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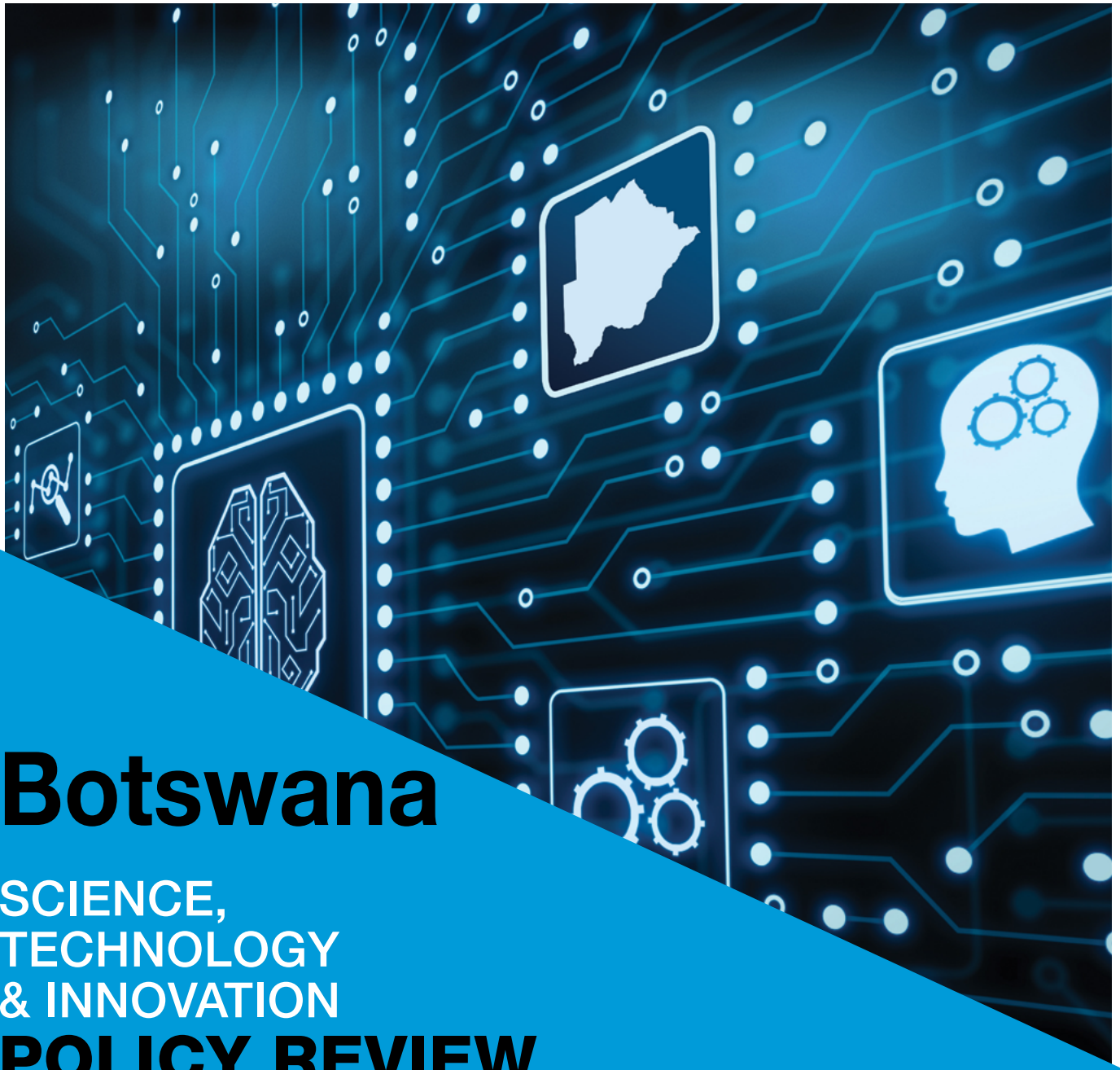

Botswana

SCIENCE, TECHNOLOGY & INNOVATION POLICY REVIEW

United Nations

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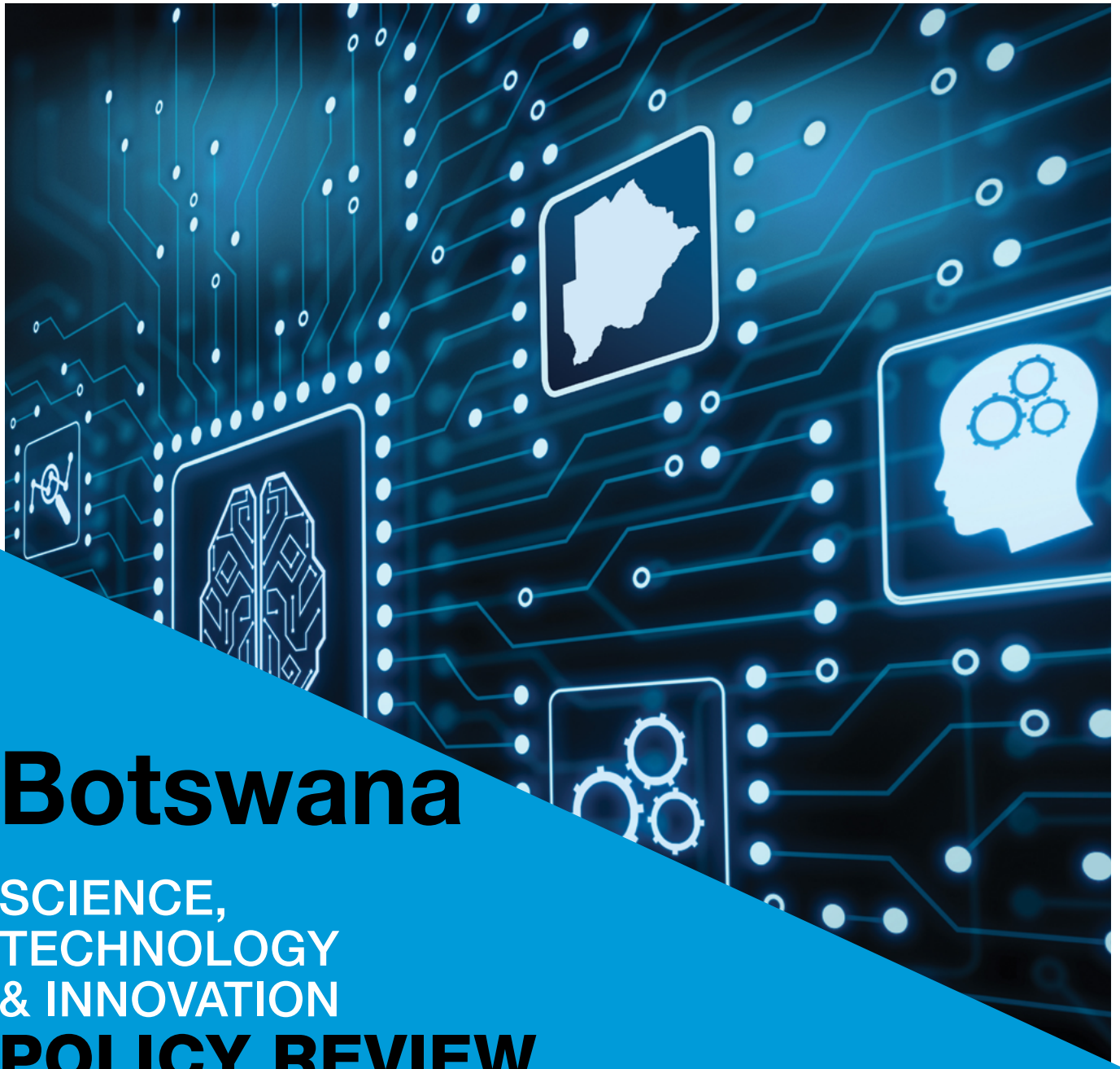

Botswana

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Acronyms

4IR	Fourth Industrial Revolution
AI	artificial intelligence
BDIH	Botswana Digital and Innovation Hub
BIDPA	Botswana Institute for Development Policy Analysis
BIF	Botswana Innovation Fund
BIH	Botswana Innovation Hub (changed to BDIH in November 2021)
BITRI	Botswana Institute for Technology Research and Innovation
BIUST	Botswana International University of Science and Technology
BNRDICC	Botswana National Research, Development and Innovation Coordinating Council
BOBS	Botswana Bureau of Standards
BOCRA	Botswana Communications Regulatory Authority
BOFINET	Botswana Fibre Networks
BOMRA	Botswana Medical Regulatory Agency
BotsREN	Botswana Research and Education Network
BUAN	Botswana University of Agriculture and Natural Resources
BWP	Botswana Pula (national currency)
CEDA	Citizen Entrepreneurial Development Agency
CEE	Citizen Economic Empowerment
CIPA	Companies and Intellectual Property Authority
DRST	Department of Research Science and Technology
EDD	Economic Diversification Drive
FDI	foreign direct investment
GDP	gross domestic product
GERD	gross expenditure on research and development
GII	Global Innovation Index
HRDC	Human Resource Development Council
HEI	higher education institution
ICT	information and communication technology
IP	intellectual property
IPRs	intellectual property rights
LEA	Local Enterprise Authority
M&E	monitoring and evaluation

MCKT	Ministry of Communications, Knowledge and Technology (created from the merger of The Ministry of Transport and Communications and the Ministry of Higher Education. Research Science and Technology in May 2022)
MELS	Ministry of Employment, Labour Productivity and Skills Development (until May 2022)
MENT	Ministry of Environment, Natural Resources Conservation and Tourism (former Ministry until May 2022)
MESD	Ministry of Education and Skills Development (created from the merger of the Ministry of Tertiary Education, Research Science and Technology, the Ministry of Basic Education and the Ministry of Employment, Labour Productivity and Skills Development in May 2022)
MET	Ministry of Environment and Tourism (formerly Ministry of Environment, Natural Resources Conservation and Tourism until May 2022)
MIAC	Ministry of International Affairs and Cooperation
MITI	Ministry of Investment, Trade and Industry (now MOTI from May 2022)
MLHA	Ministry of Labour and Home Affairs (new Ministry from May 2022)
MLGRD	Ministry of Local Government and Rural Development
MME	Ministry of Minerals and Energy (formerly Ministry of Mineral Resources, Green Technology and Energy Security until May 2022)
MNC	multinational corporation
MoA	Ministry of Agriculture (formerly Ministry of Agricultural Development and Food Security until May 2022)
MOBE	Ministry of Basic Education (until May 2022)
MOE	Ministry of Entrepreneurship (new ministry from May 2022)
MOF	Ministry of Finance (formerly Ministry of Finance and Economic Development)
MOFED	Ministry of Finance and Economic Development
MOH	Ministry of Health (formerly Ministry of Health and Wellness until May 2022)
MOHW	Ministry of Health and Wellness (now MOH since May 2022)
MOTE	Ministry of Tertiary Education, Research Science and Technology (until May 2022)
MOTI	Ministry of Trade and Industry (formerly Ministry of Investment, Trade and Industry until May 2022)
MTC	Ministry of Transport and Communications (until May 2022)
MTPW	Ministry of Transport and Public Works (from May 2022)
M&E	monitoring and evaluation
NARDI	National Agricultural Research and Development Institute
NDP	National Development Plan
NGO	non-governmental organization
NIS	National Innovation System
NRF	National Research Fund

NRSTI	National Research, Science, Technology and Innovation (Policy)
NSI	National System of Innovation
NSO	National Strategy Office
R&D	research and development
RSTI	research, science, technology and innovation
SADC	Southern African Development Community
SAIS	Southern African Innovation Support (programme)
SDG	Sustainable Development Goal
SEZ	special economic zone
SME	small and medium-sized enterprise
SMME	small, micro and medium-sized enterprise
S&T	science and technology
STEM	science, technology, engineering and mathematics
STI	science, technology and innovation
STIP	science, technology and innovation policy
STISA	Science Technology and Innovation Strategy for Africa (of the AU)
TTO	technology transfer office
TVET	technical and vocational education and training
UB	University of Botswana
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

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Executive summary

Botswana aims to transform into a high-income, industrialized economy by 2036, a goal it has been seeking to achieve since the late 1990s through dedicated national policies. Research and development (R&D), technology and innovation need to be effectively harnessed to achieve this transformation. The first explicit National Science and Technology Policy was adopted in 1998, which largely focused on the promotion of R&D to achieve sustainable social and economic development. The policy was replaced by the current National Research, Science, Technology and Innovation (NRSTI) Policy of 2011.

The 2011 NRSTI Policy's mission is to "achieve a knowledge driven economy through effective and sustainable Science and Technology based research and innovation." It is based on the concept of national systems of innovation, and aims to build national capacities in research and innovation.

The country also has a wide range of policies with STI-related measures, such as those for human resource development (education and training), industrial policy, intellectual property protection, trade and investment, public procurement, traditional and indigenous knowledge, biotechnology and biosafety, technical standards and economic diversification. Sectoral policies for health, agriculture, environmental management and tourism also have, to varying degrees, provisions that can be used to promote STI in general and R&D in particular.

Botswana's overall development plans and vision – *Vision 2036* – explicitly recognize that STI are critical for achieving structural transformation (and industrialization) of the economy and sustainable development goals. It states "The transformation and progress that we seek will be driven by investments in innovation, research and development, including indigenous knowledge across all Vision Pillars thereby domesticating and accelerating the pace of technical and scientific advancement." This visionary policy statement provides overall guidance to all policy frameworks for STI. There has been progress, but it is too slow and will need to be significantly accelerated. In particular, improving implementation of STI policy measures should become a top priority, addressed as a matter of urgency to support Botswana's transformation by 2036.

To ensure that STI are promoted and related policies are implemented, the Government of Botswana has, over recent decades, established various institutions and institutional arrangements. Coordination has not had a stable base, with the Department of Research, Science and Technology (DRST), which coordinates the RSTI and the 2011 NRSTI Policy, shifting across different ministries, including those for higher education, communications and infrastructure since its creation in 2004. Currently, the Ministry of Communications, Knowledge and Technology (MCKT) has overall executive responsibilities for STI.

The country's National System of Innovation (NSI) has grown over the years with the creation of several public and private universities and other institutions, such as the Botswana Digital and Innovation Hub (BDIH), the Botswana Institute for Technology, Research and Innovation (BITRI), the National Agricultural Research and Development Institute (NARDI), the Botswana Academy of Sciences (BAS), different ministries and parastatals, regulatory agencies, non-governmental organizations (NGOs) and private companies. The Botswana Innovation Fund is the main national mechanism for financing STI, and a national research fund is also being established. Botswana's institutionally diverse, though relatively small, NSI is highly open and interacts with other countries' NSIs around the world, particularly those within the Southern African Development Community (SADC).

To assess the effectiveness of the 2011 NRSTI Policy and the dynamism or performance of the NSI, the Government of Botswana requested the United Nations Conference on Trade and Development

(UNCTAD) to undertake an independent review. It was conducted by virtual means due to Covid-19 pandemic travel restrictions between late 2020 and 2022 through a multistakeholder process, including a scoping mission and a field mission, including interviews with many stakeholders. A comprehensive review of various reports, including policies and programmes, was also conducted.

Detailed findings and recommendations of that review are provided in the main sections of this report and summarized in the final chapter. Key high-level overarching findings and recommendations closely related to STI policy are outlined in the table below. They are organized around governance of the NSI, the relevance and effectiveness of the 2011 NRSTI Policy, enhancing funding for and investment in STI, improving STI policy implementation, STI capacity-building, and building readiness for adopting frontier or emerging technologies.

Findings	Recommendations
1. Both political and executive leaders in Botswana are keenly engaged in the promotion of STI. They recognize that STI are critical for attaining the country's Vision 2036. However, there is a weak political constituency for STI, in particular, limited involvement of the legislature in STI policymaking processes.	There is need to strengthen the leadership for STI and STI policymaking by establishing a parliamentary committee dedicated to STI. The MCKT and DRST should consider organizing workshops on STI policy for parliamentarians.
2. The NSI, though still relatively small and growing, is highly fragmented, with no clearly articulated national STI priorities. Its institutional linkages and coordination of various actors and activities are relatively weak.	The Government should establish a high-level interministerial, multi-stakeholder committee to oversee coordination of the NSI, with strong administrative support from the MCKT and a strengthened and upgraded DRST. National STI priorities should be clearly identified.
3. The DRST plays a major role in the NSI, and is responsible for STI policy, planning and programming. However, it does not have the requisite human, financial and legislative capacity to undertake its responsibilities effectively.	As per provisions of the 2011 NRSTI Policy, the DRST should be transformed into a Directorate for Research, Science, Technology and Innovation through an Act of Parliament, and be provided with adequate resources to procure personnel with the requisite skills to develop the NSI and oversee STI policy development and implementation.
4. Botswana underinvests in STI. It has not met the targets for gross expenditure on R&D (GERD) of 1-2 per cent of GDP. The Innovation Fund and the Research Fund (in the process of being established) will be key mechanisms for funding R&D, technology and innovation. The country lacks a clear resource mobilization strategy or plan for adequately funding STI.	The MCKT (and specifically the DRST) should, in consultation with various stakeholders, particularly the national treasury and parliament, develop an explicit strategy or plan for mobilizing funding and investing in R&D, technology and innovation. Such a strategy or plan should consider how the Innovation Fund and the Research Fund will operate in order to achieve synergies between them. The strategy or plan should also explore innovative financing mechanisms.

5. The 2011 NRSTI Policy is aligned with Vision 2036, and with most of the sectoral policies and policy frameworks. However, it is limited in scope, focuses too heavily on R&D and too little on technology and innovation. Moreover, it does not adequately take into account the Sustainable Development Goals (SDGs) of the United Nations and how policymaking should be informed by science. It was developed before the SDGs were adopted, and evidence-based policymaking became a key issue. Furthermore, it does not cover many socioeconomic issues associated with frontier technologies.	The Government should consider organizing a participatory broad-based national process to modernize the RSTI policy. The policy revision process should be led at a high-level and administered by a strengthened Directorate for RSTI within the MCKT.
6. Implementation of the 2011 NRSTI Policy has been weak for a number of reasons, including inadequate governance mechanisms, low STI policymaking capacity within the DRST and in the Government as whole, and low public awareness of the NRSTI Policy within the country.	To enhance STI policy implementation, there is need to build capabilities for policy analysis within the MCKT and DRST through short workshops, including STI policy training workshops and/or support to personnel to attend relevant courses offered by institutions in other countries. In order to build public awareness of STI policy, the MCKT and DRST should organize events and use various media to educate the public on key issues and provisions of the NRSTI policy. Other supportive measures include improving monitoring and evaluation (M&E) indicators and data systems for STI, making R&D more demand- driven and connected to industry needs and societal challenges, and strengthening engagement with the private sector (which should drive innovation).
7. Botswana has a wide range of implicit policy frameworks to promote and govern STI. However, these are underutilized. For example, public procurement regulations are not directly used to promote innovation in the country.	The MCKT (and DRST) should conduct a comprehensive review and identify STI provisions in all national policy frameworks, including designing a strategy for promoting their application in support of STI policy. This may help to build policy coherence and mainstream STI across sectors of the economy. Regular monitoring and evaluation of major policies, and organization of periodic M&E meetings to assess implementation across major national policies could also help.
8. Botswana is keen to leverage frontier technologies such as those for the Fourth Industrial Revolution (4IR), as evidenced in its current emphasis on digitalization and its newly launched digital transformation strategy, SmartBots. However, technological readiness and capabilities for these are in low supply and not organized.	The MCKT should develop a clear strategy and plan for building the necessary human skills, infrastructure and regulatory capacity to harness digitalization and frontier technologies (such as those for 4IR) by conducting technology foresight and assessment on selected frontier technologies such as artificial intelligence (AI).

Part I National Development, STI and the National System of Innovation

Introduction

Following several decades of high economic growth, Botswana faces social, economic and environmental challenges, uncertainty and volatility that are associated with an overall global economic slowdown and negative shocks from the spread of the Covid-19 pandemic followed by food and energy crises. The country has made strong progress in its transformation to a modern developing country, but must still overcome deep-seated challenges associated with weak productive capacity that are blocking rapid transformation from a natural-resource-based economy to a knowledge-based and innovation-driven one. Many of these challenges can be overcome by building greater technological and innovation capabilities so that Botswana can benefit fully from its current relatively strong development position, political stability, friendly international relations and integration into the world economy. In a context of rising domestic, regional and global challenges, and a more complex international economic and geopolitical environment, Botswana needs to accelerate its rate of progress in structural transformation and reconsider its strategy for future transformation.

Vision 2036, Botswana's overarching development policy framework, recognizes that the country's transition to a knowledge-based industrialized economy will depend on increased investments in STI. There has been progress in some important respects, but it is too slow; significant acceleration is needed to transform Botswana by 2036. Improving implementation of STI policy measures should become a top priority and addressed as a matter of urgency. For this to happen, STI policy needs to assume greater importance in the national development strategy. This requires a more proactive use of policy tools, stronger support provided through the NSI, and harnessing of science and technology to foster innovation and boost production, along with better coordination across key policy areas and public agencies, and stronger linkages among stakeholders in the Government, industry, academia and civil society.

This STI Policy Review provides an independent assessment to assist policymakers in Botswana to determine the state of the NSI and the effectiveness of the 2011 National RSTI Policy and other related policy frameworks for harnessing R&D, technology and innovation for sustainable development. It is hoped that the review will inform the Government of Botswana and other stakeholders, and stimulate discussions on how STI policy can steer the NSI to support faster and deeper transformation of Botswana's economy and promote sustainable development.

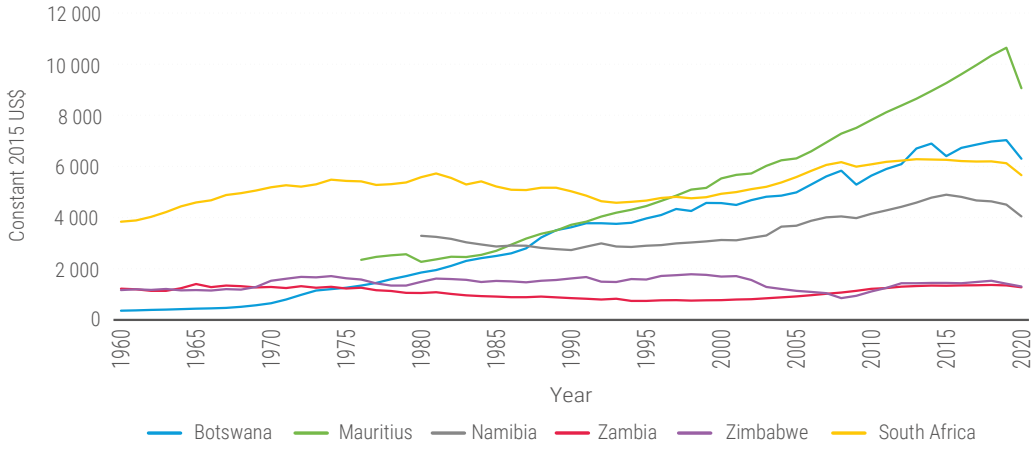
It should be noted that there was a restructuring of the Government in May 2022 resulting in changes to the names of some ministries, institutional arrangements and, in some cases, to functions as well. For example, the DRST was moved to the new Ministry of Communications, Knowledge and Technology. Given that this STIP Review was undertaken based on a process of discussions, information collection and structures that were in place prior to the restructuring, it could not be rewritten to account for the new structures, mandates and NSI-related linkages that may have changed among various ministries, departments and agencies following the restructuring. An attempt has been made in the text to use the current names of ministries, and the list of abbreviations indicates their old and new names resulting from the restructuring. The restructuring provides an opportunity to accelerate reforms on STI policy. It also has implications for the national system of innovation, and some of the analysis may be affected by it. Nevertheless, the key policy issues identified in the review remain valid.

