kpelle, Bassa, Grebo, Dan, Kru, Mano, Loma, Mandingo, Fulani, Mwani, Chewa, Tsonga, Buduma, Fulfulde, Goumanchéma, Hausa, Kanuri, Zarma, Songhai, Tamasheq, Tassawaq, Tebu, Balanta, Jola-Fonyi, Mandinka, Mandjak, Mankanya, Noon, Pulaar, Serer, Soninke, Nuer, Murle, Luo, Dinka, Ma'di, Otuho, Zande, Tetum, Ewe, Kabiye, Tuvaluan, Bemba, Tonga


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