Chapter 1. Botswana's development trajectory

Botswana has recorded consistently strong growth since the 1960s, one of the most impressive among African countries since independence. Consequently, its gross domestic product (GDP) per capita has been rising steadily over time. Only Mauritius has recorded a similarly impressive performance among selected member countries of the Southern African Development Community (SADC) (figure 1). Botswana had a Human Development Index (HDI) of 0.735 in 2019, which indicates a high level of human development.[1] Growth has enabled poverty reduction and an improvement in public welfare through greater public investment in key sectors such as education, health and infrastructure. However, growth rates have displayed higher volatility since the global financial and economic crisis of 2008–2009. The shock due to the economic crisis created by the Covid-19 pandemic in 2020 has resulted in slower growth, which has affected Botswana like most countries in the world. GDP and growth rates have been impacted heavily by trends in the mining sector, particularly diamond production which accounts for a major share of total output. Diamond exports fell following the global financial crisis in 2008–2009, reflecting reduced global demand, which led to lower GDP growth. This shows the extent to which growth outcomes are vulnerable to variations in the global diamond markets, which may create domestic economic volatility going forward. In September 2020, the Government of Botswana established the Economic Recovery and Transformation Plan (ERTP). Its objectives are to protect the vulnerable and firms during Covid-19, support economic recovery, and raise productivity, efficiency and competitiveness to promote transformation of the economy.

Figure 1

Botswana's GDP per capita compared with other selected SADC member countries, 1960–2020
(Constant 2015 dollars)



Source: World Bank (https://data.worldbank.org/).

[1] The HDI is a summary measure for assessing long-term progress on three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living.

Economic growth has been driven by a development strategy led by careful reinvestment of natural resource revenues and the pursuit of regional and global economic integration. Strong public investment of mining revenues in areas important for socioeconomic progress (notably education, health and infrastructure), and regional economic integration within the SADC, Africa and the global economy are central pillars of the strategy. With a strong record of political and social stability, and prudent macroeconomic management, Botswana has created a predictable and pro-growth environment conducive to its gradual transformation. This has been possible despite limited natural resource endowments, apart from several mineral resources (most notably diamonds) and diverse natural wildlife and ecosystems that have allowed the development of high-end ecotourism. The country's arid to semi-arid climate is not only unfavourable to agricultural production (Meulenberg and Batisani, 2004), but also results in water scarcity. This poses a further challenge to agriculture as well as to other water-intensive activities (e.g. some types of mining and manufacturing), the environment, wildlife and natural eco-systems, as well as to society more broadly.

Extreme poverty has been substantially reduced, but inequality and unemployment remain high. Poverty reduction has trailed economic growth, partly due to high inequality. Part of the problem stems from mining, which is capital intensive and creates few jobs. Job creation is a strong poverty reduction mechanism, but is stymied by a weak level of innovation that constrains productivity growth and economic diversification. Extreme poverty fell from 33 per cent of the population in 1993 to 17 per cent in 2015, according to World Bank data.[2] This is similar to the rate of multidimensional poverty, as measured by the United Nations Development Programme's (UNDP) Multidimensional Poverty Index (MPI), at 17.2 per cent of the population in 2015–2016. However, an additional 19.7 per cent of the population is classified as being vulnerable to multidimensional poverty. Reducing inequality, which was at extreme levels before independence, has been a long-standing societal challenge. Progress in reducing inequality has been slower than reducing extreme poverty. Public policies have succeeded in lowering the Gini index (measuring wealth inequality)[3] from 60.8 in 1993 to 53.3 in 2015 (figure 2). However, this still represents a very high level of wealth inequality compared to the average for upper middle-income countries. Several of its neighbouring countries have similar levels of inequality. Among selected SADC member countries, Mauritius has been moderately more successful in reducing inequality.

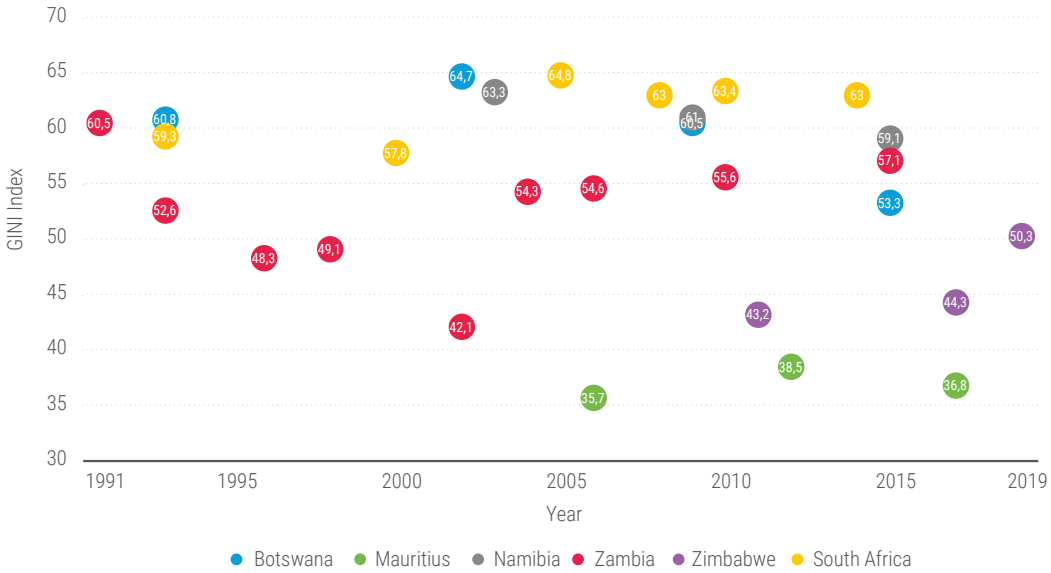
High unemployment contributes to sustaining poverty and inequality. The unemployment rate was estimated at 26 per cent in the fourth quarter of 2021 (Statistics Botswana, 2021). The pattern of unemployment varies widely by both age and gender, and is particularly high among youth, reaching lower levels after the age of 30 years. And it is higher for women than for men in every age group. Reducing poverty, unemployment and inequality require sustained support for further improvement in access to quality primary and secondary education, along with a stronger innovation performance (particularly in labour-intensive activities) and private sector expansion to support higher job growth. Raising productivity levels across industries and sectors will be necessary to raise wage levels in the medium and long term.

[2] https://data.worldbank.org/indicator/SI.POV.DDAY?locations=BW.

[3] The Gini index measures the extent to which the distribution of income or consumption expenditures among individuals or households within an economy deviates from a perfectly equal distribution across the population. Botswana has one of the highest Gini coefficients in the world, despite significant progress in reducing poverty and inequality in recent decades.

Figure 2

Gini index in Botswana and selected SADC member countries, 1991–2019

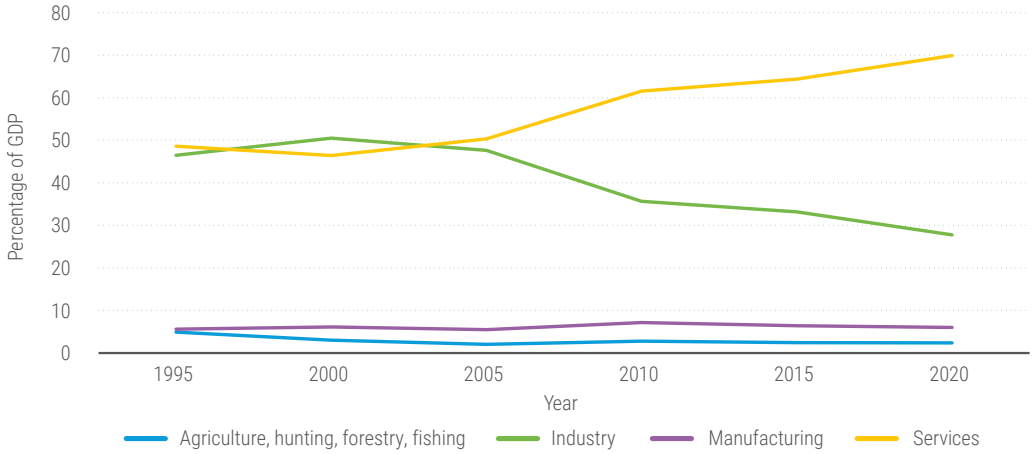


Source: World Bank (https://data.worldbank.org/).

A major weakness is limited structural economic transformation into manufacturing and from primary production into services. Little progress has been made in strengthening the manufacturing sector. A major shift in production has been the steady decline in the share of industry (dominated by mining) and a rise in the share of services in output (figure 3). This pattern is common in the region, and indicates difficulty in expanding the manufacturing base. The share of manufacturing has increased only marginally, from 5.6 per cent in 1995 to 6 per cent in 2020. Agriculture remains a sector with potential for further diversification, which would also help to improve food security. The latter is now a higher priority in countries across the world in the context of greater global food insecurity and a global food crisis. Improving agriculture could also contribute to higher job creation and wage opportunities for low-skilled labour, which would help reduce unemployment, poverty and inequality. Accelerating impacts of climate change, combined with growing water scarcity (and possibly drought), will present challenges to agricultural development in Botswana in the future. Addressing these challenges will require the application of a range of new and existing technologies and agricultural R&D. The production structure has shifted towards services without any increased specialization in manufacturing. Some services can provide useful diversification opportunities that would bring development gains, in particular modern knowledge-intensive services that have high value added (such as medical, information and communication technologies (ICT), software, architecture, financial services, R&D and consultancy services), as well as some labour-intensive services, such as tourism, that could create jobs for low-skilled labour.

Figure 3

Share in GDP of value added by type of economic activity, 1995–2020
(Percentage)

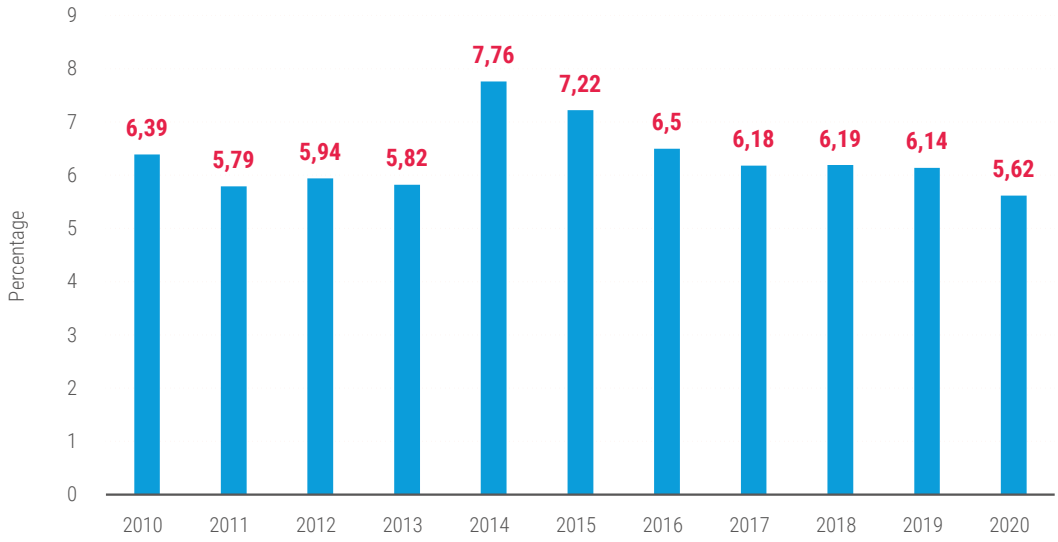


Source: UNCTADStat (https://unctadstat.unctad.org/EN/Indext.html).

The contribution of manufacturing to GDP has steadily declined since 2014, a trend that needs to be reversed. Increased specialization in manufacturing typically occurs in countries that have progressed from low-income through middle-income and to high-income levels through a rapid process of development. Manufacturing generally offers considerable scope for rapid learning, technological upgrading and innovation that can raise productivity levels and drive economic transformation. As with agriculture, the expansion of labour-intensive manufacturing activities in low- and medium-tech areas, such as textiles and garments, can also help create jobs. Manufacturing value added as a share of GDP declined marginally during the period 2010–2013, rising markedly in 2014, only to decline steadily thereafter (figure 4).

Figure 4

Share of manufacturing value added in GDP, 2010–2020
(Percentage)



Source: World Bank (https://data.worldbank.org/).

Botswana's economy remains heavily dependent on its natural resources, and shows a mixed performance in the process of its transformation into a knowledge-based, innovation-driven economy. The export structure is dominated by primary products, with resource-based production becoming more pronounced in recent decades, rising from 83.6 per cent in 2000 to 93.6 per cent in 2020 (table 1). Low-tech exports have fallen over the two decades, from 3 per cent in 2000 to 0.8 per cent in 2020, and high-tech exports have stagnated at 0.6 per cent. Medium-tech exports have increased moderately from 2.7 per cent to 3.7 per cent. Within the region, Mauritius has steadily reduced primary and resource-based exports by developing a mix of low-, medium- and high-tech exports. Outside the region, Malaysia provides an interesting comparison: it started from a heavily natural-resource-based production structure before diversifying into more technology- and skill-intensive low-, medium- and high-tech industrial products for export.

Table 1

Composition of Botswana's exports by technological classification of products compared with those of selected countries, 2000–2020
(Percentage)

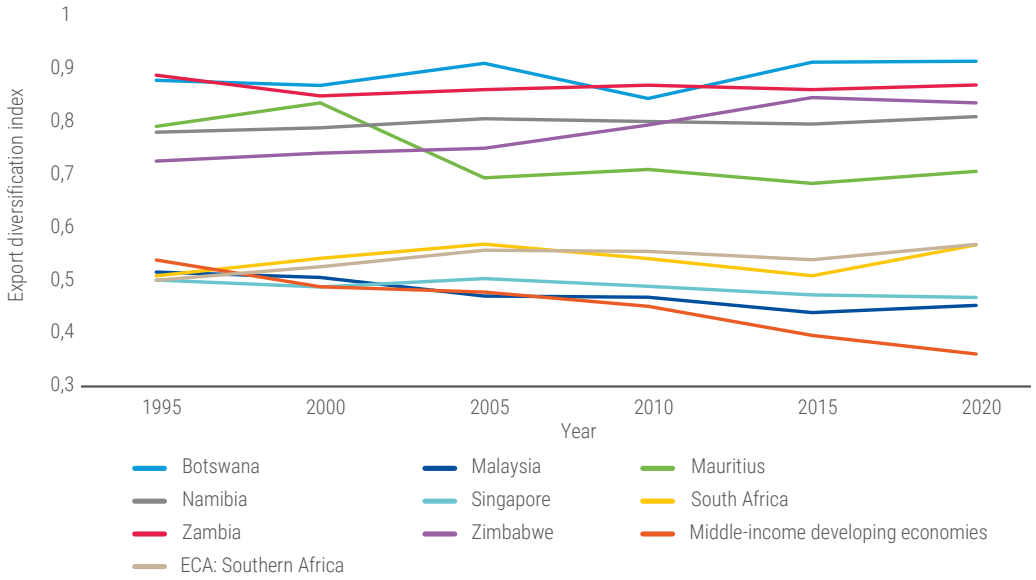
	Botswana			Namibia			Malaysia			Mauritius			South Africa		
	2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020
Low-tech	3.2	4.4	0.8	3.2	2.4	1.0	8.5	9.7	11.6	72.2	38.1	33.2	11.6	8.8	5.1
Medium- tech	2.7	4.8	3.7	2.9	6.1	3.7	15.9	16.4	16.2	3.8	4.8	8.3	23.8	29.4	25.2
High-tech	0.6	0.9	0.6	4.4	9.1	6.9	52.6	36.8	42.3	1.0	2.8	3.1	4.3	3.4	2.8
Primary products and resource based	83.6	88.5	93.6	76.8	73.0	76.6	22.1	36.3	29.3	22.2	35.5	41.0	46.6	57.3	57.8

Source: UNCTAD (https://unctadstat.unctad.org/EN/Index.html).

Export diversification in Botswana is also extremely low, which reveals structural weakness in the economy, and the limited capacity of firms and entrepreneurs to innovate. The development of new export products since 1995 has been limited. The economy was heavily dependent upon cattle at the start of independence, and then on diamonds, before slowly diversifying mainly into services. Indeed, Botswana has the lowest level of export diversification among the countries shown in figure 5. For example, over the past 50 years Malaysia and Singapore have achieved a high degree of export diversification by upgrading production into more technology- and skill-intensive products. Botswana should follow their example and improve its innovation capabilities to produce new goods and services (e.g. by creating new industries through product innovation or through horizontal diversification), improve the cost and quality mix of existing goods and services, and add more value to natural resource exploitation through increased processing and by creating new activities along natural resource value chains (vertical diversification).

Figure 5

Export diversification in Botswana and selected countries, 1995–2020



Source: UNCTADStat (https://unctadstat.unctad.org/EN/Indext.html).
Note: 0 = fully diversified, 1= no diversification.

Botswana's slow structural economic transformation is related to factors that have inhibited local productive capacity and the country's ability to establish competitive local industries, particularly in manufacturing activities. These include low levels of productivity growth associated with low skills development, as well as inadequate physical capital and capabilities for innovation. Productivity growth is essential for raising income levels in the long term. Since independence, substantial cumulative public sector investments have considerably improved physical infrastructure and reduced infrastructure gaps. However, the country's large physical size and small population pose an infrastructure challenge (for roads, railways, airports, energy grids, water and communications), which is compounded by its landlocked situation, resulting in high transport and logistics costs for goods and people. Deficiencies in infrastructure – particularly in transport, ICTs and energy – also continue to contribute to weak productive capacity.

Economic integration, trade and foreign investment have played a key role in Botswana's economic development. As a small economy with limited domestic demand, Botswana has relied heavily on international trade, investment and technology, as well as international collaboration, which play a major role in its development strategy. Trade has been extremely important as a source of demand for minerals, tourism and cattle. The country is deeply integrated into SADC, and has close economic relations with neighbouring countries. This is inevitable, given its need for international maritime transport via its neighbours. The founding of the African Continental Free Trade Area (ACFTA) in 2018 has opened the potential for Botswana to further leverage the opportunities for regional trade and investment.

Foreign direct investment (FDI) outside the mining sector has been relatively low: in 2014 (the latest year for which data were available in the UNCTAD FDI/MNE database), FDI stock was predominantly in mining (representing 47 per cent of the total) and to a lesser extent in financial services (representing 27 per cent of the total) (table 2), whereas manufacturing accounted for only 8 per cent of total FDI stock. The lack of sufficiently disaggregated data does not allow identification of the specific industries targeted by FDI. The low rate of FDI in manufacturing in Botswana impedes the ability to develop dynamic linkages in manufacturing activities that would

stimulate local manufacturing, as occurred in Malaysia, for example. FDI inflows into Botswana rose to an average of $233 million per year during the period 2015–2019, but then fell to $80 million in 2020 at the start of the Covid-19 pandemic. The rate of FDI inflows has increased over the past decade, with the stock of FDI rising to $5.4 billion in 2020. Unfortunately data are not available on FDI by sector since 2014.

Botswana's development plans include an ambitious initiative to attract FDI into special economic zones (SEZs) that are being established across the country to stimulate local production in different activities and regions of the country. To benefit fully from this initiative, foreign companies in high priority areas will need to invest locally, and linkages with the local economy developed. These linkages should include collaboration with local firms, universities and research institutes on production, technology development and innovation. Anecdotal evidence suggests that, apart from diamond mining, such linkages are weak.

Table 2

FDI stock in Botswana by sector, 2000–2014

	Millions of dollars				Share (Percentage)			
Sector	2000	2005	2010	2014	2000	2005	2010	2014
Primary	1 453	480	295	1 443	0.79	0.60	0.28	0.49
Agriculture, hunting, forestry and fishing	-	-	5.34	40			0.00	0.01
Mining, quarrying and petroleum	1 453	480	290	1 403	0.79	0.60	0.27	0.47
Manufacturing	64	26	47	249	0.03	0.03	0.04	0.08
Electrical and electronic equipment	-	-	0.40	2			0.00	0.00
Food, beverages and tobacco	-	-	27	51			0.03	0.02
Other manufacturing	-	-	1.51	177			0.00	0.06
Publishing, printing and reproduction of recorded media	-	-	11	9			0.01	0.00
Rubber and plastic products	-	-	2.53	-			0.00	
Services	315	296	727	1 281	0.17	0.37	0.68	0.43
Business activities	30	17	17	80	0.02	0.02	0.02	0.03
Construction	2.98	0.18	10	4	0.00	0.00	0.01	0.00
Electricity, gas and water	-	-	82	197			0.08	0.07
Finance	115	234	518	789	0.06	0.29	0.48	0.27
Health and social services	-	-	-	8			0.00	0.00
Hotels and restaurants	3.17	4.17	20	15	0.00	0.01	0.02	0.01
Other services	-	-	3.86	9			0.00	0.00
Trade	144	23	53	68	0.08	0.03	0.05	0.02
Transport, storage, and communications	20	18	22	111	0.01	0.02	0.02	0.04
Unspecified	-	3.99	-	- 0		0.00	0.00	
Total	**1 833**	**806**	**1 069**	**2 973**	**1.00**	**1**	**1.00**	**1.00**

Source: UNCTAD, FDI/MNE database.

The successful implementation of an STI policy as part of its broader development strategy should help Botswana break out of the "middle-income trap". The challenges that Botswana faces in transformation, diversification and economic upgrading are common to many middle-income countries that are stuck in such a trap, and block progress towards economic transformation. While Botswana has made good progress in many respects, there remain significant barriers to rapid economic transformation. Reliance on natural-resource-based development has already reached its limits for stimulating growth. Moreover, the convergence of multiple national and international challenges also heavily affects the policy goal of economic transformation. An effective STI policy that is better articulated with other major development policy areas could play an important role in overcoming these barriers.

Chapter 2. Indicators of STI capacity in Botswana

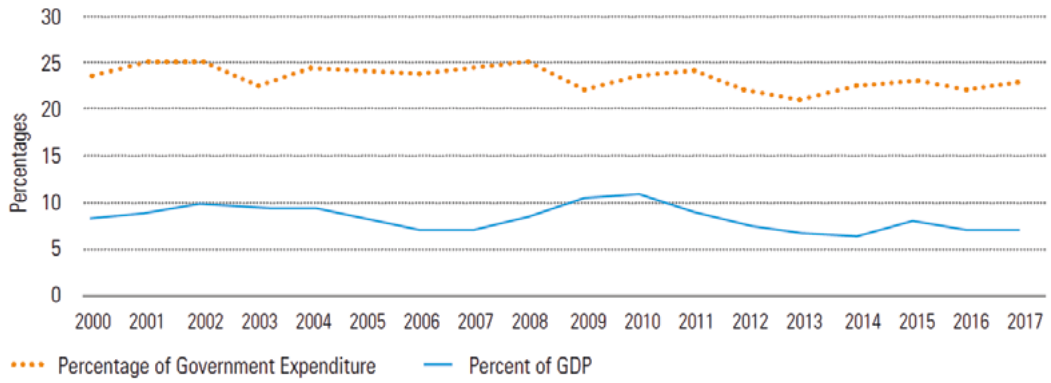
2.1 Human resources for STI

The Government has invested heavily in education for decades to build human capital at the elementary, secondary and tertiary levels, with a special focus on achieving basic universal education. Since 2000, the share of government expenditure on education, as a percentage of total government expenditure, has fluctuated close to 25 per cent, and has been over 7 per cent of GDP (figure 6). Access to basic education has improved significantly in the country, despite the sparsity of the population across rural areas, which impedes the provision of universal public services. The Government's strong efforts to achieve basic universal education resulted in a high net enrolment rate of 90 per cent at the primary level in 2002, which it has since maintained. The transition rate from primary to secondary education is also quite high. Technical and vocational education and training (TVET) is considered a means to promoting self-reliance, widening opportunities for people to find jobs that fit their talents and preferences, and helping them find decent work with a fair income. It is regarded as critical for initial skills development and for retooling. Tertiary education in Botswana has significantly increased in the past decade, with the gross enrolment rate (GER) rising from 15.1 per cent in 2009–2010 to 19.5 per cent in 2020 (HRDC, 2021).

Figure 6

Share of government expenditure on education in total expenditure and GDP, 2000–2017

(Percentage)

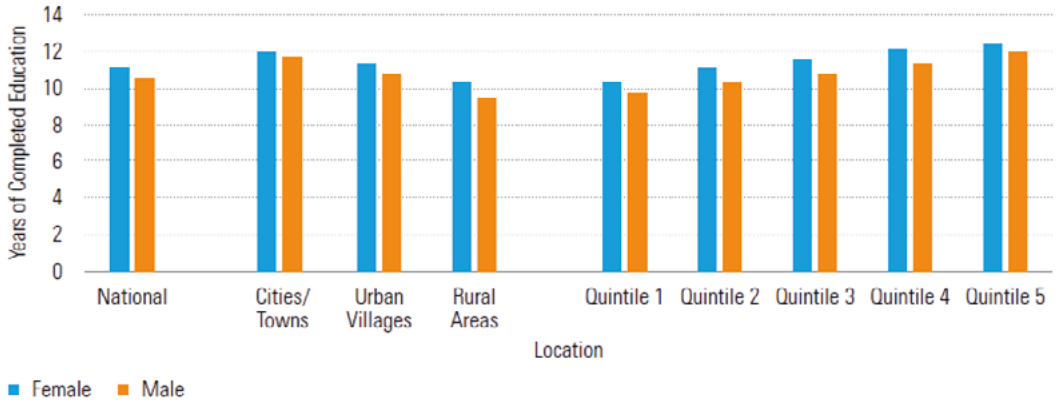


Source: World Bank (2019).

There has been a high level of success in providing at least nine years of education to both boys and girls across Botswana. Girls tend to spend more years in education than boys (figure 7). However, access to education is unequal: typically, children in rural areas have fewer years of education than those in urban areas.

Figure 7

Years of education attained, by gender, location and socioeconomic status quintile among 18–22-year-olds, 2015–2016



Source: World Bank (2019).

Education-related challenges include deficiencies in the quality of education, and limited access to post-graduate university education, as opposed to access to basic education. Table 3 presents the performance of grade 4 and grade 6 students in PRLS and TIMMS tests for reading, mathematics and science across selected countries including Botswana.[4] The results show that the proportion of students in Botswana attaining a high (or low) international benchmark standard in the tests is small compared mainly with their developed-country peers. The low scores in mathematics and science could create difficulties for students to pursue technical disciplines in the higher education system. In interviews, many stakeholders noted the weaknesses in the quality of education and difficulties in finding people with certain skills in the country, especially technical skills. Surveys of firms also reported similar challenges in finding the right skills. This indicates mismatches between the demands of industry and the skills that the education and training systems are providing. Interviews revealed that a significant number of stakeholders also identified other challenges such as weak communication skills, trust issues, as well as a lack of transparency and the ability to work autonomously and as part of teams. These soft skills are also important, as is problem-solving and innovation/creativity in finding solutions to problems. These skills should be developed through the education and skills systems from the earliest ages, starting from basic education, in order to build a culture of creativity, problem-solving and innovation, and change mindsets in ways that promote innovation and transformation.

[4] TIMSS (Trends in International Mathematics and Science Study) and PRLS (Progress in International Literacy Study) are international assessments that monitor trends in student achievements in mathematics, science, and reading.

Table 3

Performance in joint PIRLS/TIMMS tests, Botswana and selected countries, 2011

	Percentage who reach high international benchmark (550)				Percentage who reach low international benchmark (400)			
	All 3 subjects	Reading	Maths	Science	All 3 subjects	Reading	Maths	Science
Australia	22	42	35	36	86	93	91	92
Czech Republic	21	50	30	45	92	98	93	96
Slovak Republic	21	44	30	44	89	96	91	94
Lithuania	21	39	43	31	92	97	96	95
Italy	18	46	28	37	90	98	93	95
Sweden	18	47	25	44	91	98	93	95
Romania	17	32	28	37	73	86	79	84
Poland	12	39	17	29	83	95	87	92
Spain	9	30	17	28	82	94	87	92
UAE	6	14	12	14	48	64	64	61
Iran	4	13	9	16	57	76	64	72
Azerbaijan	3	9	21	13	55	82	72	65
Saudia Arabia	2	8	7	12	43	65	55	63
Botswana (Gr.6)	3	9	7	7	37	56	60	43
Honduras (Gr.6)	2	11	3	8	43	74	49	60
Morocco (Gr.6)	0	1	2	1	8	21	26	15

Source: World Bank (2019).

Higher education in science, technology, engineering and mathematics (STEM) is critical for skills development in STI, particularly for undertaking R&D and for developing technologies or mastering technologies developed elsewhere. These are central to building absorptive capacity. They form the basis for engaging in technological upgrading and innovation by firms, universities and research institutes. The TVET system is similarly important for generating practical technical skills needed by the country. However, obtaining data on the TVET system has proved to be a challenge, as there does not seem to be a consolidated source of statistics available. This in itself presents a challenge for policymakers, for whom up-to-date TVET statistics are important to help inform policy.[5]

Tertiary education is dominated by bachelor's degree programmes, with relatively few enrolments at the master's and PhD levels in the higher education system. Public universities dominate enrolments in bachelor's programmes, but there are also substantial enrolments in private universities (table 4).

[5] Given the importance of TVET to STI development, there should be greater national investment in collecting the statistics that are required to inform policy on TVET and on education/skills development more broadly.

Table 4

Enrolments by higher education institution and level of qualification, 2017–2018 and 2018–2019

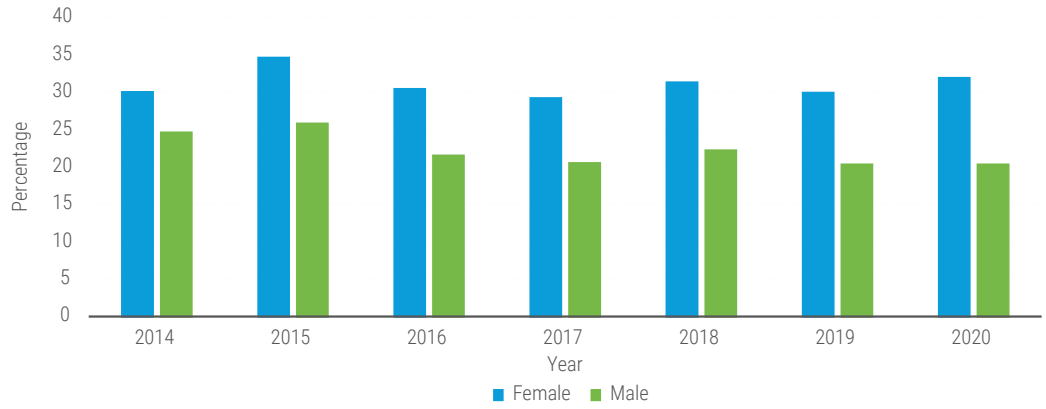
Institution Type	Year	Bachelor	Masters	PHD	Professional
Private institutions	2017/18	5158	43	0	311
	2018/19	5107	25	0	276
Private universities	2017/18	7719	164	0	321
	2018/19	7752	99	0	163
Public institutions	2017/18	3381	72	0	1149
	2018/19	4465	99	0	805
Public universities	2017/18	15102	1885	193	0
	2018/19	15956	2043	123	15

Source: Statistics Botswana (https://www.statsbots.org.bw/).

Women account for more than half of gross tertiary enrolments, which is high (figure 8). The relatively higher unemployment rates for women than men may provide an incentive for girls to push hard to attain higher education to avoid unemployment upon graduation. This high rate of participation in higher education does not necessarily reflect the situation for STEM disciplines, where women are underrepresented. Although women's enrolment in science subjects in tertiary education institutions represented 47 per cent of total enrolments in 2019–2020, they accounted for only 29 per cent of enrolments in engineering, manufacturing and construction (HRDC, 2021). The low participation rate of girls in engineering disciplines is common to many countries. Policymakers need to understand the reasons for this in order to mitigate the problem. Female enrolments in higher education are higher than those of males at the bachelor's degree level (accounting for 58.6 per cent of the total) and at the master's degree level (54.8 per cent), but this trend is reversed at the PhD level (42.4 per cent) (HRDC, 2021). Female participation in technical jobs appears to be relatively low, based on the available data relating to researchers presented in subsection 2.2 below. Some stakeholders suggest there is low female participation in higher level STI positions, although the review could not find data to substantiate this.

Figure 8

Gross enrolment rate in tertiary education in Botswana by gender, 2014–2020 (Percentage)



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO) (http://uis.unesco.org/en/country/bw).

The proportion of graduates in tertiary education in STEM disciplines is low (at only 17.5 per cent in 2017), with social sciences dominating enrolments (table 5).[6] By implication the pool of graduates to replace ageing R&D personnel is limited. It is unclear why there is such low interest in pursuing these disciplines. Understanding the reasons would be a useful input into policy decisions. It may reflect students' expectations of better paid job prospects from competing areas of study. Given the high rate of unemployment, there is an incentive for students to pursue studies in areas that are expected to lead to better job prospects upon graduation. Or it may reflect the fact that many students believe they are ill-prepared to pursue studies in STEM disciplines due to deficiencies at the lower education levels of science and mathematics. A third potential reason is lack of awareness among students of the possibilities for employment in technical areas based on studies in science, engineering and technology (SET). The DRST is conducting science weeks as a means of raising awareness on science-based occupations. While this will help raise awareness, it is unlikely to be enough to boost STEM participation rates. Based on discussions, it is found that many students struggle to successfully complete the course work in science and to graduate in scientific disciplines.

There are good technical skills available in Botswana, but many such skills, as well as research skills, are in short supply. There is need to build a critical mass of people with technical skills for R&D, especially at the master's and PhD levels. The challenge of retaining critical skills in Botswana is problematic, as some stakeholders reported a moderate brain drain. Ageing researchers and research managers must be replaced with a supply of graduates with research experience. In addition to technical skills, soft skills, such as effective communication, creativity, working in teams and problem-solving, are also critical, and should be developed through education and training starting at the earliest levels. Achieving this requires close collaboration across ministries and agencies. In the past, such collaboration was a challenge, necessitating coordination among several ministries: the Ministry of Basic Education (MOBE), the Ministry of Tertiary Education (MOTE), the Ministry of Employment, Labour Productivity and Skills Development (MELS) and the Human Resource Development Council (HRDC). It should be easier to achieve following the restructuring of May 2022, which merged these ministries into a single Ministry of Education and Skills Development (MESD).

Table 5

Share of graduates in science and engineering in total graduates at the tertiary level, selected countries, 2017
(Percentage)

Country	Share in all graduates (Percentage)	Country	Share in all graduates (Percentage)
Botswana	17.5	Namibia	2.6
Malaysia	33.3	Mauritius	22.9
Singapore	n.a	South Africa	19.0
Zambia	n.a	Zimbabwe	29.4

Source: Global Innovation Index (https://www.globalinnovationindex.org/).

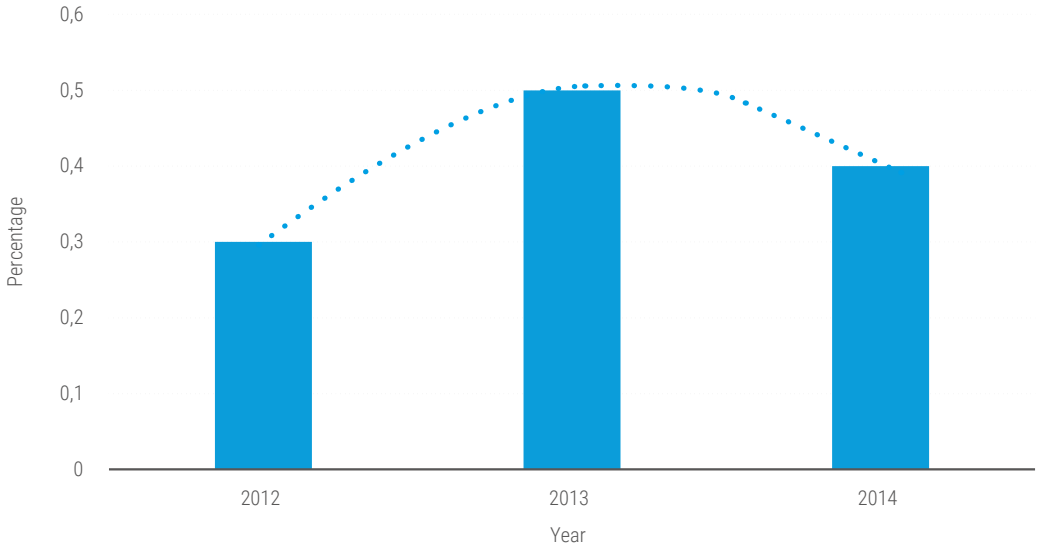
[6] It is not clear whether these graduates are being absorbed into the national workforce in STI-related jobs, owing to a lack of available data.

2.2 R&D, and financing for R&D

Expenditure on R&D in Botswana is low by international standards, and far lower than the national target of 2 per cent of GDP. Botswana's gross expenditure on R&D (GERD) has been rather volatile in recent years: at 0.3 per cent in 2012 increasing to 0.54 per cent in 2013 before falling to 0.4 per cent in 2014 (figure 9). This unstable pattern of investment creates uncertainty in the continuity of R&D projects. However, it may simply reflect poor quality of data and the reporting system underlying it. This issue needs further investigation of more recent data through an updated survey in order to inform policy decisions.[7] Nevertheless, the level of R&D investment is far below the national target set by the NRSTI policy of 2011, which aimed to increase GERD to over 2 per cent of GDP by 2016. It does not achieve even the much lower 1 per cent target established for African countries in 2005 by the Science and Technology (S&T) Consolidated Plan of Action laid out by the New Partnership for Africa's Development (NEPAD) and the African Union. Re-establishing the 2 per cent target within an appropriate time frame should be considered, while recognizing that achieving it will require much higher private sector investment in R&D as well as higher public investment. An interim target of 1 per cent of GDP may be attainable within a shorter time frame. Stronger engagement with the private sector through discussions on STI and bridging current gaps between the Government (and the DRST) and the private sector, as well as between research institutions and the private sector should be accorded high priority. The DRST is making initial efforts in this direction by drafting a Private Sector Engagement Strategy.

Figure 9

Gross expenditure on R&D as a percentage of GDP in Botswana, 2012–2014
(Percentage)



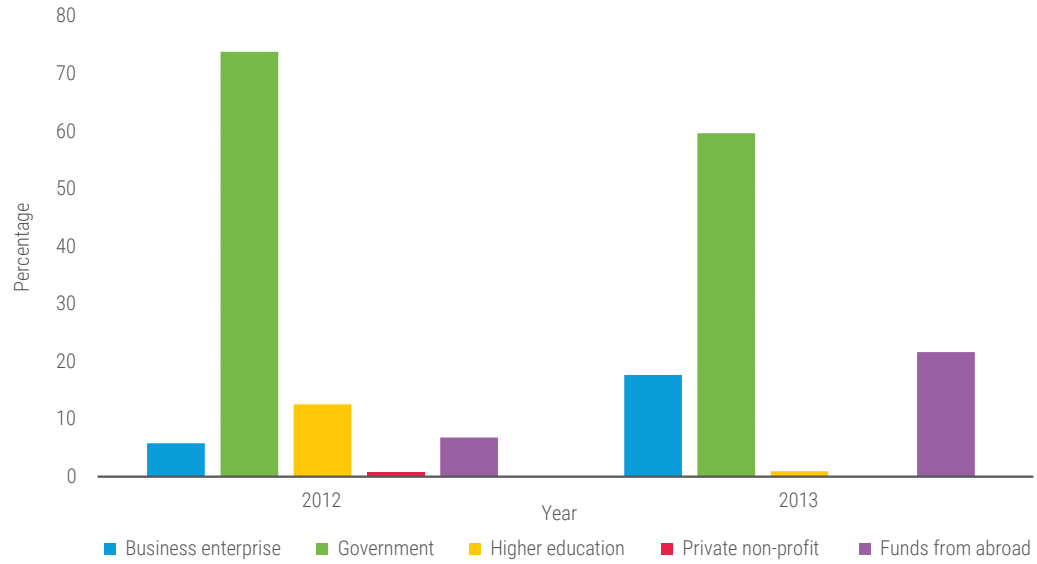
Source: UNESCO (http://uis.unesco.org/en/country/bw), and Botswana National Survey of Research and Development, 2014–2015.

[7] Collecting data on standard STI indicators through R&D surveys and innovation surveys is critical for effective monitoring and evaluation and to inform policymaking. However, so far, such data are not being collected on a regular basis. As a result, the data being used for analysis is out of date. The DRST should undertake regular surveys and ensure rapid analysis and dissemination of survey results.

R&D is largely financed by the Government, which accounted for over 70.5 per cent of total R&D funding in 2012, but falling to 60 per cent in 2013 (figure 10). Most of that funding has been directed at R&D institutions and public universities. The private sector invests little in R&D: 5.8 per cent of total R&D spending in 2012, increasing to 17.7 per cent in 2013. Funding for R&D by the higher education system accounted for 12.6 per cent in 2012, but fell to a marginal 0.9 per cent in 2013. Private non-profit funding was marginal in both years. Funding from abroad accounted for 6.8 per cent of R&D in 2012 and grew substantially to 21.7 per cent in 2013. For GERD to rise to 2 per cent of GDP, the Government will need to provide incentives for higher private investment in R&D, as the Government is unlikely to cover the large gap on its own. The Government can also play a critical role in creating an environment conducive to R&D, as well as coordinating and setting priorities for public R&D.

Figure 10

GERD by sources of funds, 2012 and 2013
(Percentage)

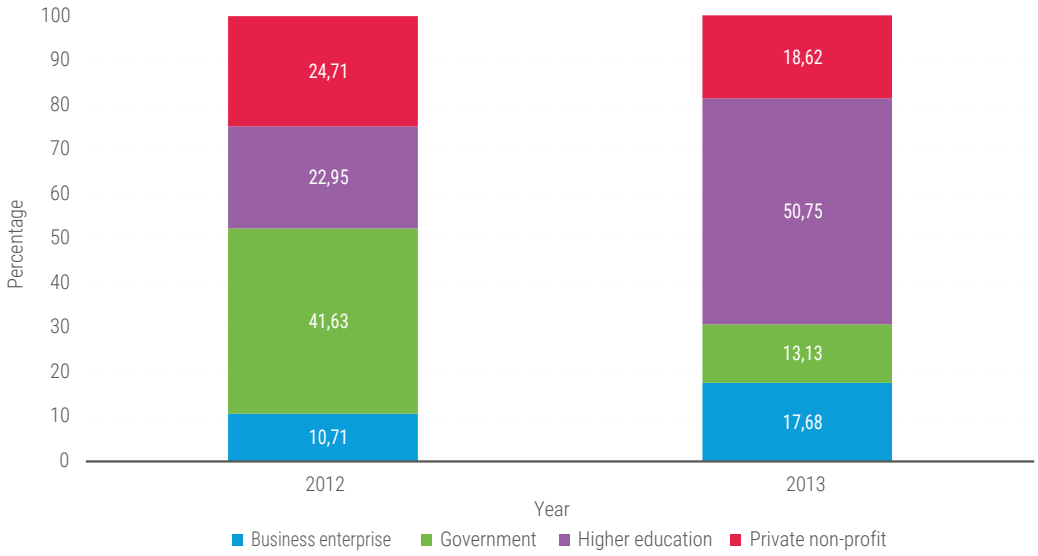


Source: UNESCO (http://uis.unesco.org/en/country/bw).

R&D is largely undertaken in higher education institutions, followed by government entities (which may be a mix of public research institutes and government agencies) and the private sector. There was reportedly a major shift towards institutions of higher education between 2012 and 2013 (figure 11) and away from government entities. There is no breakdown available for 2014 to gauge whether this has become a trend. The private sector accounted for 17.7 per cent of research in 2013, although business enterprises seem to have employed virtually no researchers that year (figure 12). It is possible that the researchers in business enterprises are not full-time research staff, and undertake research as only part of their jobs, but also that researchers may only be hired for a short period for specific research projects. More up-to-date data need to be collected, with additional investigation by the DRST, to enable a fuller analysis of trends in R&D. Collecting data and developing reliable R&D and innovation indicators to investigate underlying trends provides an evidence base that is an important part of developing national STI capacity, as well as for M&E purposes. Mainstreaming of M&E in Botswana is an important policy goal, to be led by the development of a national M&E system under the National Strategy Office and then taken up as a responsibility by concerned line ministries and departments.

Figure 11

GERD by sector, 2012 and 2013
(Percentage)



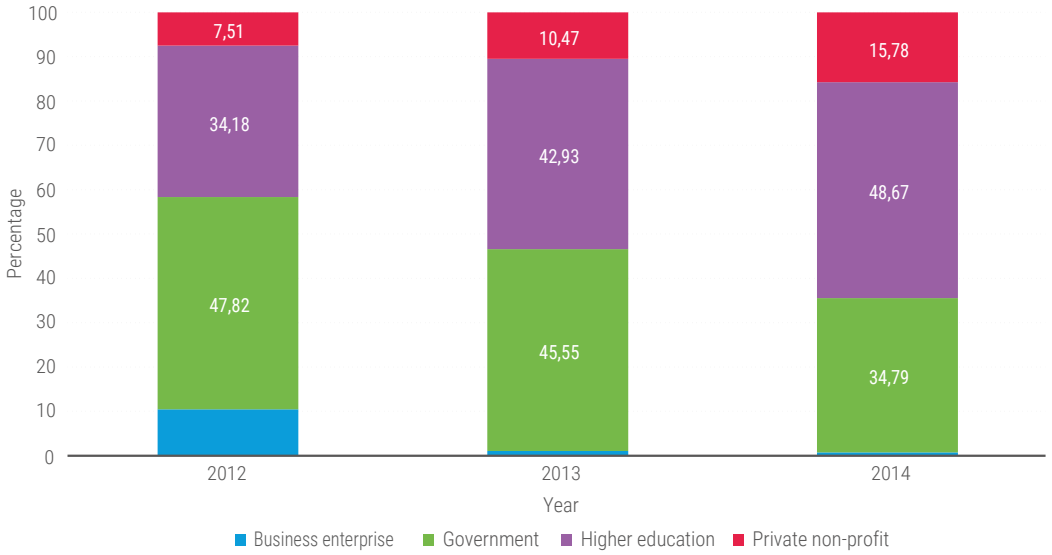
Source: UNESCO (http://uis.unesco.org/en/country/bw).

Researchers are employed mainly by institutions of higher education and the Government, and Private non-profit organizations and business enterprises are a third source of employment for research personnel on a full-time-equivalent (FTE) basis (figure 12). It is important to understand the reasons for the decline of R&D personnel in the private sector, from already low levels in 2012 to virtual non-existence in 2013 and 2014. In terms of gender, it is notable that women accounted for only 34 per cent of FTE researchers in 2014 (up from 31 per cent in 2013), although they account for more than half of all tertiary level enrolments. The percentage of female researchers is relatively low compared to other SADC countries, such as Mauritius (where their share is 48.8 per cent) or South Africa (45.1 per cent).[8]

[8] Female researchers as percentage of total researchers, http://data.uis.unesco.org/.

Figure 12

Full-time equivalent researchers by sector of employment in Botswana, 2012–2014
(Percentage)



Source: UNESCO (http://uis.unesco.org/en/country/bw), Botswana National Survey of Research and Development 2014-2015.

Botswana has rapidly increased its research publications over the past decade, but its research output remains relatively low by international standards. The number of scientific publications more than doubled between 2011 and 2019 (the latest available figure) (table 6). Indeed, Botswana ranks fourth among SADC countries in terms of its number of publications (with 272.2 publications per million inhabitants in 2019), following Seychelles (532), South Africa (359.7) and Mauritius (342.6). Most publications have foreign co-authors (81 per cent of publications between 2017 and 2019), mainly from South Africa, the United States, the United Kingdom, India and Zimbabwe (*UNESCO Science Report*, 2021). The consistent rise in the number of publications appears to be at odds with the R&D data, which show investment in R&D falling in 2014. This issue deserves further investigation to resolve whether this may represent a data measurement issue.

Table 6

Scientific publications in Botswana, 2011–2019
(Number)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Scientific publications	263	250	287	349	300	473	458	592	627

Source: UNESCO Science Report (2021).

In recent years, most publications have been in the field of health sciences, followed by environmental sciences. There are far fewer publications in the other key STEM-related disciplines, such as ICT, mathematics and statistics, cross-cutting strategic technologies and engineering (table 7). Agricultural research accounts for a relatively small share of total publications, although such research may include a significant amount of testing of crops in the field, which may not be recorded in publications. Nevertheless, the relatively high level of investment in what appears to be pure sciences (physics and astronomy) compared to agriculture, which is related to one of the most productive industries in the country, may indicate a disconnect of R&D from Botswana's productive sectors.

Table 7

Share of publications in broad science disciplines, 2014–2016 and 2017–2019
(Percentage)

	2014–2016	2017–2019
Health sciences	40.5	36.5
Environmental sciences (excl. geosciences)	11.2	13.0
Cross-cutting strategic technologies	8.8	10.3
Engineering	7.0	9.7
ICTs, mathematics and statistics	10.3	7.6
Physics and astronomy	3.1	7.0
Agriculture, fisheries and forestry	6.0	4.5
Chemistry	5.3	3.5
Animal and plant biology	4.0	4.7
Geosciences	3.3	2.5
Built environment and design	0.5	0.8

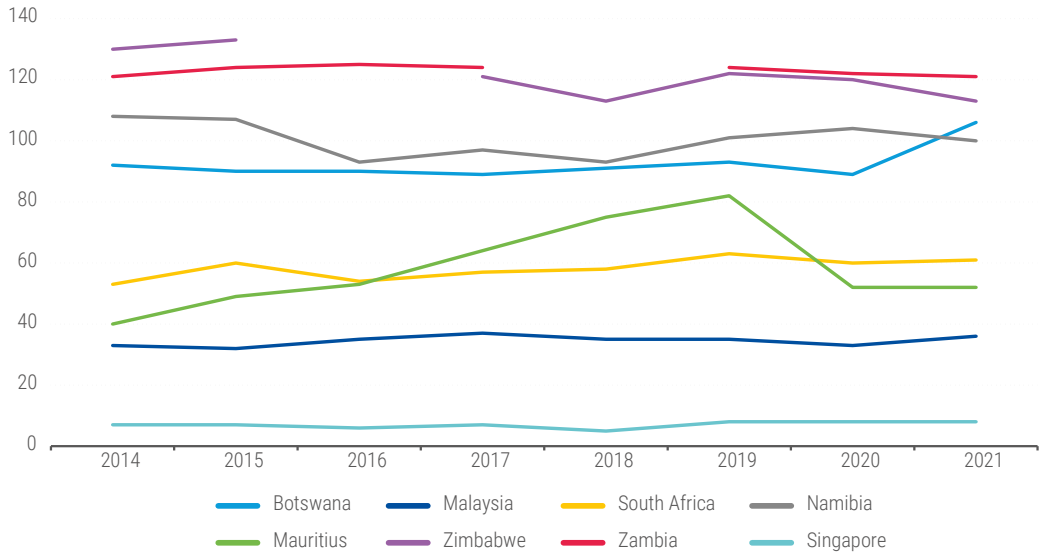
Source: UNESCO Science Report (2021).

2.3 Innovation capacity and firm-level innovation

Botswana ranks low in the overall Global Innovation Index (GII) of the World Intellectual Property Organization (WIPO), which indicates a country's innovation capacity, although it is relatively strong when compared solely with sub-Saharan African countries. It ranked 106 in 2021 (down from 89 in 2020), well below South Africa and Mauritius (figure 13). Its ranking was stable from 2014 to 2020, but declined in 2021. The innovation profile has not changed much over the period, except for a marked decline in the score for human capital and research in 2021 (figure 14), most likely due to the lack of data for this variable. Botswana ranks very high on institutions and the rule of law, both of which provide a good environment for innovation, which requires stability to thrive.

Figure 13

Global Innovation Index ranking of Botswana and selected countries, 2014–2021



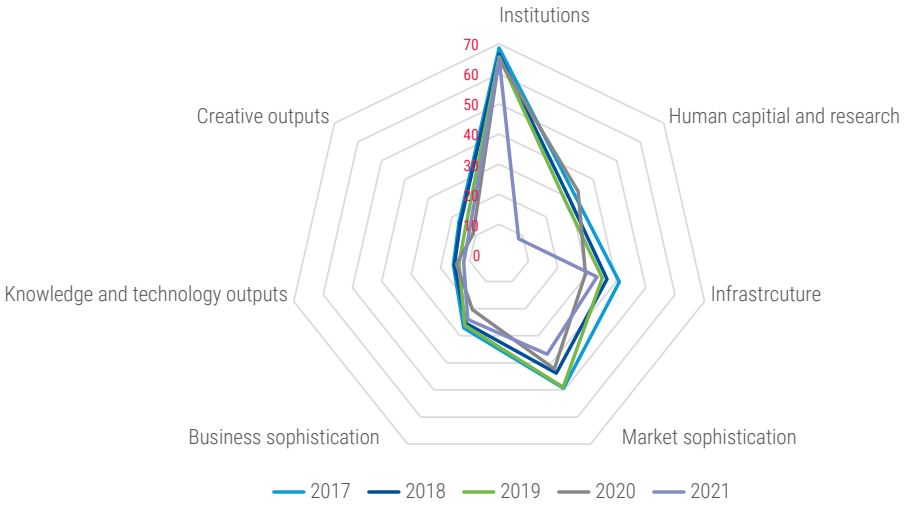
Source: WIPO, Global Innovation Index (https://www.globalinnovationindex.org/Home).

Note: The highest ranked country in the world is ranked as number one.

Benchmarking using the GII index score and GDP per capita for 2019, Botswana is found to perform below the level of innovation expected for its income level. In figure 15 Botswana sits to the right of the fitted line. These findings indicate that Botswana should improve its innovation capacity and performance, although it has moderately strong innovation capabilities. The GII provides a useful international benchmarking tool, even if its results are imperfect, as are all indicators of innovation capacity. It is important to look also at the results of national innovation surveys to gain insight into the innovation performance of firms, which should be actively innovating to drive economic transformation.

Figure 14

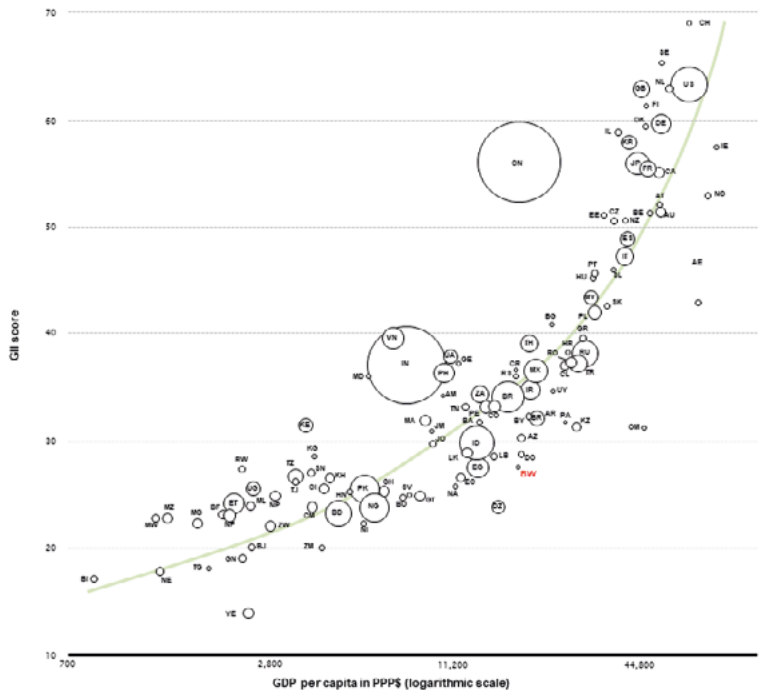
Botswana's score on GII indicators, 2017–2021



Source: WIPO, Global Innovation Index (https://www.globalinnovationindex.org/Home).

Figure 15

GII score and GDP per capita, various countries, 2019



Source: Cornell University et al. (2019).

According to the various GII indicators, Botswana's innovation-related strengths are led by high spending on education, a good record of new business creation and low applied tariff rates. Also mentioned are political and operational stability and the rule of law (table 8). Botswana's innovation-related weaknesses include a low level of knowledge absorption (related to absorptive capacity of the recipient, who must have the knowledge and skills to master the knowledge), weak government online services and e-services, low attainment of ISO quality standards and few registered patents.

Table 8

Botswana's innovation-related strengths and weaknesses by GII indicators, 2020

Strengths		
Code	Indicator name	Rank
1.1.1	Political and operational stability	21
1.2.2	Rule of law	43
2.1.1	Expenditure on education, % GDP	1
2.1.2	Government funding/pupil, secondary, % GDP/cap	7
3.2.3	Gross capital formation, % GDP	16
3.3.1	GDP/unit of energy use	31
4.3.1	Applied tariff rate, weighted avg, %	4
5.1.2	Firms offering formal training, %	15
5.2.3	GERD financed by abroad, % GDP	34
6.2.2	New businesses/th pop, 15-64	3
Weaknesses		
2.3.3	Global R&D companies, top 3, mn USD	42
2.3.4	QS university ranking, average score top 3	77
3.1.3	Government's online service	127
3.1.4	E-participation	125
5.2.5	Patent families 2+ offices/bn PPP$ GDP	101
5.3	Knowledge absorption	130
5.3.5	Research talent %, in business enterprise	79
6.1.1	Patents by origin/bn PPP$ GDP	121
6.1.2	PCT patents by origin/bn PPP$ GDP	100
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	124
7.1.2	Global brand value, top 5 000, % GDP	80

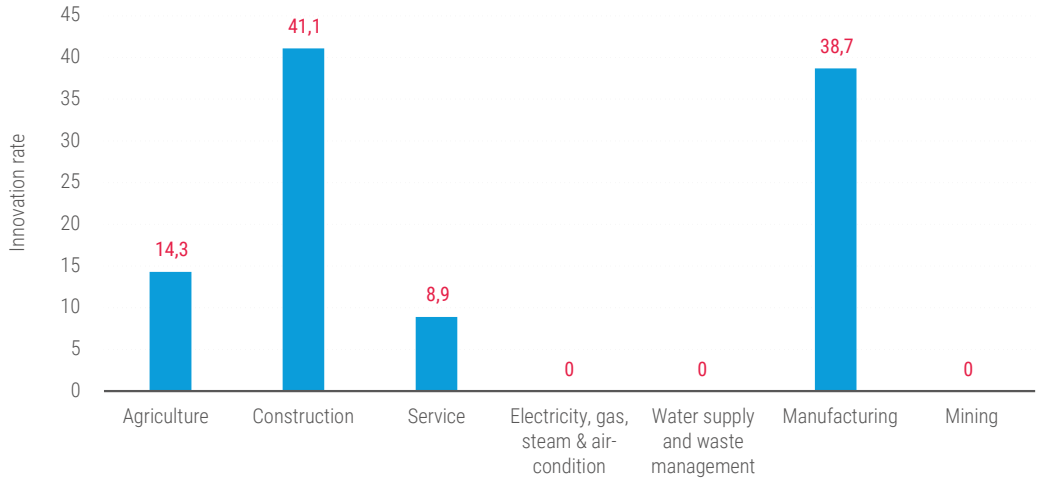
Source: Cornell University et. al. (2019).

Botswana's first National Innovation Survey covering the period 2013–2016 indicates that the overall rate of innovation in firms is low, at 20 per cent of the total. The most common types of innovation were organizational innovation (at 10 per cent of all firms) followed by product innovation (8 per cent), process innovation (6 per cent) and marketing innovation (5 per cent). These innovation rates are low by international standards, meaning that firms in Botswana do not appear to be highly innovative, and require nurturing to improve their innovation performance. The four types of innovation mentioned in the OECD/Eurostat *Oslo Manual* on innovation statistics are shown in figures 16 to 19. Manufacturing firms are generally the most innovative in Botswana, which confirms the argument in chapter 1 that manufacturing is likely to offer greater opportunities than other sectors for learning and upgrading in terms of skills and technology. The rate of product innovation in manufacturing is relatively high (38.7 per cent) compared with agriculture and services (figure 16). In mining, product innovation is difficult, as the product generally does not change, which is why it is not surprising to see no product innovation in that sector. The same is likely true for electricity, gas and steam, as well as water supply and waste management. Process innovation is also most common in manufacturing firms at 27.6 per cent (figure 17). Organizational innovation

is most common in manufacturing firms, followed by services firms and construction firms, with other firms reporting no organizational innovations (figure 18). Marketing innovations have been the most common in the electricity, gas, steam and air conditioning industries (25 per cent), just ahead of manufacturing firms (24 per cent) (figure 19).

Figure 16

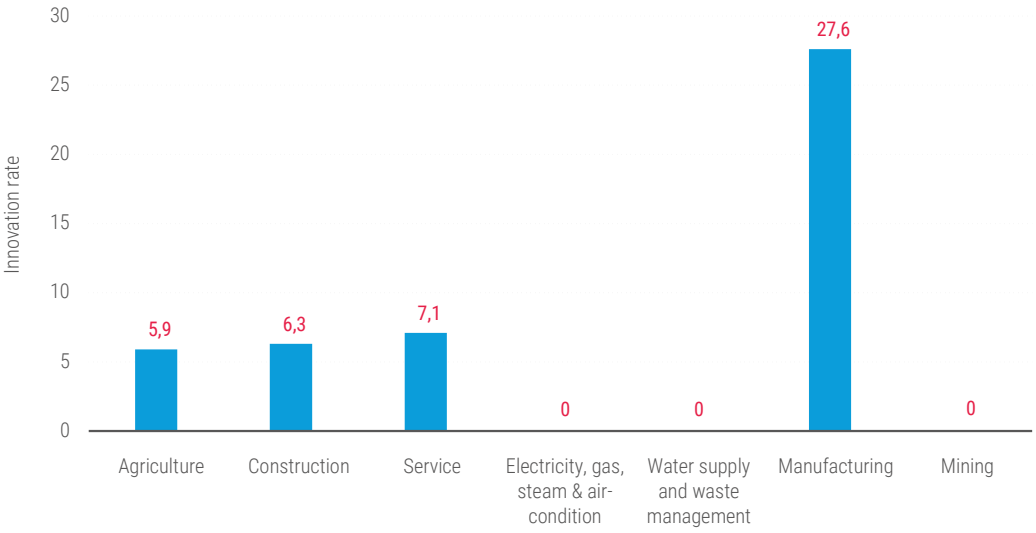
Product innovation rate among innovative firms, by industry classification, 2015–2016
(Percentage)



Source: Botswana National Innovation Survey, 2013–2016.

Figure 17

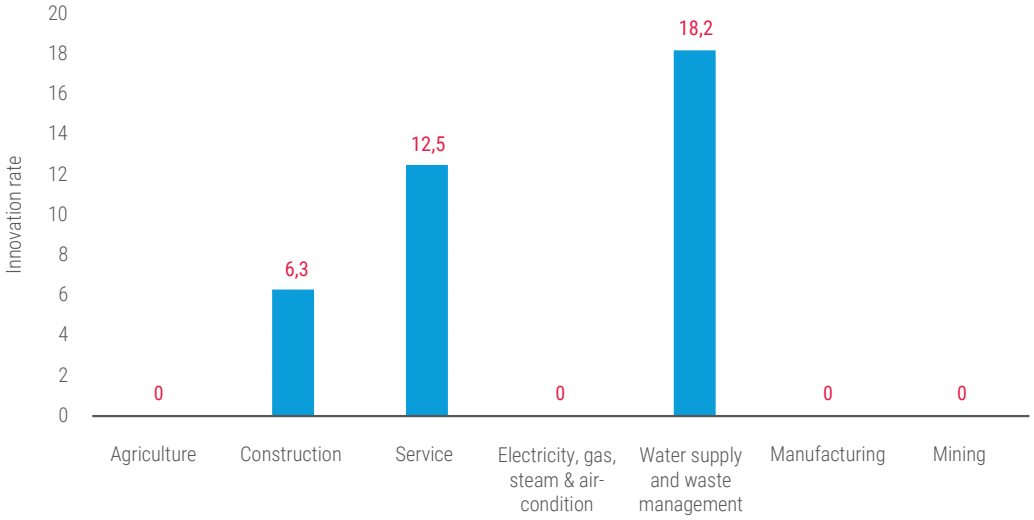
Process innovation rate among innovative firms, by industry classification, 2015–2016
(Percentage)



Source: Botswana National Innovation Survey, 2013–2016.

Figure 18

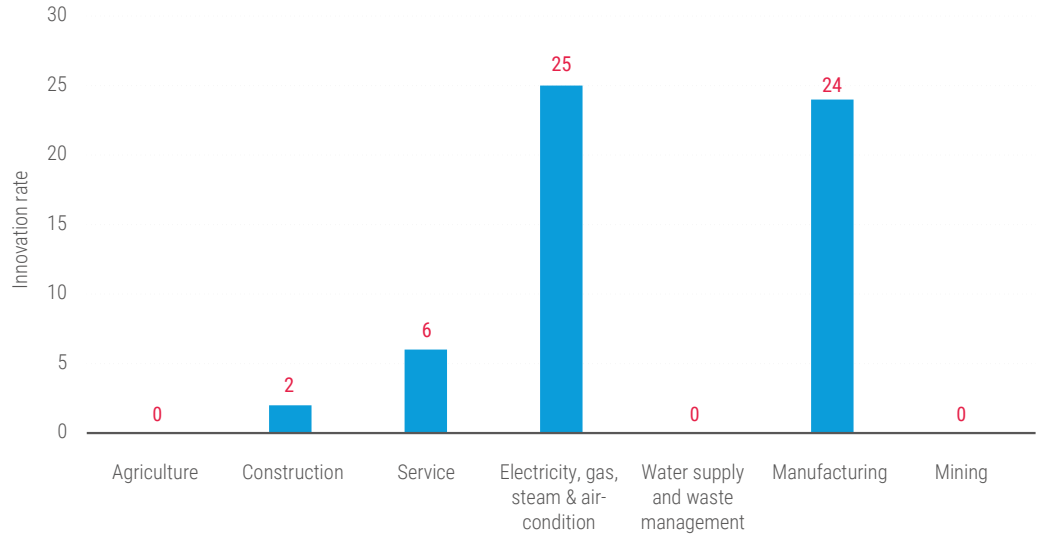
Organizational innovation rate among innovative firms, by industry classification, 2015–2016
(Percentage)



Source: Botswana National Innovation Survey, 2013–2016.

Figure 19

Marketing innovation rate among innovative firms, by industry classification, 2015–2016
(Percentage)

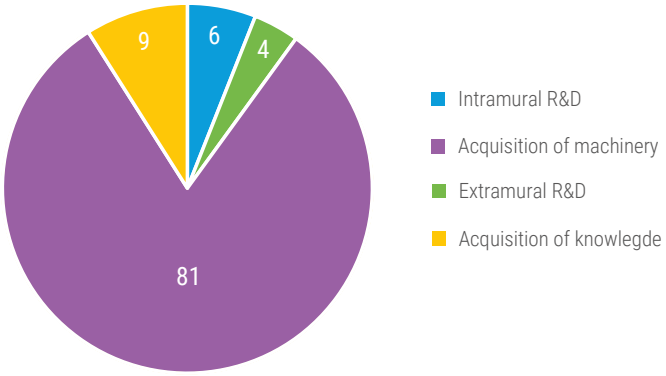


Source: Botswana National Innovation Survey, 2013–2016.

Business enterprises reported their main spending on innovation activities consists of buying machinery, tools, equipment and software, whereas undertaking R&D accounts for only a small share of their spending on innovation (figure 20). They rely heavily on the use of knowledge from abroad embedded in imported machinery and equipment. Indeed, this is the largest source of innovation in Botswana. Thus, building strong absorptive capacity among domestic firms, farmers and other innovators to master this knowledge and build indigenous technological capabilities is critical. Businesses in Botswana do little collaborative R&D with outside R&D organizations (presumably including universities and public research institutes). Indeed, discussions with stakeholders in Botswana confirm that collaborative linkages between business and R&D organizations are weak.

Figure 20

Firms' expenditure on innovation activities, 2016
(Percentage)



Source: Botswana National Innovation Survey, 2013–2016.

According to the Botswana Innovation Survey, lack of financing within the firm was the most frequently mentioned as hindering its ability to innovate. The lack of finance from outside the firm was also mentioned by many firms as a major constraint (table 9). Other reported constraints included the high cost of innovation, domination of markets by established enterprises (i.e. larger foreign firms or State-owned enterprises), difficulty in finding partners for cooperation, a lack of qualified personnel and a perception of high economic risks associated with innovating. A large proportion of respondents believed there was no need to innovate, either because of prior innovations or because there was no demand for innovations. These two reasons relate to the level of competitive pressure in the market, which, for a significant proportion of firms, is not strong enough to require innovation in order to compete.

Table 9

Major factors hampering innovation among innovative and non-innovative firms

Hampering Factor	Innovative firms (percentage)	Non-innovative firms (percentage)
Cost factors		
Lack of funds within your enterprise or group	52.3	48.5
Lack of finance from sources outside your enterprise	36.8	27.2
High innovation costs	36.2	29.8
Market Factors		
Lack of information on markets	20.7	17.3
Market dominated by established enterprises	41.4	24.7
Uncertain demand for innovative goods or services	22.0	19.8
Knowledge factors		
Lack of qualified personnel	23.7	21.1
Lack of information on technology	16.6	14.6
Difficulty in finding cooperation partners for innovation	29.3	19.2
Organizational/Policy factors		
Organizational rigidities within the enterprise	8.5	14.3
Excessive perceived economic risks	27.3	25.0
Innovation being easy to imitate	11.9	14.6
Insufficient flexibility of regulations or standards	20.3	17.0
No need factors		
No need to innovate because of no demand for innovation	23.7	21.1
No need to innovate due to prior innovations	36.2	29.8

Source: Botswana National Innovation Survey, 2013–2016.

2.4 Financing for STI

Access to finance is a challenge for most firms in Botswana, especially for small, micro and medium-sized enterprises (SMMEs) and for innovative investment. The constraint created by a lack of financing available in the NSI for innovation is confirmed by respondents to the National Innovation Survey, as noted above. The financial sector is heavily dominated by commercial banks, which limits the potential for private financing of RSTI, as those banks are generally risk averse and unsuitable for participating in high-risk activities such as R&D, technology development and innovation. Innovation is subject to high levels of uncertainty, as outcomes of innovation efforts are hard to predict. Therefore it is important for countries like Botswana to nurture specialized financing instruments.

Botswana is gradually developing specialized mechanisms for funding innovation, and access to specialized risk capital has begun to flow, which should reduce the funding gap. In addition, specialized financing mechanisms that are better suited to financing highly uncertain or high-risk investments need to be developed. The Government has taken some action in this direction by supporting the establishment of the Botswana Innovation Fund (BIF) in 2018. Efforts are also under way to establish a National Research Fund.

The Government is also supporting greater funding for entrepreneurship, particularly for youth entrepreneurship, notably through the Citizen Entrepreneurial Development Agency (CEDA). CEDA offers loans at below market rates of interest. The rules on access to CEDA financing have been relaxed to make access easier for entrepreneurs, and stakeholders (including small enterprises) reported during interviews that CEDA had become a preferred source of funding that suits the needs of youth and women entrepreneurs. However, it appears from discussions that CEDA does not provide much financing for R&D or risky innovation, but rather for more standard, less innovative entrepreneurship.

Other development finance institutions are the National Development Bank (NDB) and the Botswana Development Corporation (BDC). The NDB specializes in lending to agriculture, while the BDC has, over time, adopted more commercial approaches to lending to avoid extending large, non-performing loans to preserve its financial viability. However, neither of these institutions fill the need for innovation financing.

Venture capital remains nascent, and business angels started operating only in 2019. Local venture capital is developing, and some financial institutions reportedly have some degree of equity stake in businesses, although this appears to be on a small scale. A private-sector-led business angel group, Angel Network Botswana (ANB), started in 2019, and was formally constituted as a company limited by guarantee in 2020. It is now established and active. So far, ANB members have made three angel investments in Botswana in addition to a few others in different parts of Africa.

To provide funding on the scale required for R&D, technology development and adoption, and innovation, some governments have established a natural resource levy on abundant, high-value natural resources such as oil and copper. Under such an arrangement, a small percentage of the proceeds from production are allocated to a special fund to provide financing for STI. Botswana has the possibility of introducing a similar arrangement that could be tied to diamond production. Such a levy could be placed on the large diamond that was discovered by Botswana in 2022 as a pilot project.

2.5 Recommendations

There is a need to build a critical mass of technical skills for the R&D system in particular, and the economy in general, including at the master's and PhD levels. In addition to technical skills, soft skills should be developed through the education and training system, starting at the earliest levels. These include effective communication, working in teams, creativity and problem-solving. This requires action starting from lower education, to TVETs and higher education, implying close collaboration across relevant education and training bodies. It also requires the following: (1) improving the linkages between skills development and industry needs (e.g. strengthening planning and linkages to induce industries to provide internships and scholarships for graduate studies); (2) encouraging and providing favourable conditions to attract diaspora and international specialists in RSTI; (3) strengthening formation of technology-based skills in line with national research and technology priorities; (4) expeditiously updating school, TVET and university curricula to develop skills to harness rapidly developing frontier technologies; (5) improving the quality of teaching and performance of students in STEM subjects at lower school levels, and upgrading standards in the TVET system; (6) further strengthening STEM education at the tertiary level; and (7) supporting the development of capable researchers and research managers to take over from ageing researchers and research managers.

Data on STI in Botswana is not up-to-date; it should be regularly updated through surveys as a basic part of the M&E framework for STI. There has been progress in initiating R&D surveys, and there has been one innovation survey. However, the survey results are now out of date and new surveys should be launched. The Government should also consider the feasibility of establishing a national data centre on STI to integrate all data collection, management and dissemination of information on STI. Several African countries (e.g. Egypt and South Africa) have established national observatories for STI that act as national data centres. The DRST is working to establish a Research and Information Management System (RIMS) which would allow the collection of data on research in Botswana as part of its M&E framework.

Botswana should explore innovative ways of increasing financing for R&D, technology and innovation. Progress has been made in recent years in offering specialized sources of financing for innovation. However more needs to be done. The National Innovation Fund remains very small in terms of the amount of funding it allows. Consideration should be given to: (1) assessing the operation and effectiveness of the fund and increasing its size; (2) designing incentives to encourage the private sector to invest in R&D (such as offering R&D tax credits), particularly in areas of high priority; and (3) developing new sources of financing such as business angels, venture capital, financing of innovation by the national development bank and imposing a mineral levy on diamonds. Business angels and venture capital should be supported as emerging sources of innovation financing that can contribute to parts of the early and growth stages of innovation funding. Establishing a National Research Fund could help to increase R&D funding, and channel R&D investment into priority research areas.

Chapter 3. Actors in the national system of innovation in Botswana

3.1 Overview

The Government of Botswana has been giving increasing attention to STI over the past few decades. Efforts to strengthen the country's NSI have been focusing on, inter alia, the following:

- Institutional reforms to improve oversight, management and the operational mechanisms of RSTI, including establishing the DRST to oversee STI;
- Strengthening digitalization in order to transform the public sector and create the appropriate infrastructure for greater private sector participation in economic activities and innovation;
- Supporting the commercialization of innovation through start-ups; and
- Increasing support to research and innovation in universities and public research organizations.

Despite these efforts, Botswana's NSI remains weak due to inadequate institutional articulation or linkages within public sector organizations and between them and private sector ones.

3.2 Mapping Botswana's national system of innovation

The NSI comprises both public and private sector actors that oversee, support or undertake STI activities. It operates through systemic linkages among these actors and their activities, as well as through policies and policy instruments that nurture knowledge production and diffusion, and innovation. The efficiency and effectiveness of the NSI depend on the coherence and integration of the activities and functions of different actors and their activities, which are facilitated by the existence of a common vision that guides the overall direction of STI activities.

The purpose of this section is to map the key NSI actors, and explore their main functions and linkages. The actors include organizations dedicated to R&D, technology adoption, development and diffusion, entrepreneurial activities and innovation, the development of skills, policy design and implementation, financing of STI activities and overall institutional coordination of the system.

3.2.1 The STI Institutional landscape

The country's STI institutional landscape has changed considerably over the past decade with the creation of new universities and research institutes, new innovation funding mechanisms and shifting of the ministerial location of STI as a result of restructuring. Various R&D coordination functions seem to be spread across the landscape, with departments dedicated to R&D located in different sectoral ministries.

The functions of coordinating and helping to build institutional linkages in the NSI are performed by several organizations responsible for creating an enabling environment through regulations, policies and strategies. The Cabinet and the Office of the President provide the highest level of oversight, approving policies and providing strategic guidance to the national STI agenda.

The Vision Council 2036, which was established by a Presidential Directive in November 2017, reports directly to the Office of the President. Its role is to "provide overall guidance, direction and leadership to ensure that the destination of Vision 2036 remains in clear view of all stakeholders". Botswana's Vision 2036 is a transformational agenda, detailing the country's aspiration to become a high-income country by 2036. It prioritizes innovation by stating that transformation and progress "will be driven by investments in innovation, research and development, including indigenous knowledge across all Vision Pillars thereby domesticating and accelerating the pace of technical and scientific advancement".

The National Strategy Office, which started operating in 2010, is mandated to coordinate the development and implementation of national strategies through research, management, monitoring and evaluation of sectoral strategies. Located in the Office of the President, it is responsible for overseeing the establishment of the National Monitoring and Evaluation System which is to be implemented by concerned line ministries, departments and agencies in the country.

The Smart Bots Office has been entrusted with the implementation of the Digital Transformation Strategy (SmartBots) – a newly launched action plan that aims to drive digital transformation across the economy, government and society. The plan is aligned with Vision 2036.

Governance of the NSI in Botswana is highly centralized, with most policy and operational functions resting at the ministerial level.

3.2.2 Ministerial oversight

The Ministry of Communications, Knowledge and Technology (MCKT) provides leadership, and is responsible for overall STI policy development, strategy and standards relating to communications, knowledge utilization, research, science and technology. It also plays an important role in digital transformation (see section below on support to the digital ecosystem). Before the creation of the MCKT in May 2022, STI policy functions were undertaken in the then Ministry of Tertiary Education, Research, Science and Technology (MoTE), which was also responsible for tertiary education and partly responsible for the implementation of the digital transformation strategy.

The DRST is responsible for coordinating the activities of different actors in the NSI. It was established "to provide leadership in science and technology in Botswana through the provision of an enabling policy and legislation environment and coordination of science and technology activities in the country". Since RSTI support and performance are spread across different ministries and organizations, one of the DRST's main tasks has been to coordinate those activities to ensure their alignment with national goals. Its creation was therefore an important milestone, given that, previously, there was no specific organization dedicated to coordinating RSTI activities.

Initially, when the DRST was established in 2004, it was under the Ministry of Communications Science and Technology, but then moved in 2009 to the Ministry of Infrastructure, Science and Technology (MIST), and subsequently to MoTE in 2016, before moving to the new MCKT in the May 2022 restructuring. This sequence of migrations negatively affected its institutional stability and growth, posing significant challenges to its ability to accomplish its mandate. The institutional location of the DRST limits its ability to play an effective guiding and coordinating role in the National Innovation System (NIS). The NRSTI policy (2011) and its Implementation Plan (2012) envisaged upgrading the DRST to a Directorate for Research, Science, Technology and Innovation that would fall under the ministry responsible for S&T, providing it with the institutional authority to carry out its mandate.

As the central coordinator of public activities in Botswana, the DRST is expected to establish strong linkages with other major NSI actors. However, at present, its connections with most of them are weak. For effective governance of the NSI, it needs to strengthen linkages with bodies dealing with technology and innovation (i.e. the Botswana Institute for Research and Innovation and the Botswana Digital Innovation Hub, both of which are under the MCKT along with the DRST), education (the new Ministry of Education and Skills Development along with the universities and the HRDC that is now placed under it), diversification, foreign investment, trade and intellectual property (Ministry of Trade and Industry and its agencies: the Botswana Investment and Trade Centre, the Special Economic Zone Authority and the Companies and Intellectual Property Authority (CIPA), entrepreneurship (the new Ministry of Entrepreneurship and its agencies, the Local Enterprise Authority and the Citizen Entrepreneurial Development Agency), agriculture (the Ministry of Agriculture and its research institutes: National Agricultural Research and Development Institute and the Botswana Vaccine Institute), health (the Ministry of Health and its research and education agencies) mining (the Ministry of Minerals and Energy), public procurement, statistics (Statistics Botswana), and with the private sector (including Business Botswana and other industry bodies).

Owing to these weak linkages the DRST's ability to fulfil its expected role is limited. It does not possess adequate legislative authority and institutional/organizational capacity to both coordinate the NSI as well as build institutional linkages among public actors and between public and private actors within the NSI. Unlike similar STI bodies in some other African countries (e.g. the National Commission for Research, Science and Technology of Namibia and the National Commission for Science, Technology and Innovation of Kenya) that are established by legislation or Acts of Parliament, the DRST's creation is through an administrative instrument. Therefore, its mandate as a coordinating body of the NSI is not on a strong legal footing.

The DRST should be adequately staffed and funded if it is to build effective organizational capacity to coordinate the NSI, establish relevant linkages, and engage in policy advice and design. Currently, it is severely understaffed in terms of technical (substantive) personnel. Of a total staff of 32, there are two managers, seven technical personnel, and 23 administrative and human resources personnel. The balance between technical and support staff should be revised so that technical staff with expertise (training and experience) in the key areas within the DRST's mandate are doubled, at a minimum. Skills are needed in the following areas: STI/innovation policy; M&E, STI indicators and data management; technology foresight and technology assessment; evaluation of research and innovation policies and programmes; technology management and technology transfer to firms; innovation management; and STI/science communication and outreach. This implies the need for the DRST to invest in staff training in relevant areas and recruit people with the requisite skills.

The Ministry of Education and Skills Development (MESD) was created from the merger of functions previously performed by three ministries – those for Tertiary Education, Basic Education and Skills Development (as noted earlier). The institutions of higher education (public universities), the HRDC and various other related bodies critical for human capital development fall under the MESD. Other actors involved in the NSI include ministries responsible for sectoral policies and plans that implicitly engage in STI or related activities, as described below.

The Ministry of Trade and Industry (MOTI) broadly supports the promotion of trade and development of industries to diversify and grow the economy. It provides direct support to entrepreneurship through its parastatals, which include the Botswana Bureau of Standards, the Botswana Development Corporation, the Botswana Investment and Trade Centre, the Botswana Trade Commission, the Companies and Intellectual Property Authority (CIPA) and the Special Economic Zones Authority. Two parastatals (the Local Enterprise Authority and the Citizen Entrepreneurial Development Agency) were moved from MOTI to the new Ministry of Entrepreneurship in May 2022.

The Ministry of Agriculture is mandated to support agricultural development. Realizing that many of the challenges and opportunities in agriculture can be addressed through R&D and the application of new technologies, its parastatals – the National Agricultural Research and Development Institute, the Botswana Agricultural Marketing Board and the Botswana Vaccine Institute – play major roles in agricultural R&D within the NSI.

The Ministry of Environment and Tourism supports environment-related issues under one roof for better coordination of policies, strategies and programmes, although its work is not visibly connected to RSTI activities.

The Ministry of Foreign Affairs manages and coordinates Botswana's foreign policy, and advances the country's national interests abroad. This ministry does not have dedicated budgets to support science diplomacy, research activities, or monitoring and evaluation of the impact of international cooperation activities. However, it promotes international STI cooperation with governments and international organizations.

The Ministry of Local Government and Rural Development is responsible for creating an enabling environment for community development, addressing issues of rural poverty and ensuring that local institutions perform effectively and efficiently. It facilitates the provision of social development services and municipal infrastructure, promoting village connectivity and integrating digital technologies to improve the provision of social services. Together with the DRST, it is developing a national Indigenous Knowledge Strategy.

The Ministry of Finance formulates financial and economic policies and oversees the effective coordination of the Government's financial operations. While it acknowledges the importance of RSTI, its budgetary allocation for these activities and its linkages with the other institutional structures of the NSI are limited. It is more visibly involved in supporting digitalization, especially through Smart Botswana.

The Ministry of Minerals and Energy is mandated to coordinate mineral development and regulation of mining activities, as well as to promote the use of green technologies (renewables) and the use of a mix of alternative energy sources to ensure energy sustainability and security in Botswana. It oversees the Botswana Geoscience Institute, which undertakes research in geosciences and provides specialized geoscientific services.

3.2.3 Coordination, data and networking

This "meso" level function is an essential layer of the NSI, and is composed of organizations dedicated to coordinating specific sections of the system, providing data to monitor its performance, and/or rendering a range of support services to actors involved in RSTI (universities, research organizations, firms and communities). Some of the major actors at this level are described below:

The Human Resource Development Council (HRDC) was established by the HRDC Act No 17 of 2013. It **is responsible for providing policy advice on matters of national human resource development**, as well as coordinating and promoting implementation of the National Human Resource Development Strategy, formulating Sectoral Human Resource Development Plans), and advising on tertiary education financing and workplace learning.

The HRDC developed the National Human Resource Development Plan (NHRDP), which was adopted in 2020, after extensive stakeholder consultation with representatives of the public and private sectors. Its implementation will require significant reforms across the education sector.

Five lines of activity in the Council are aligned with the NHRDP.

1. Contribution to the production of demand-led skills. The HRDC produces an annual list of occupations that are needed to facilitate alignment with the development of relevant skills in collaboration with the Department of Tertiary Education Financing. It has also developed the Labour Market Information System (LMIS) to monitor changing trends in labour market patterns taking into account changing trends in, for example, demography, technology and skills requirements.
2. The HRDC institutional framework provides guidelines and assistance to education and training organizations to develop their institutional plans.
3. The Workplace Learning unit assists workplaces to design training plans and assess the relevance of training for different sectors.
4. The TVET advisory committee has established links across ministries, including the former Ministry of Basic Education and the Ministry of Employment, Labour Productivity and Skills Development. Its membership includes representatives from the Botswana Accountancy College, Botswana Qualifications Authority, University of Botswana and Business Botswana. This structure will need to change following the creation of the new Ministry of Education and Skills Development in May 2022.
5. Funding: the HRDC currently manages the HRD Fund (levy) aimed at supporting workplaces to train workers. The proposed Tertiary Education Institutions Fund is intended to provide institutions with funding for research as a critical component. It is yet to be approved by the Government, as is the Tertiary Education Student Support Fund, which is planned to fund students, administered by the Department of Tertiary Education Financing.

Linkages and collaborations

The HRDC aims to assist the development of human resources in Botswana by engaging and accommodating inputs from and broad participation of the public and private sectors, civil society, labour, youth, education and training providers, and other key stakeholders. It appears to have strong linkages with the private sector, universities and government ministries.

- ***Partnerships with industry***: The HRDC has active linkages with employers from 12 different sectors (agricultural, manufacturing, tourism, health and wellness, research and innovation, ICT, finance, mining, public services, creative and performing arts, and transport) in order to identify the skills they require as a matter of priority.
- ***Partnerships with universities***: The HRDC supports the commercialization of research through the HRDC Research and Innovation Grant Project Initiative, which is designed for people in academia who formulate research ideas that can be turned into prototypes and then scaled and taken to market (i.e., commcercialized). This grant has had two rollouts in previous financial years but with limited funding. Efforts to link academia and industry could revive the grants to support the commercialization of research.
- ***Partnerships with government entities:***
  - Collaboration with the former Ministry of Basic Education on the Multiple Pathways Programme.
  - Cross-ministerial collaboration through platforms such as the TVET Advisory Committee.

The Botswana Digital and Innovation Hub (BDIH), formerly the Botswana Innovation Hub (BIH), runs the only Science and Technology Park and the most important incubator in Botswana, administers the Botswana Innovation Fund (BIF), and generally supports innovative entrepreneurship and the diffusion and commercialization of new technologies.

It was established through a Presidential directive in 2012 and is registered under the Companies Act as a wholly State-owned company. Its services include training and networking events aimed at capacity-building and supporting the development of an enabling innovation ecosystem. It runs the Technology Transfer Office, established in partnership with the University of Botswana. They reportedly build capabilities in intellectual property rights (IPRs) to support those who wish to register their intellectual property in academic institutions.

The Botswana Innovation Fund, established in 2018, aims to transform ideas into tangible products and solutions. By 2021, it had issued three calls for applications and supported 15 projects for a total investment of 13 million Botswana Pula (BWP). Additional investment from the Government (of about BWP 15 million) was made available in 2021 under the Economic Transformation and Recovery Plan. The average size of the grant is less than BWP 1 million, with a focus on financing projects up to, but not including, the commercialization stage.

The role of the BDIH has grown over the years. Its new strategy (2019) identifies five priority focal areas: mining technology, biotechnology, cleantech, ICTs and indigenous knowledge. BDIH's rebranding in November 2021 was part of the country's efforts to embrace 4IR and accelerate implementation of the digital transformation strategy. This also involves a stronger focus on public sector transformation, and linking public sector innovation with start-ups and corporate entities. The BDIH currently has over 200 members, such as universities, international partners and investment entities.

Through its Innovation and Technology Division, the BDIH supports entrepreneurs and innovators in implementing ideas that have progressed to the prototype level for eventual commercialization. Innovation support services include the Technology Entrepreneurship Development programme, Microsoft Innovation Centre programme, Southern African Innovation Support (SAIS) programme, Technology Transfer services, the Clean Technology Centre of Excellence programme, and the Botswana Innovation Fund.

The BDIH aims to nurture, grow and accelerate technology-led and innovation-inspired businesses in Botswana through its flagship Technology Entrepreneurship Development Programme, which has supported over 100 start-ups. It houses the National Technology Transfer Office (NTTO), which was established in partnership with the University of Botswana. The NTTO aims to support local entrepreneurs and innovators with the required tools to develop, protect and commercialize their innovations. The BDIH builds capacity in IPR to support those who seek to register their intellectual property (IP) in academic institutions. It provides training, capacity-building and mentorship. Some of the training provided is focused on digital technologies, such as the BDIH App Factory Launch, which provides training on digital skills. It hosts regular networking events, including innovation round tables, coffee sessions and hackathon competitions. It also has several collaborative programmes, including the Microsoft Innovation Centre (a partnership between the BDIH and Microsoft, offering capacity-building activities and initiating projects), the Southern Africa Innovation Support (SAiS) programme funded by the Finnish Ministry of Foreign Affairs (a four-year pilot project that ended in 2021, which sought to guide innovation in Southern Africa), and the Clean Technology Centre of Excellence programme (which supports new business development in clean, environmentally friendly technologies).

Linkages and collaborations

Partnerships with industry: Given its mandate, the BDIH has strong linkages with industry, especially with large international private partners (e.g. partnering with Microsoft in the establishment of the Microsoft Innovation Centre), and start-ups that are supported through the incubator. Through its outreach initiative, the BDIH aims to reach out to grassroots innovators and social enterprises, and connect with the informal sector mainly by providing training in STEM skills.

***Partnerships with universities*:** The BDIH has strong connections with some domestic universities (particularly the University of Botswana) and a few international universities. However, further efforts are needed in order to provide more systematic support for the commercialization of research outputs emerging from universities.

Partnerships with the Government: The BDIH has limited interaction with the coordinating government bodies in the NIS. However, it is assuming responsibility for implementation of important elements of the Digital Transformation Strategy (SmartBots) that are related to public sector digitalization following its rebranding.

Other partnerships: In 2021, the BDIH launched a new funding programme dubbed Grand Challenges Botswana, which aims to support local innovations that could help accelerate progress towards achieving national development priorities and economic transformation, as well as aligning with the Sustainable Development Goals of the United Nations. This programme is a collaboration between the BDIH and the Alliance for Accelerating Excellence in Science in Africa (AESA) under the Grand Challenges Africa initiative.

Challenges and opportunities

Botswana needs system-wide support for innovation initiatives to ensure that innovations advance social and economic inclusion. Efforts should support different stakeholders to develop the leadership capabilities needed to infuse and engender a culture of innovation.

So far, the amounts allocated to the Botswana Innovation Fund (BIF) are insufficient to have an impact on the national system of innovation at scale. The public funding provided to the BIF should be increased following an evaluation of its performance. As a secondary measure, appropriate mechanisms should be pursued to attract international resources for the BIF. For example, international collaborations should be strongly considered and strategically targeted as a route to expanding funding. Linking innovation funding to solving development issues in Botswana and the region presents a valuable opportunity to prioritize innovation support that can accelerate the achievement of national development priorities and economic transformation. This type of approach could also be adopted for wider application.

Universities' capacity to conduct research is weak, which limits the BDIH's ability to support the commercialization of knowledge emerging from the universities, and for universities to be active players in the innovation system. A large proportion of most universities' programmes and resources is dedicated to teaching. Some have established research programmes and a research policy, but this is recent and remains work in progress. Excellence in teaching is critical. However, building excellence in some research areas within some of the universities in select, preferably high priority, areas, and building a critical mass of experienced researchers are also important for the future of Botswana. Consideration should be given to supporting the role of universities as poles of innovation, is another objective to achieve in the future.

The provision of high-quality mentorship is essential for successful incubation. Some firms that received support from the BDIH reported that mentorship support needs to be improved. Some have also reported that fees charged for office spaces are unaffordable for many of the start-ups.

Rebranding the BIH to the BDIH in November 2021 has implications for the BDIH's focus and prioritization. It implies a stronger focus on digital technologies and public sector transformation, linking public sector innovation to digital start-ups and corporate entities. It is unclear whether this new focus will come at the expense of its traditional role in supporting innovative entrepreneurship and the diffusion and commercialization of new technologies.

3.2.4 Support to the entrepreneurial ecosystem

The Ministry of Entrepreneurship (MOE) oversees entrepreneurship and the development of small and medium-sized enterprises in Botswana. The Local Enterprise Authority and the Citizen Entrepreneurial Development Agency, both parastatals, provide direct support to entrepreneurs. The former provides entrepreneurs and MSMEs with technical assistance, and runs five business incubators across Botswana (Francistown Industrial Business Incubator, Gaborone Leather Industries Incubator, Glen Valley Horticulture Incubator, Pilane Multipurpose Business Incubator and Kutla Incubation Centre). These incubators teach businesses various skills, including research and innovation. The latter agency provides funding for entrepreneurs.

Business Botswana is a business association of employers representing employers in all sectors of the country's economy in an advocacy capacity. It engages with the Government through various platforms, but it has limited connections with the NSI.

Under the Ministry of Labour and Home Affairs, the Botswana National Productivity Centre is mandated to make direct contributions to the NIS by enhancing firms' and organizations' capabilities through the provision of training, and assisting them in the adoption of best management practices through productivity-enhancing tools and techniques.

3.2.5 Support to the digital ecosystem

Under the MCKT, as a key driver of the digital transformation strategy – SmartBots– the Botswana Communications Regulatory Authority (BOCRA) could play an important role in aligning and streamlining the digital-related regulatory environment; and the Botswana Fibre Networks (BOFINET) could support all the government's digital infrastructure and connectivity objectives. The new focus of the BDIH on digital technologies and e-Government envisages its becoming a key player in the country's digital ecosystem and SmartBots for public sector digitalization. The role of the MCKT in implementing SmartBots should be clarified following the Government's restructuring, which has brought together the RSTI and digital transformation/ digital technology areas.

3.2.6 Support to the data ecosystem

Statistics Botswana, under the Ministry of Finance, is responsible for collecting and disseminating all official statistics in Botswana. **The lack of data in many areas poses limitations on the innovation system, as some key indicators, such as information on research activities and R&D data, are either outdated or missing** (e.g. technology balance-of-payments, or innovation in key sectors outside the formal private sector, such as public-sector innovation or innovation in the informal economy). Inadequate data limits the ability to monitor and evaluate the impact of specific policy interventions on the overall system, prevents regular monitoring of the innovation system's overall performance. An effective national M&E framework that is successfully adopted by ministries, departments and agencies will require improved data collection, including data on STI, and adequate information systems for collecting, recording and processing data.

3.2.7 Advice and support to the science, technology and innovation system

The Botswana Academy of Sciences (BAS) was established in 2015 as an NGO mandated to advise the government on STI, strategize on the use of STI, and make recommendations for policy and actions. BAS also seeks to teach and sensitize the general public on topics concerning STI, and to position Botswana as a leader in STI in regional and international settings.

3.2.8 Research, science, technology and innovation performance

The constellation of organizations that perform RSTI activities ranges from firms in the private sector (both formal and informal businesses) to universities and research organizations, as well as communities. RSTI outputs may take the form of scientific publications, trained graduates and technicians, producing technology prototypes and new technologies, securing patents, and inventing new products, new processes and social innovations.

Some of the key organizations involved in Botswana's NSI are described below.

The BITRI was established in 2012 with the mandate to identify, develop and/or adapt appropriate technologies that provide sustainable innovative solutions through co-creation and collaboration in line with Botswana's national priorities and needs.

BITRI conducts both basic and applied research in the following six areas: building materials science, climate change, nanomaterials, electronics and communications, information systems and technology, and energy. However, the prioritization of these technology areas is not aligned with the priorities and activities of other actors across the innovation system. In mature economies, technology policy traditionally has had a strong focus on the promotion of specific technology areas that are expected to contribute to societal and economic policy objectives. Setting priorities in technology development and adoption is therefore a key component of technology policy. The identification of technological priorities needs to be accompanied by strategic and proactive intervention in the form of subsidies and other incentives, along with effective coordination of priorities across the system to enable realization of the potential advantages from the development of new/frontier technologies. However, so far, the level of prioritization and coordination is inadequate.

The Technology Transfer Office at the BITRI has a mandate to commercialize the BITRI's invented technologies and their adoption by SMEs and other companies through the effective implementation of the BITRI institutional Intellectual Property Policy and Innovation Management Framework. Currently, BITRI's IPR portfolio consists of one patent, five trademarks, one industrial design and several copyright works in the form of computer programs authored by the Information and Science Technology Research Unit.

Linkages and collaborations

- ***Partnerships with industry***: Collaboration with industry is limited to raising awareness on IPRs and finding ways to maximize the utilization of BITRI's laboratories.
- ***Partnerships with universities***: the BITRI has only limited interaction with universities, despite common objectives in research activities and need for trained researchers in a range of disciplines.
- ***Partnerships with government entities:*** the BITRI has limited interaction with the various government bodies engaged in RSTI through the NIS.

Challenges and opportunities

- There are no clear national R&D priorities. The lack of clear criteria for national prioritization undermines the country's long-term strategic vision. The BITRI's priority areas are guided by the National Development Plan (NDP), Vision 2036 and the RSTI policy. However, their broad guidelines do not seem to be concrete enough to drive more targeted efforts and a long-term strategy. This results in duplication of efforts with other actors in the system (e.g. the BDIH).
- The current funding structure seems unsustainable. There are opportunities for creating more sustainable funding by combining government grants and a portfolio of income sources.

Other research organizations include:

- The Botswana Vaccine Institute and the National Agricultural Research and Development Institution under the Ministry of Agriculture.
- The Botswana Geoscience Institute, which was established to undertake research in geosciences and provide specialized geoscientific services under the Ministry of Minerals and Energy.
- The Botswana Institute for Development Policy Analysis (BIDPA), which is a non-governmental research organization established by a deed of trust. The two key areas of BIDPA's mandate are development policy analysis and capacity-building. It aims to promote policy analysis through research, capacity-building, assisting organizations or individuals, where appropriate, monitoring the country's economic performance and disseminating policy research results.
- Universities: Institutions that offer university education in Botswana include the University Botswana, Botho University, Limkokwing University of Creative Technology, Ba Isago University, Botswana International University of Science and Technology (BIUST), Botswana Open University (BOU), Botswana University of Agriculture and Natural Resources (BUAN) and Botswana Accountancy College.
- Private sector players.

Universities

The levels of research intensity vary among the different universities. Some universities have established research programmes and a research policy, but this is recent. Some of them, such as the University of Botswana, the BIUST and BOU, appear to be relatively active in research activities, with structures to support research (allocated budgets, incentive mechanisms and institutional systems to guide their advancements in research and innovation). However, most of them are teaching-oriented, with research constituting a secondary objective. Research tends to be undertaken on a small scale because of various factors (e.g. limited funding, lack of a research culture, and non-prioritization of research activities). Overall, the management of research at universities and across the country is weak.

Given the recent focus on digitalization under the SmartBots strategy, universities are expected to contribute to the broader digitalization agenda/Fourth Industrial Revolution with human resources, skills and knowledge outputs that would build the country's digital capabilities. This is happening in small pockets, but most universities are not yet actively contributing to the national digitalization project. Some examples of the main contributors are described below.

- Botswana Open University (BOU) is geared towards utilizing digital technologies for teaching (given that it is a distance learning institution). However, challenges arise in remote areas that lack stable/affordable Internet connections. Lessons from digitally enabled universities should be diffused across the university system (outscaling and upscaling).
- Botswana Open University's Department of Computing and Information Systems (CIS) provides computer programs, and has set up a Huawei ICT Academy that offers training on Huawei technologies. It is in the process of creating a bachelor's degree in information systems.
- The Botswana Accountancy College has made 4IR one of its research priorities around ICT, big data analytics, machine learning, and the Internet of things (IoT). The programmes in this cluster deal with big data analysis in agriculture and social health services, Internet of things in agronomy (end-to-end farm management systems, cattle monitoring and management, as well as ICT systems for enhanced information management and communication.

Commercialization of research is very limited. This was one of the most widely reported limitations of the NSI during stakeholder discussions. **Partnerships between universities and the private sector are very limited.** The BDIH plays a role in facilitating some of those connections (e.g. the University of Botswana has a strong link with the Botswana Innovation Hub). Some of the partnerships are with large businesses (e.g. the University of Botswana with De Beers, or the BOU with Huawei). However, collaboration with small businesses is weak. A few universities indicate that they focus on commercialization of research. For instance, the BIUST established a Technology Transfer and Science Park to assist students and lecturers establish their own companies at a later stage, and is currently undertaking incubation activities. However, lack of funding remains a major constraint on upscaling these types of activities.

Through their engagement with other stakeholders, such as international donors or public sector organizations, universities can also play a key role in the NSI. They can influence policy decisions in their interactions with government agencies. For instance, the University of Botswana has been a major supplier of research and analyses in key development areas, and has participated in several policy development forums. In line with national priorities, it has spearheaded research on how Botswana can diversify the economy.

Linkages and partnerships

- ***Partnerships with industry***: Collaborations between universities and industries are limited. There are a few examples of partnerships with large businesses and multinational corporations, but linkages with small local businesses are few and weak, with a few exceptions, such as efforts with incubation. The lack of accreditation for research laboratories hinders their engaging with industry.
- ***Partnerships among universities***: Interaction among local universities is limited, resulting in overlapping of efforts and lack of cross-pollination of ideas, experiences and institutional learning. However, most local universities have active partnerships with international universities abroad.
- ***Partnerships with the government entities****:* Alignment of research activities with broad policy priorities appears to be limited. Some universities have strong connections with government agencies, and engage in policy processes. The DRST does not have comprehensive and accurate statistics on research in the country since reporting was done at the level of the former Ministry of Tertiary Education, Research Science and Technology (MOTE) and not to DRST. In 2021, the Government established the Botswana Research and Education Network (BotsREN) to digitally connect universities and research centres nationally, as well as to connect with research and education networks within Africa and globally.

Challenges and opportunities

- **Insufficient collaboration among universities, and between universities and industries and universities and government entities** (a) prevents the flow of knowledge, and opportunities for demand-driven research; and (b) results in fragmentation and duplication of research efforts. Universities end up competing for research funding in the same domain. Complementarities among universities need to be identified and strengthened.
- **Most research projects are handicapped by severe funding constraints. It is important to establish institutional structures that would help centralize research funding** (e.g. the proposed National Research Council in the 2012 RSTI policy implementation plan).

- **Tertiary and graduate studies have been accorded lower priority than basic education.** In order to augment human resources in RSTI, greater emphasis needs to be given to graduate level education. **There must be a delicate balance struck at both ends of the education spectrum as both are important.** Government support based partly on ability to pay and on performance criteria may need to play a role.
- **ICT investments at the institutional level remain limited.**
- **There is lack of a research culture**, which should be addressed by popularizing research as a viable career choice.
- **Staff retention is reportedly a challenge**, although the team could not clearly identify the reasons for this. The reasons should be determined in order to inform the design of measures to address the problem.
- **None of the university laboratories in Botswana is accredited**, which increases costs and hinders university collaboration with industry.

Private sector players

General collection, processing and maintenance of data, including up-to-date statistics on private sector activity in Botswana, are weak. Therefore, it is difficult to obtain an accurate picture of the current state of SMEs or large firms in the country. Available information indicates that SMEs account for more than 30 per cent of the workforce and contribute 15–20 per cent to the country's GDP (BIDPA, 2011). SMEs are also critical for women's empowerment, as approximately 67 per cent of micro-enterprises in Botswana are owned by women (Okurut and Ama, 2013). However, the SMEs face many challenges, including lack of access to finance, lack of entrepreneurial and innovation skills, lack of marketing skills, lack of support policies and lack of networking opportunities (Rapitsenyane et al., 2014; Khanie, 2018). The failure rate of SMMEs in Botswana is extremely high – reportedly 80 per cent – with the majority (over 70 per cent) failing within the first 18 months of operation (Gaetsewe, 2018). Botswana's private sector overall is characterized by low productivity and declining competitiveness, and is generally positioned at the entry-level of global value chains (World Bank, 2020).

Several studies have advocated for inter-firm relationships and collaborative innovation as avenues for firms to build capabilities and mitigate resource limitations, and for integrating SMEs into the innovation system (Ama and Okurut, 2018; Zulu-Chisanga et al., 2020). **However, this is hindered by the high presence of informality.** BIDPA reports (Gaetsewe, 2020) indicate a substantial growth of informality in Botswana. National surveys of 1999 and 2007 show a 72.3 per cent increase in the number of informal businesses, from 23,454 in 1999 to 40,421 in 2007. This growth in informality has been largely driven by unemployment and exacerbated by Covid-19. Moffat and Kapunda (2015) estimate that the informal sector employs 191,000 people representing approximately 31 per cent of total employment, while it contributes an estimated 5.3 per cent to GDP.

The profile of the private sector is highly skewed towards small and micro (largely informal) enterprises, mainly in services and struggling to survive and access resources. Consequently, such firms are unlikely to be able to undertake R&D, upgrade technologically or invest in risky innovation activities. To resuscitate the private sector from the shocks caused by Covid-19, and provide long-term support to build a strong local industrial ecosystem in Botswana, there is a need to: (1) fully understand the challenges and obstacles facing firms for accessing resources (including financial), infrastructure and support for innovation and technological upgrading , which requires up-to-date data and information; and (2) make concerted efforts across the system to ensure that SMEs are embedded as key players in the innovation system and included in the country's ambitions to digitalize.

3.3 Innovation hubs, firm incubation and STI parks

Supporting entrepreneurship as an avenue for economic diversification and employment generation is well acknowledged in various policy documents. Significant efforts have been made towards the development of entrepreneurs through incubation. However, there is inadequate monitoring and measurement of the effectiveness of such efforts in terms of identifying the number of successful start-ups, and their ability to attract investment and generate employment.

The BDIH is the main innovation hub and the only Science and Technology Park (STP) in Botswana as described in section 1.2 above.

There are some privately supported incubators, including the following:

- The Institute of Entrepreneurial Development (IED), which provides business incubation and training while prioritizing the development of women entrepreneurs. Gender inequalities persist in Botswana, and to strengthen its Women Economic Empowerment Programme, Bostwana committed additional resources to it in 2018, from $2.5 million to $5.5 million.
- The Ngwana Africa Accelerator, which Botswana's first pre-seed start-up accelerator established in 2011, provides education, technology and entrepreneurship, focusing on the youth.
- The Satoshi Centre, which was founded in 2014 to create awareness in blockchain technology in Botswana. It supports entrepreneurs to use blockchain technology to solve "African problems".

These initiatives, combined with significant grants and support for the establishment of new firms, provide opportunities for the establishment of start-ups. However, SMEs continue to experience high failure rates despite these initiatives. This is attributed to the lack of robust policies to build and promote domestic competitiveness. Due to the dominance of large and established firms – often local subsidiaries of international firms – and some State-owned enterprises, it is necessary to introduce regulatory supervision to ensure fair competition that will allow SMEs and new start-ups to survive and thrive.

It is good practice to undertake periodic monitoring and evaluations of the effectiveness of initiatives such as incubators and STI parks for purposes of learning and refinement of policy interventions. These evaluations would need to allow for gestation periods before incubators and science and technology parks begin to register success in terms of incubating successful new start-ups and creating collaborative knowledge, technology, innovation and production linkages between firms and knowledge institutions, and among firms. Such evaluations may be warranted also for the public incubators and science and technology parks where they have been operating for a significant period of time.

3.4 Strengths, weaknesses, opportunities and threats of the NSI

Based on the above exploration of the development context STI capabilities, the institutional landscape and activities of various actors, an analysis of the strengths, weaknesses, opportunities and threats (SWOT) of Botswana's NSI is presented in table 10.

Table 10
SWOT analysis of Botswana's NSI

Strengths	Weaknesses
• Botswana enjoys political stability and the macroeconomic conditions needed for growth of the NSI. • High-level recognition of the critical importance of STI in economic transformation as provided in Vision 2036. • Existence of a diverse range of institutional actors in the NSI that are involved in a variety of complementary STI activities. • Existence of high-level STI policy coordination bodies (the MCKT and the DRST) • Botswana's public universities and some private ones have accumulated capabilities in basic sciences. • Considerable efforts are under way to support entrepreneurship and incubation of start-ups using the Botswana Innovation Fund, BDIH and incubators. • Significant investments are being made in human resource development, particularly in primary and secondary education. The country's gross expenditure on education as a percentage of GDP is one of the highest among SADC countries.	• The country's NSI is fragmented despite its relatively small size (compared to those of many larger African countries, such as South Africa). • R&D is highly fragmented among ministries, parastatals and universities in the country. • There is weak articulation between policy-making public agencies and those conducting practical activities in RSTI. For example, the DRST has weak links with the universities, the BDIH, the BITRI and the research entities in sectoral ministries. • Coordination of the NSI is weak, and linkages across the system are underdeveloped, particularly between public and private sector actors. • The DRST has relatively weak legislative authority and organizational capacity to coordinate the NSI effectively. • Botswana has not established clear national R&D, technology and innovation priorities, despite an attempt to do so in 2005. • Research and innovation are insufficiently funded. There are few specialized instruments for financing high-risk innovation activities, which include research and technology development or adoption. • The private sector is predominantly composed of a few large foreign companies and many small and microenterprises. Except in mining, local firms are mostly micro or small enterprises operating in the informal sector. • Botswana's universities are mainly focused on teaching, and conduct limited research. There is an absence of a research culture, and the institutional capacity to manage and commercialize research in universities is in its infancy. • The lack of comprehensive and up-to-date data and a weak M&E system undermine effective governance of the NSI.

Threats	Opportunities
• The Covid-19 pandemic has wrought long-term damage worldwide, disrupting global production chains, and resulting in loss of employment and closure of businesses on a large scale. There will be future pandemics. • The BDIH's new focus on digitalization and transforming the public sector should not be at the expense of its traditional role in supporting innovative entrepreneurship and the diffusion and commercialization of new technologies. • A weak physical ICT infrastructure exposes Botswana's NIS to threats of cyber-attacks. • There is a lack of information on the use of frontier technologies in Botswana and the opportunities for adopting them for use in different industries.	• The country's President and executive leadership of the MCKT offer new opportunities to strengthen the NSI. The President is championing several STI initiatives such as SmartBots, and has been engaging various stakeholders in the NSI. • Botswana could harness more fully its growing economic integration into SADC and the African continent in general, as well as its proximity to the large South African economy, to strengthen its NSI. • There is a strategic opportunity for growing Botswana's NIS related to the recent discovery of a huge diamond in the country. The country's natural endowments could be used to strategically support and/or increase investments in the NSI. • The country's diaspora constitutes a potential human resource and intellectual input into the NSI. Dedicated efforts to identify and attract the diaspora could be activated.

3.5 Recommendations

Improve institutional coordination of the STI system. Coordination of the NSI is weak, and linkages across the system are underdeveloped, including between research and industry, between sectoral ministries and between the main coordinating body and other key actors. The weak coordination of R&D adversely affects inter-institutional linkages in the NSI. The DRST, as the main coordinator of the RSTI, should be given the ability to effectively fulfil its mandate. This requires: (1) upgrading the DRST to a fully-fledged Directorate for Research, Science, Technology and Innovation as envisioned in the NRSTI policy and its implementation plan; (2) adequately staffing and funding the DRST to provide it with a sufficient number of technical staff with the required skills; (3) investing in capacity-building on STI policy for technical staff; and (4) developing a strong M&E system with relevant STI indicators, by fostering the necessary data collection of STI indicators and the creation of an effective data management system.

Take measures to improve management of the research system. Developing a more functional research system requires: (1) establishing a National Research Fund; (2) establishing a National Research Council or similar body; and (3) creating mechanisms to ensure ministries, departments and agencies, universities and research institutes collect and report data on R&D programmes and projects to the DRST.

Identify national priorities for R&D and technology to form a national research agenda for the future and guide future investments in STI and education/skills development. As noted, R&D is highly fragmented across the institutional landscape, and there is a lack of clearly articulated national priorities. Establishing national priorities would allow the funding of a limited set of research areas identified as high priority, which the National Research Fund could adopt as a criterion for funding proposals. This would also reduce the fragmentation of the R&D system and the duplication of efforts across the system. For this, it is important to consider initiating further discussions on national research priorities taking into consideration the results of the STI foresight exercise organized as part of this STI Policy Review. Along with establishing national priorities, efforts should be made to align national research at universities and research institutes, especially publicly funded research, with the national research agenda.

Adopt a balanced approach to RSTI policy by increasing the focus beyond R&D to include technology and technology transfer (both within Botswana and through international technology transfer) and innovation with the aim of contributing to sustainable development and the goals of Vision 2036. It would be useful for purposes of policy design and implementation in general to fuse together research and technology with innovation and production systems. Innovation is important for creating an impact, using research and technology for solving economic, social and environmental challenges. Based on discussions during the review process, there are differences in perspective among actors in the innovation process, and many officials follow a linear approach to thinking about innovation. This should be revisited to move towards a systemic approach to innovation, which recognizes that, in most cases, innovation does not follow a linear approach. Striking the right balance between applied and basic research should be kept in mind when it is funded by the public sector. The risk of investing too heavily in research that is unlikely to be applied can be moderated by establishing a target upper limit for the share of Government-funded basic research in total Government-funded research, and by channelling funding more towards high priority research areas that correspond to needs and to the goals of Vision 2036. This is taken up further in chapter 4.

Improve the commercialization and use of research to meet sustainable development challenges. This can be done by: (1) increasing the focus on demand-driven research that provides solutions to sustainable development problems (economic, social or environmental) by strengthening linkages between universities and research institutes, on one side, and industry, including farmers, on the other, as well as by including users of research, to the extent possible, in the framing of research projects; (2) supporting key actors in the "commercialization ecosystem" through, for example, technology transfer offices, consultants and prototype developers, and ensuring they are present in adequate numbers with adequate capacity and the appropriate infrastructure to reach a critical mass; (3) establishing a strong data/information network for easy access by researchers and users of innovation, and designing a national policy on data that encourages open science and open data, ensures data protection, and recognizes the growing importance of data as a potential economic resource for creating value; and (4) implementing the national IP policy, on the basis of action taken by Parliament, supporting universities and research institutes in designing IP policies at the level of individual institutions, and improving the usefulness of the IPR system by raising awareness of the value of IP, and building capacity for its management and use by innovators and others in Botswana.

Private firms need to become more innovative for Botswana to achieve its transformation agenda. They do not innovate on their own but within a system, the NSI (or innovation ecosystem), which provides support for knowledge and technology flows and innovation. Private sector firms and entrepreneurs, including start-ups and firms that are seeking to adopt new technologies and innovate, need to be nurtured, and commercial innovation promoted through enhanced policy support. They should be supported to engage in technology upgrading, access knowledge and expertise, improve their innovation capabilities, use the IP system and invest more in R&D and innovation. Support for innovation hubs, science and technology parks or co-creation spaces, incubators and the development of innovative clusters of firms is warranted, by learning from other countries' successful experiences. Establishing SEZs provides an opportunity to promote collaborative linkages with foreign firms (see 4.3.1 below). Stronger private sector representation in STI discussions is also needed, as it is a key partner in creating a more innovative country. To enable this, the high-level committee should include private sector representation, and private sector engagement should in general be strengthened.

Build national capacity to enable the regular implementation of technology foresight exercises as a tool for strategic planning and adopting more forward-looking policy processes. One possibility is to establish a national foresight office to achieve these goals. Consider also building national capacity in technology assessment to be able to better assess the potential future impacts of new and emerging technologies in Botswana, the desirability of adopting those technologies for local use and to aid in improving readiness for adoption.

Chapter 4. Science, technology and innovation policy

4.1 Overview and evolution of STI policy in Botswana

Mainstreaming STI across all sectors of the economy and society is key to realizing Vision 2036. Vision 2036 explicitly recognizes that the country's transition to a knowledge-based industrialized economy will depend on increased investments in STI. It states: "The transformation and progress that we seek will be driven by investments in innovation, research and development, including indigenous knowledge across all Vision Pillars thereby domesticating and accelerating the pace of technical and scientific advancement."[9] This policy statement provides guidance to all STI-related policies and measures for its implementation. Translating this statement into practice requires that STI be mainstreamed in all facets or sectors of the economy.

Botswana has developed different kinds of explicit and implicit STI policies and measures over the years. The first explicit policy for STI in post-independent Botswana was the 1998 *Science and Technology Policy for Botswana.* It was developed under the leadership of the Ministry of Finance and Development Planning and adopted by the country's Parliament in July 1998. Its overall goal was "to achieve sustainable social and economic development so as to meet the present and future needs of the nation, and to meet the challenges of the next millennium, through the co-ordinated and integrated application of S&T for the upliftment of the standard and quality of life of Batswana and conservation of the environment."[10] However, this Policy had little focus on innovation, and was largely aimed at promoting scientific research in sectors such as agriculture, forestry, health, energy, mining, wildlife and tourism, and water. Its emphasis was on measures to finance scientific and technological development, protect intellectual property, strengthen management of S&T information, coordinate publicly financed R&D, strengthen cooperation in S&T, build systems for technology monitoring, assessment, forecasting and acquisition, and develop national institutional arrangements for the management of S&T.

The 1998 Policy had little impact in terms of growing the country's NIS because it was not fully or effectively implemented, as suggested by various reviews of its effectiveness. For example, an assessment by UNESCO (2013: 40) concluded, "Sadly, the policy achieved little over the next ten years, failing to overcome the very problems it had been designed to address. These included insufficient investment in research, a fragmented national system of innovation, haphazard research, an unfavourable environment for technology transfer, scarce qualified human resources and inadequate infrastructure for research." During the fact-finding mission (March-July 2021) for this review, some stakeholders observed that, for a long time, the 1998 S&T policy lacked an implementation plan and stable institutional leadership. Implementation was relatively slow. It took at least five years after the adoption of the policy for the Department of Research, Science and Technology (DRST) to be created in 2004, and ten years before the Botswana Innovation Hub was established in 2008. The implementation plan for the 1998 S&T policy – the Botswana Research, Science and Technology Plan – was developed and adopted only in 2005. This relatively long gestation period from the adoption of the policy to the formulation of the plan was inimical to the effectiveness of the policy.

The institutional landscape and leadership for STI policy has changed frequently, causing uncertainty and discontinuity in strategic planning, and is likely to have negatively affected policy implementation. Between 1998 and 2016, the administration of the S&T policy

[9] Government of Botswana, 2016, *Vision 2036—Achieving Prosperity for All* (Gaborone): 4.

[10] Quoted from page 5 of Government of Botswana, 1998, *Science and Technology Policy for Botswana*. Adopted by Parliament of the Republic of Botswana, July 1998 (Gaborone).

(and its successor, the 2011 National Research, Science, Technology and Innovation Policy) was moved from the Ministry of Finance and Development Planning (1998–2003) to the Ministry of Communications, Science and Technology (2004–2008), then to the Ministry of Infrastructure, Science and Technology (2008–2017), and then to the Ministry of Tertiary Education, Research and Technology (2017–2022). In May 2022 it was moved to the new MCKT.

4.2 Review of the 2011 national research, science, technology and innovation policy

The current National Research, Science, Technology and Innovation (NRSTI) Policy had a relatively long gestation period from initiation to adoption. Beginning in 2009, the then Ministry of Infrastructure, Science and Technology, with the technical support of UNESCO, launched a review of the 1998 National Science and Technology Policy for Botswana. The policy review process was largely consultative between 2009 and 2011 (UNESCO, 2013), and the new NRSTI policy was finalized and adopted only in 2011. Its mission is to "achieve a knowledge driven economy through effective and sustainable Science and Technology based research and innovation."[11] The Policy has goals framed around building national capabilities in research and innovation, with six policy objectives (see table 11).

Table 11

Objectives of the NRSTI Policy

The NRSTI Policy lists the following six objectives:

4.4.1 To promote research and innovation in the areas of priority for sustainable socio-economic development of Botswana and foster collaborative scientific research among academic, scientific institutions and the private sector.

4.4.2. To mobilize adequate resources, both human and financial, for research, technology development and transfer, innovation and development of technology driven and knowledge intensive industries.

4.4.3. To provide an enabling environment for the coordination, development and implementation of RSTI Policy and promotion, support and participation in research and integration of S&T into all sectors of the economy and nurture creativity.

4.4.4. To cultivate a sense of responsibility among the science and technology institutions in the country for ensuring attainment of high standards of quality, safety and quantity of research outputs as part of their social responsibility and commitment.

4.4.5. To promote the establishment of collaborations, partnerships and linkages among stakeholders, private sector and international science, research and development community.

4.4.6. To build a national culture of innovation and integration of traditional knowledge into modern science.

Source: Republic of Botswana (2011: 5), *National Policy on Research, Science, Technology and Innovation*.

To attain the six objectives, the Government of Botswana has committed itself to 11 actions, as follows:

1. Strengthen the NIS and improve its coordination;
2. Increase gross expenditure on research and development (GERD) to at least 2 per cent of national GDP, and the improve the quality of funding of research and innovation by developing coordinated funding mechanisms and instruments as well as providing incentives for private sector investment in R&D;
3. Increase private sector participation in research and innovation;

[11] Government of Botswana, 2011, *National Policy on Research, Science, Technology and Innovation: 4*.

4. Strengthen focus on demand-driven research through a coordinated priority-setting process that aligns investments in R&D with national development goals (articulated in Vision 2016);
5. Build a culture of innovation in the country;
6. Improve ethical and technical standards for research and innovation;
7. Promote and protect indigenous knowledge systems (IKS) by developing specific policies for such knowledge systems, documenting IKS and encouraging the youth to be involved in programmes for IKS;
8. Strengthen intellectual property protection;
9. Mainstream gender considerations in STI, and increase women's and girls' enrollment in science, technology, engineering and mathematics (STEM);
10. Strengthen technology assessment, monitoring and forecasting; and
11. Improve or strengthen governance of the NIS and the institutional arrangements (structures for implementing the NRSTI Policy) by establishing the Botswana National Research, Development and Innovation Coordinating Council, upgrading or strengthening the DRST into a fully autonomous legally created Directorate for Research Science, Technology and Innovation, establishing a National Research Fund and creating national centres of excellence in research.

The 2011 NRSTI Policy vision, mission and objectives are aligned with Vision 2036's overall aspiration of a knowledge-based innovation-driven industrialized economy, even though the policy predates Vision 2036. The NRSTI Policy has objectives related to social inclusion in STI, though these are very limited, or framed around the promotion of women's and girls' participation in STEM disciplines. It does not address issues of responsible research and social inclusion, particularly how to ensure that the benefits of STI are equally and fairly distributed across all social groups in the country, or utilizing STI to address issues relating to disabilities.

With regard to environmental sustainability goals, the 2011 NRSTI Policy has general provisions on promoting research and technology for natural resource management, with emphasis on pollution control, conservation of biological diversity and climate change. It has specific provisions on the use and protection of indigenous knowledge and related cultural innovations, and for conserving and sustainably using biological diversity. The policy's objective on technology assessment can be interpreted require specific measures for assessing environmental impacts of new technologies. However, there is no empirical evidence for implementation of technology assessment programmes or activities. It is also unclear whether STI are being used to enforce environmental standards, or if environmental sustainability considerations are considered in technology development and transfer.

The NRSTI Policy has no explicit provisions on and for the use of science in policymaking. It has no provisions to guide the Government in procuring and using scientific evidence in public policy. It is therefore limited, premised on orthodox rationales of policy for R&D. This is starting to change as the scope and rationales of modern STI policy frameworks are broadened to include provisions on science for policymaking. To modernize Botswana's STI policy framework and make it more relevant for evidence-based policymaking, the NRSTI Policy should be revised by expanding its scope and rationale to include science for policymaking and governance of STI.

A review of the NRSTI Policy will necessitate an evaluation of the relevance and effectiveness of its current implementation plan. In 2012, the then Ministry of Infrastructure, Science and Technology adopted the NRSTI Policy Implementation Plan. The plan is comprehensive, specifying short-, medium- and long-term interventions to implement the policy's objective (see table 12 for an outline of the proposed interventions).

Table 12
Sequenced interventions in the NRSTI Policy Implementation Plan

1.	*Short-term actions and targets (1–2 years)*
1.1	Establish institutional structures and operational institutional capacity to coordinate and fund RSTI activities.
1.2	Establish a National Research Fund
1.3	Establish a Botswana Research Centre
2.	*Medium-term actions and targets (2–5 years)*
2.1	Design and deploy monitoring and evaluation tools
2.2	Raise public awareness of RSTI
2.3	Strengthen local and international linkages
3.	*Long-term actions and targets (3–5 years)*
3.1	Develop policy instruments to expand the NIS
3.2	Develop legislative frameworks

Source: UNCTAD, based on the NRSTI Policy Implementation Plan.

Based on discussions with key stakeholders during the fact-finding mission and a comprehensive review of various reports, including the NRSTI, it appears that progress on implementing the NRSTI Policy Implementation Plan has been disappointingly slow. Several critical measures under action area 11 (listed above) have not been implemented to strengthen governance of the NIS and the requisite institutional arrangements (structures for implementing the NRSTI Policy). These include, specifically: (1) establishing the Botswana National Research, Development and Innovation Coordinating Council, and (2) upgrading or strengthening the DRST into a fully autonomous, legally created Directorate for Research, Science, Technology and Innovation. The proposed National Research Fund is currently being established. In addition, actions 2, 3 and 4 have not been implemented. Some actions have been taken (relatively few and very recently) to develop frameworks or strategies such as those for M&E,[12] private sector engagement, R&D data and information management, and IP protection. However, there are no specific or identifiable programmes and projects that are focused or based on the implementation plan.

There are a number of nascent initiatives focusing on or related to various aspects of the 2011 NRSTI Policy and its Implementation Plan. They include the SMART Botswana (SmartBots) strategy,[13] which is still under formulation (or yet to be finalized), and the Private Sector Engagement Strategy in Research, Science, Technology and Innovation 2021–2026 that was finalized in 2021. Under the SmartBots Strategy, there are proposals to establish centres of excellence in research and innovation, and fast-track digitalization of the economy. The Private Sector Engagement Strategy is crucial to strengthening private companies' participation in the NSI. Its implementation and effectiveness will depend on the DRST's capacity, including dedicated human and financial resources.

Overall, the institutional arrangements and structures needed to ensure that the NRSTI Policy and its Implementation Plan are effective have not yet been established. In particular, the Botswana National Research, Development and Innovation Coordinating Council, the National Research Fund and the Directorate for Research, Science and Technology (DRST) are yet to be established. **The slow progress in implementing the NRSTI Policy and its Plan may be attributed to at least three interrelated factors.**

[12] The National Research, Science, Technology and Innovation Monitoring and Evaluation Framework was adopted in December 2020, almost 10 years after the NRSTI Policy was instituted.

[13] A draft report, *"SMART" Botswana: Strategic Initiatives and Priority Setting*, is being reviewed or considered by various stakeholders, particularly the Presidency and the Cabinet.

First, the DRST has relatively low capacity, mainly due to scarce technical human resources (as opposed to support personnel), a very limited budget, and institutional instability related to its frequent relocation from one ministry to another over time.

Second, awareness of the NRSTI Policy and its Implementation Plan is low among policymakers, government officials and the country. Most interviewees (or stakeholders) surveyed during the fact-finding mission had very limited knowledge of the content of the policy. Many of them were not even aware of the existence of the NRSTI Policy and its Implementation Plan. Some reportedly researched the policy and its contents before being interviewed in order to familiarize themselves with it.

Third, the mechanisms and frameworks for policy accountability are weak. The NRSTI's M&E framework has been adopted but not yet institutionalized. Key institutional actors (particularly from civil society, the private sector and the legislature) are not actively involved in NRSTI policymaking processes and activities. There are no organized civil society organizations that actively participate in STI policy processes and programmes in the country. In addition to the weak engagement of these organizations and members of the legislature, the parliamentary portfolio committee for RSTI is not yet operational. Policy accountability requires active engagement by citizens and parliamentary members, which is weak or lacking in Botswana. Because RSTI policy responsibilities have been shifting or frequently transferred from one ministry to another, there seems to have been discontinuity in executive leadership for policy implementation.

Overall, to be better aligned with Vision 2036 and the SDGs, and to better address current circumstances, the NRSTI Policy should be revised by expanding its scope and rationales. It should encompass sustainability goals, with an emphasis on the SDGs and a science-for-policy approach, greater integration or inclusion of provisions on governance of the NSI and an enhanced focus on policy instruments for diversification of innovation to include public procurement, technology transfer, financing, digitalization and frontier technologies. In addition, it should focus more on specific high priority technology areas, and technology foresight and assessment, as well as giving more emphasis to measures that strengthen the innovation capabilities of domestic companies and provide incentives for private investment in R&D. It should have a balanced focus on R&D, technology and innovation, keeping in mind that innovation and applied knowledge are key to achieving economic, social and environmental goals, and that knowledge creation (through R&D) alone is not enough.

4.3 Review of implicit STI policy frameworks

4.3.1 Industrial policy frameworks

Innovation-driven industrial development is a key objective of Botswana's Vision 2036. The country aspires to diversify its economy by shifting from mainly diamond mining, tourism and beef exports to industrial manufacturing. To achieve this goal, the Government has developed various policy measures. However, most of the measures for innovation-driven industrialization are implicit and scattered in various documents. The main policy framework for industrial development is the Industrial Development Policy (IDP) of 2014, whose overall goal is to promote "the development of diversified and viable industries as well as commercial sectors, using skilled personnel and appropriate technology, whilst leveraging active private sector collaboration and participation."[14] The IDP explicitly recognizes that technology and innovation are critical to the structural transformation of the economy through industrialization.

[14] Government of Botswana, 2014, *Industrial Development Policy for Botswana 2014* (Gaborone, Ministry of Trade and Industry), 30 July.

The main industrial policy instruments used by the Government to promote industrialization are:

(a) A low company tax regime (about 15 per cent) for manufacturing enterprises;

(b) Grant support to companies (initiated under the old Financial Assistance Policy);

(c) Subsidies provided to local businesses through training and advisory services to local businesses and reserved sectors administered by the Local Enterprise Authority;

(d) Protection of infant industries using the infant industry clause within the Agreement of the Southern African Customs Union (SACU); and

(e) Duty exemption and drawback schemes for industrial inputs for the export sector.

Most of these instruments lack any significant STI content or STI provisions. They largely focus on supply-side aspects, and less on the promotion of knowledge and development of technologies that would increase the productivity of manufacturing enterprises. There is no reference to public procurement, a critical demand-side measure. Moreover, there is no coherence between the industrial policy measures and the NRSTI Policy. The Industrial Development Policy is being revised to align it more closely with Vision 2036, the NDP and other national policies. According to officials at the Ministry of Trade and Industry, the new or renewed industrial policy and related strategies will focus much more on harnessing digital technologies to promote economic diversification, the creation of more enterprises in manufacturing in sectors such as mining and agroprocessing, and upgrading of production technologies in SMEs engaged in manufacturing. The DRST should actively participate in the review and revision of the current industrial policy to ensure that RSTI considerations are adequately integrated into the new policy.

Other national policies also relate to the industrial development of Botswana. The 2012 Citizen Economic Empowerment Policy,[15] focuses on building the capacity of the private sector, infusing an entrepreneurial culture and fostering innovativeness in citizen-owned businesses. The 2010 Special Economic Zones Policy aims at attracting a diverse range of manufacturing enterprises to produce globally competitive goods for export.[16] In 2019, the National Entrepreneurship Policy was adopted to promote the development of innovative entrepreneurs by supporting start-ups through the provision of incubation, training and credit facilities.[17]

In 2015, Parliament enacted the Special Economic Zones law, which established the Special Economic Zones Authority (SEZA) with the mandate to develop SEZs around the country. The law streamlines investments in sector-targeted geographic areas in the country, including in the Gaborone area (multi-use, diamond processing, and financial services); two in Selebi-Phikwe (mineral processing and horticulture); and additional ones in Lobatse (beef, leather, biogas), Palapye (energy), Pandamatenga (agriculture) and Francistown (mining and logistics). SEZA has prioritized four more SEZs – Lobatse (leather park), Gaborone Fairgrounds (financial services), Gaborone Sir Seretse Khama Airport (diamonds and logistics) and Pandamatenga (agriculture).

[15] Government of Botswana, 2012, *The Citizen Economic Empowerment (CEE) Policy for Botswana*, National Assembly, Government Paper No 1 (Gaborone).

[16] Government of Botswana, 2010, *Special Economic Zones (SEZ) Policy for Botswana* (Gaborone, Ministry of Trade and Industry), September.

[17] Government of Botswana, 2019, *National Entrepreneurship Policy (NEP) for Botswana* (Gaborone, Ministry of Investment, Trade and Industry), August.

Overall, there is a wide range of policies and measures for the industrialization of Botswana. Most of them are implicit STI policies in the sense that they indirectly promote research, technology and innovation. There is a need to ensure that they are aligned with the NRSTI Policy, and that any new NRTSI policy is aligned with them. That is, there must be coherence across these policies. The Industrial Development Policy, for example, could target particular support to encourage innovation in medium- and high-tech activities, particularly those that introduce new industrial goods and services to Botswana and promote diversification. The policy could seek to offer technology extension services to industrial firms, similar to agricultural extension services to farmers, to help firms upgrade their technologies. The investment plans for the SEZs could include consideration of the technologies that foreign firms bring with them, and collaborative arrangements of these firms with local firms on production, as well as flows of technology, knowledge and skills within and near the SEZs. The National Entrepreneurship Policy should be aligned with the STI policy, providing support to entrepreneurs through such measures as encouraging innovative entrepreneurship projects – particularly medium- and high-tech projects – that introduce new goods and services to Botswana. The Industrial Development Policy, SEZ Policy, National Entrepreneurship Policy and the RSTI Policy should work in tandem, creating synergies to support local firms to upgrade their technological and innovation capabilities. This would necessitate establishing active communication and collaborative practices across the relevant ministries, departments and agencies, particularly with respect to policy design and implementation.

4.3.2 National public procurement policy frameworks

Public procurement can be a key policy instrument for innovation if properly designed and used. It is a means whereby government entities purchase goods, services and systems in order to meet specific national goals or address defined public problems such as those relating to health, environment, food production and manufacturing (Borras and Edquist, 2019). **However, in Botswana there is no indication that it is being used to stimulate innovation in either the public or private sector.**

In Botswana, public procurement is governed and promoted through a variety of measures, including the Public Procurement Act of 2021, which replaced earlier procurement regulations, including the Public Procurement and Asset Disposal Act. Similarly, the Public Procurement and Asset Disposal Board (PPADB) was replaced by the Public Procurement Authority (the Authority). Under the Act, the Authority is the overall regulator for government procurement and performs other functions including standard-setting, monitoring and evaluation, and monitoring of enforcement of adherence to the Act. The Public Procurement Act is the principal legislation for facilitating procurement and disposal of goods and services for or by the State, and its agencies.

Related to the Public Procurement Act is the Citizen Economic Empowerment (CEE) Policy of 2012. The CEE Policy aims at promoting the effective participation of citizens in Botswana's economic growth and development; enhancing social cohesion and harmony; promoting nationhood and pride; and building citizen's entrepreneurial capacity. As part of the implementation of the CEE Policy and the PPAD Act (and its successor), in 2020 the Government announced that all government contracts worth less than $900,000 would be reserved for or allocated to Motswana-owned businesses.

Botswana's current public procurement policy measures are not designed to promote innovation. While there is recognition among government officials that public procurement is a critical innovation policy instrument, tenders are not developed and implemented with specific provisions to enable the country to procure and deploy new technologies and/or non-technological innovations. The DRST should work with the Ministry of Finance to review existing public procurement policy frameworks in order to integrate STI objectives into them. In addition, specific tendering/bidding guidelines should be formulated for functional procurement that is oriented towards sourcing which spurs innovation.

Building the capacity of key institutional actors and investing in policy learning are critical to promoting innovation-enhancing public procurement in Botswana. In this regard, the DRST and the Ministry of Finance should seek technical support from institutions such as the National Innovation Council of Sweden to organize training workshops on innovation-enhancing public procurement mechanisms. Such workshops would help to build knowledge (and skills) of government officials on how best to use public procurement to stimulate innovation. South Africa offers lessons on how to incorporate innovation-enhancing procurement in STI-related policies. Its 2019 White Paper on Science, Technology and Innovation contains a section on the use of public procurement to promote innovation (Department of Science and Technology, Republic of South Africa, 2019).

4.3.3 Investment and trade policy

Foreign direct investment (FDI) and international trade are important avenues for promoting STI, as they provide the means for the transfer of new knowledge, ideas and technologies. Through imports, especially of machinery and equipment, technology can be bought directly. FDI can be used as a mechanism for acquiring and building skills (e.g. technical and managerial), and as a channel for the international transfer of technology. Mauritius, Malaysia and Singapore, for example, have managed to leverage FDI for building dynamic local industries, as have some other countries, such as China, Finland, Ireland and the Republic of Korea, with varying levels of success, under different circumstances and with different policies.

Botswana does not have an explicit FDI policy; rather, it uses economic diversification and sustainable growth strategies to guide FDI. The 2008 Strategy for Economic Diversification and Sustainable Growth and its implementation plan, the Economic Diversification Drive (EDD), contain STI provisions. The EDD is the main instrument for promoting and regulating FDI. Its thematic areas are:

- Sectoral Development and Business Linkages
- Export Development and Promotion
- Investment and Finance
- Quality Control, Standards and Production
- Technology Development, Innovation and Transfer
- Research and Development
- Entrepreneurship Development

A draft investment strategy for Botswana has been under preparation since 2009 and recognizes the role of FDI in promoting technology transfer and acquisition. However, the extent to which the Government of Botswana has deliberately used FDI to attract new technologies is not clear. It was not possible to obtain data on technology imports or receipts during the review.

The 2011 Economic Diversification Drive: Medium to Long-Term Strategy 2011–2016 contains explicit STI policy provisions. It has objectives for the role of STI in enhancing economic diversification, and focuses on the use of FDI to promote technology transfer to local enterprises, particularly SMEs. The strategy also encourages business-to-business linkages among SMMEs and between them and large companies. Both of these business linkages offer Botswana many advantages, including maximization of local content in goods and services, promoting technology transfer and innovation, promoting the transfer of modern management know-how, promoting the development of a robust SMME sector and attracting FDI into Botswana."[18]

[18] Government of Botswana, 2010, *Economic Diversification Drive: Medium to Long-Term Strategy 2011-2016* (Gaborone, Ministry of Trade and Industry): 18.

Under the thematic area on technology development, innovation and transfer, the strategy aims to facilitate the development of Botswana to become a vibrant technology-driven economy. To achieve this objective, the strategy outlines the following measures: (a) developing policies that facilitate R&D, (b) improving funding for technology adaptation and R&D, (c) establishing performance-based budgeting for R&D, (d) establishing a technology acquisition fund, (e) improving R&D infrastructure, and (d) improving R&D leadership capabilities.[19]

The coherence between the EDD Strategy and the NRSTI Policy offers a good example of how STI can be mainstreamed into economic development policies and strategies. It is important to note that the EDD Strategy was developed and adopted in the same year (2011) as the NRSTI Policy. However, most of the STI policy measures in the strategy are yet to be implemented. Some of the reasons for this are: (a) weak linkages between the DRST and the Ministry of Trade and Industry (responsible for the EDD Strategy), and (b) weak capacity of the DRST to coordinate across various ministries and departments.

The EDD and other elements of the investment framework have not been effective in attracting FDI that facilitates technology transfer and innovation. According to UNCTAD's *World Investment Report 2021* (UNCTAD, 2021), FDI inflows into Botswana declined to $80 million in 2020 from $94 million in 2019. This is largely due to the global economic crisis triggered by the Covid-19 pandemic. Most FDI goes into the mining and minerals sector (see chapter 1). The main sources of FDI for Botswana are South Africa, Canada, the United States of America and Germany.

There are several bottlenecks to attracting FDI to Botswana. They include the high cost of local production and transport due to a weak physical infrastructure (deficiencies in energy production and related power outages, high transport costs, shortages of water supply and slow Internet speed), scarcity of skilled labour, the relatively small market size and the country's landlocked position. The World Bank ranked Botswana 87th worldwide in its *Doing Business 2020 Report*.[20]

The Government of Botswana has been developing an investment facilitation law that would strengthen the implementation of various FDI-related policy areas. The law will streamline procedures for establishing new businesses. The Government has also established institutions such as the Botswana Investment and Trade Centre and the Companies and Intellectual Property Authority to assist foreign investors to register new companies or businesses in the country.

The 2019 Trade Act has implicit policy measures for promoting innovation. It can be used to stimulate local techno-entrepreneurship. For example, Article 17 of the Act aims at promoting and protecting local enterprises by reserving licences only for citizens' engagement and investment in selected reserved sectors of the economy. It states: "Without prejudice to the generality of subsection (1), the Minister may make regulations prescribing that only citizens or companies wholly owned by citizens shall — (a) be entitled to carry on a reserved trade or business — (i) in such areas in the country, as may be prescribed, or (ii) from such premises, as may be prescribed."[21] The Trade Act also provides for the creation of joint ventures between citizens and foreigners. This provision can be used to enable local companies to acquire foreign technology, create employment, transfer skills and help diversify economic activities in the country.

In 2015, the Ministry of International Trade and Industry launched a national programme that allocates to local small companies a 15 per cent preferential price margin in government procurement projects, with medium-sized companies receiving a 10 per cent margin and large companies a 5 per cent margin. The directive applies to 27 categories of goods and services

[19] Government of Botswana, 2010, *Economic Diversification Drive: Medium to Long-Term Strategy 2011-2016* (Gaborone, Ministry of Trade and Industry: 49–51.

[20] https://documents1.worldbank.org/curated/en/688761571934946384/pdf/Doing-Business-2020-Comparing-Business-Regulation-in-190-Economies.pdf.

[21] Government of Botswana, 2019, *Trade Act, No. 25 of 2019* (Gaborone).

ranging from textiles to chemicals and food, in addition to a broad range of consultancy services. In 2021, about 35 areas of economic activity, including boutiques, auctioneers, car washes, butcheries, general trading establishments, curio shops and fresh produce supply, were reserved for citizens of Botswana.

The 2005 Botswana Competition Policy is also relevant for STI in Botswana. This policy aims at enhancing Botswana's ability to attract both domestic and foreign investment, innovation and transfer of technology from IPR holders. The Competition Policy and the Competition Act mandate the Competition Authority to monitor mergers and acquisitions, ensuring that they enable the country to exploit foreign IP and related technologies.

However the investment and trade policy frameworks are not being strategically implemented and used to promote STI in the country for various reasons. First, there are weak linkages between the DRST and trade and investment institutions, particularly the Companies and Intellectual Property Authority, the Botswana Trade and Investment Centre and the Competition Authority. Second, entrepreneurs are not adequately informed of the technology and innovation dimensions or provisions in the country's investment- and trade-related policies and plans. In most cases, entrepreneurs tend to focus solely on acquisition of financing for establishing businesses, and not on ways and means of accumulating firm-level scientific and technological capabilities to innovate. Third, the national capacity for technology prospecting, assessment and road-mapping to enable enterprises (and entrepreneurs) to integrate technology and innovation considerations into their businesses is relatively weak.

Building the capacity of local businesses or companies to develop and use enterprise technology and innovation strategies (including technology road maps) is key to realizing STI provisions in investment- and trade-related measures. In this regard, it is recommended that the Botswana Digital and Innovation Hub, the DRST, the Botswana Institute for Technology Research and Innovation and the institutions responsible for investment and trade should organize relevant workshops.

4.3.4 Intellectual property protection

Botswana's main policy and legal framework for IPR protection is the Industrial Property Act No. 8 of 2010, amended in August 2012. The Act provides for the protection of patents, trademarks, utility designs, indigenous knowledge, geographic indications and handicrafts. The Companies and Intellectual Property Authority (CIPA) administers the Act.

The Act is important for promoting research, technology transfer and innovation in a number of ways. First, patent protection can be a mechanism for making new scientific and technological information available to local researchers. To obtain a patent (exclusive right), the inventor must disclose sufficient scientific and technical information about the patented invention, which makes it publicly available and accessible. Researchers can access the information by doing patent searches. Such information may provide "technical leads" for technology development and innovation.

Article 12(1) of the Act states:

> Every application for a patent shall be filed with the Registrar and shall contain-
>
> (a) a request;
>
> (b) a description;
>
> (c) one or more claims defining the matter for which protection is sought;
>
> (d) drawings (where referred to in the description or the claims);
>
> (e) an abstract in the prescribed form, and shall be accompanied by such fee as may be prescribed.[22]

Second, patent protection may enable the country to acquire foreign technology. The Act provides incentives to local and foreign inventors, including monopoly rights to exploit IPRs. It balances the interests of inventors and the public. The application for a patent is published 18 months after the filing date. If granted, a patent is valid for 20 years from the date of filing. After a certificate is granted, third parties are prevented from exploiting the patent in Botswana. The inventor is required to supply the Botswana market with the patented product within three years from the granting of the patent. If sufficient amounts of the product are not supplied, the Government is required to issue compulsory licences to third parties to exploit the patent.

Other forms of IP that are protected in Botswana are trademarks, industrial designs, copyrights and geographic indications. Trademarks or industrial designs are basically words or symbols or logos, or combinations of these, used to identify the sources of the products, goods or services. The procedure for filing for protection of trademarks and industrial designs is similar to that of a patent application. A trademark may be removed if it has not been used for three years or more, in which case, it may be licensed and made available for third parties to exploit.

There are number of challenges to implementation of the IP policy to promote STI in Botswana. First, there is a relatively low level of awareness of the IP policy and its utility among researchers (scientists), entrepreneurs and the public. Although the Companies and Intellectual Property Authority and WIPO have conducted some training and awareness workshops, knowledge of the IP policy and how to use it is still limited. Some entrepreneurs and researchers noted that there is a paucity of information (and guidance) on procedures and the benefits of securing IP. Greater support to innovators and those creating IP for the management of IP would make the IP system more useful.

Secondly, the costs of IP (particularly patent) applications and management are relatively high in Botswana. According to some university researchers (scientists) and entrepreneurs, the high costs are due to scarcity of local IP expertise. They noted that many IP applicants have to procure expert support from law firms or companies based in South Africa. These firms charge relatively high fees that most start-ups and universities in Botswana cannot easily afford.

Lastly, until very recently there was no modern, consolidated national IP policy that would guide institutional level policies to address issues such as the use of IP from publicly funded research. IP policy statements have been scattered across various policies, documents and regulations, including in industrial property and copyright legislation. As a result, some institutions (particularly universities) have been adopting their own IP policies that might be in conflict (or disharmony) with international standards. To address this challenge, the Companies and Intellectual Property Authority finalized the development of the Botswana Intellectual Property Policy, with WIPO providing technical support, which was approved by Parliament in late 2022.

[22] Government of Botswana, 2010, *Industrial Property Act 8, 2010* (Gaborone).

4.3.5 Measures for protecting traditional and indigenous knowledge

Botswana's Vision 2036, the NDP and the NRSTI Policy recognize that traditional and indigenous knowledge, and related local technologies, are important for achieving sustainable development. Traditional and indigenous knowledge are critical in developing health products (treatments), conserving and sustainably using the country's rich biological diversity and improving agriculture. They are also an important part of Botswana's cultural diversity needed for the promotion of tourism and industry in general. Thus, such knowledge is an essential contributor to socioeconomic transformation and industrialization to achieve Vision 2036.

The Government of Botswana has formulated various policy measures and programmes for protecting and promoting traditional and indigenous knowledge. These are included in the Industrial Property Act, the National Biodiversity Strategy Action Plan of Botswana (2011–2020) and the Biocultural Community Protocol. Legislation on access to genetic resources and sharing of benefits arising from their use is being developed by the Department of Environmental Affairs with the support of the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

Section XII of the Industrial Property Act of Botswana provides for the protection of traditional knowledge of communities and practitioners. It defines traditional knowledge as "an idea, knowledge, practice, use or invention, written or unwritten, which may be associated with biological diversity, is a cultural, traditional or spiritual belief or value of a group of people."[23] The protection of the knowledge aims to exclude third parties from unauthorized use of the knowledge by conferring economic rights on a local traditional practitioner or a community who may apply for IP protection. Similar to patents and other IP applications, registration for traditional knowledge is possible "with a description of such knowledge if it has not been disclosed to the public by any means and if it was disclosed there must have been no commercial or industrial exploitation in Botswana. The description must disclose the TK (traditional knowledge) in a manner that is sufficiently clear and complete to permit a third party to reproduce/utilize the TK to obtain results similar or identical to those obtained by the user of the knowledge."[24]

The Biocultural Community Protocol (BCP) contains policies and regulations guiding or determining how local communities, as providers of genetic resources and associated traditional knowledge, interact with users (scientists, scholars, collectors and the private sector) of the resources. It sets out the rules and conditions under which users have access to a local community's resources and knowledge. The BCP is in line with (and is an implementing mechanism for) the Convention on Biological Diversity and its Nagoya Protocol on Access to Genetic Resources and Benefits Sharing, to which Botswana is a contracting party.

The national policies for indigenous knowledge and cultural practices are aligned with the NRSTI Policy, and can be invoked to promote STI. However, there are challenges to their implementation. The main challenges relate to the low levels of knowledge about, and understanding of, the policies, weak coordination between the DRST and the relevant ministries and departments (particularly the Department for Environmental Affairs) responsible for administering the policies on indigenous knowledge and cultural practices, and lack of M&Es and implementation plans for the various policies. In addition, there is a relatively small, though active, community of NGOs involved in advocacy on STI and indigenous knowledge issues.

Building the capacity of various stakeholders, in government, the private sector and NGO circles, to raise their awareness of STI aspects of the various measures relating to traditional and indigenous knowledge is critical.

[23] This definition can be interpreted to conceptualize traditional knowledge as an integral component of STI.

[24] Section 116 of the Industrial Property Act of Botswana.

4.3.6 ICT policy and supporting measures

Botswana has an array of laws, regulations and strategies relating to ICT, which are aligned with Vision 2036, Botswana's eleventh National Development Plan (NDP 11) that was adopted in December 2016 and the NRSTI Policy.[25] Specifically, these include the National Broadband Strategy, the National e-Government Strategy, and the Information and Communications Technologies (ICT) Policy (*Maitlamo*), which was approved by the National Assembly in August 2007. Together, they focus on digital transformation of the public sector and the economy in general, and on strengthening infrastructure for and regulation of key sectors of national development as defined in Vision 2063 and NDP 11.

The Information and Communications Technologies (ICT) Policy is perhaps the most comprehensive of the ICT-related policy measures. It aims to achieve the Botswana's digital transformation by harnessing and applying ICTs covering e-Government, e-Learning (*Thuto*Net), e-health and e-commerce. Its specific goals are to: (a) create an enabling environment for the growth of an ICT industry in the country, (b) provide universal service and access to information and communication facilities in the country, and (c) make Botswana a Regional ICT Hub so as to empower Batswana and to make the country's service sector globally competitive.[26]

An UNCTAD review of e-commerce and ICT-related measures concludes that Botswana has accelerated the adoption of digitalization and e-commerce-related regulations since 2014 (UNCTAD, 2021b). These instruments include the Electronic Communications and Transactions Act (2014), the Electronic Records Act (2014), the Customs Act (2018), the Consumer Protection Act (2018), the Cybercrime and Computer Related Crimes Act (2018), the Data Protection Act (2018) and the Competition Act (2018). The review notes that Botswana's legal framework is favourable for e-commerce, and that key ICT laws are now in place. However, the main challenge is to enforce the laws and implement the policy frameworks to expedite digitalization and e-commerce. It recommends that the Government of Botswana consider consolidating policies and laws governing ICT and e-commerce.

Despite the accelerated adoption of ICT policies and regulations since 2014, the pace of policy implementation and enforcement of related laws has been slow. This is mainly due to relatively low institutional capacities and coordination among the agencies involved in implementation. A comprehensive review of current institutional arrangements, or the landscape for digitalization and ICT in general, should be undertaken, and reforms conducted to align responsibilities of various agencies with their capabilities. It is envisaged that through the Smart Botswana Strategy, institutional and other challenges to implementation of the ICT and digitalization policies will be addressed. Smart Botswana is a very ambitious initiative with plans to establish centres of excellence for research and innovation in 4IR and to achieve digital transformation of the country as whole. Its success will depend on how well the Government mobilizes adequate resources and configures relevant institutions for its implementation.

[25] Since Independence in 1966, Botswana adopted an approach of development planning. Since then, the Government has produced a series of National Development Plans (NDPs) starting with Botswana's Transitional Plan for Social and Economic Development prepared in 1965.

[26] Government of Botswana, 2007, *National Information and Communications Technology Policy*. Government Paper No. 3 (Gaborone, Ministry of Communications, Science and Technology): 4.

4.3.7 Human resource development, higher education and training policy and plans

Vision 2036 and the NDP 11 recognize that human resources (including skills development), higher education and vocational training are critical for the country's transition to a knowledge-based innovation-driven economy. Accordingly, the Government has adopted an array of policies and strategies, and established various institutional arrangements for education and vocational training. Key policy initiatives include the National Human Resource Development Strategy (NHRDS), the Tertiary Education Policy: Towards a Knowledge Society, the Education and Training Sector Strategic Plan (ETSSP) for 2015–2020 and the Act Establishing the HRDC.

The Tertiary Education Policy: Towards a Knowledge Society, considers tertiary education as a key component of Botswana's NSI. The policy states that the tertiary education sector is expected to "produce inventive, pioneering, high impact research and educate creative, talented and capable researchers for the successful transformation of Botswana into a Knowledge Society." It outlines several policy measures for improving mechanisms for funding of universities' R&D and ensuring that higher education and vocational technical training are aligned with the goal of developing a modern, sustainable, knowledge-based economy that supports inclusiveness and diversity.

The ETSSP emphasizes strengthening the country's ICT infrastructure and enhancing ICT training in schools. It outlines measures for implementing the *ThutoNet* component of the national ICT policy. Such measures include providing schools with high-speed Internet access, increasing the computer-to-student ratio in schools, designing and implementing an ICT content and curriculum development programme for primary and secondary schools, as well as for vocational and tertiary colleges. However, implementation of the ETSSP has been slow, mainly because of budgetary constraints and the huge demand for ICT infrastructure in rural schools scattered around the country.

The Act establishing the HRDC contains explicit provisions for promoting STI. The HRDC is also responsible for formulating human resource development plans for key sectors of the economy.

Recent assessments show that Botswana's education system has expanded in terms of the numbers of schools, colleges and universities (see, for example, World Bank, 2019). There has also been expansion in access to education in general as a result of various government policy interventions over the past several decades. However, there are concerns regarding the quality of education and training in the country. Botswana's students in primary and secondary schools score low in international assessments such as the Trends in International Mathematics and Science Study (TIMSS) and Southern and Eastern African Consortium for Monitoring Educational Quality. The gross tertiary enrolment rate is only 23.4 per cent. This undermines the attainment of SDG4 (Inclusive Education for All), and the development of human resources in general as envisaged in Vision 2036.

4.3.8 Technical standards policies and regulations

Technical standards are drivers of innovation, and are critical to ensuring that the new technologies (products, processes and services) developed, acquired/imported, traded and/or transferred meet safety, environmental, labour, technical and health requirements. Companies are required to develop and trade in goods and services that meet international standards. Botswana has set standards for approving technologies imported into the country. For example, in the broadcasting sector, technologies that have been approved in Botswana are DAB Plus, DRM, ISDB-T (including the Botswana specific characteristics), DVB-S and DVB-S2 and DVB-T2. Standards for these technologies are in the Broadcasting Standards TS010.

Botswana's policies and regulations for technical standards focus mainly on safety considerations and less on the promotion of STI. The country has adopted a number of regulations covering a wide range of national and international standards, including the following:

- Radiation Protection Regulations (Chapter 24:03).
- Agrochemicals Act (Chapter 35:09).
- Workmen's Compensation Act (Cap. 47:03) (Act 23, 1998).
    - Employment Act 1982 (Cap 47:01) (Act 29, 1982).
    - Mines, Quarries, Works and Machinery Regulations 1978. No. 127.
    - Mines, Quarries, Works and Machinery Act 1973. No. 20.
    - Factories Act 1973. No. 31.

However, the policy and regulatory frameworks for standards are outdated and are not aligned with Vision 2036 or with the imperatives of structural transformation through STI. Most of them were adopted in the 1970s and 1980s, and did not keep up with the changes in Botswana's development goals. At that time, STI considerations were not high on the Government's agenda, whereas today STI-driven economic transformation is the core goal of Vision 2036. Moreover, they do not address contemporary challenges. Thus, it is important that the regulations for technical standards be reviewed to align them with Vision 2036, the NRSTI Policy and policy frameworks for industrial development.

Integrating STI into policies and regulations for technical standards will require greater cooperation and coordination between the DRST, the Botswana Bureau of Standards (BOBS) and the Ministry of Trade and Industry. BOBS, under the Ministry of Trade and Industry, is the national agency that develops and implements national standards, both compulsory and voluntary. Compulsory standards cover labour, food safety, human health and the environment, and BOBS is responsible for monitoring and ensuring compliance with those standards. Voluntary standards are not legally required, but compliance may increase product competitiveness. Foreign and local companies are required to certify their products in Botswana.

Botswana is a signatory to international treaties that set standards and regulate the safety of specific technologies. For example, it has ratified the Cartagena Protocol on Biosafety, and has adopted the National Biosafety Framework and the National Biosafety Policy. The goal of the Policy is to regulate and promote the development of biotechnology through the application of biosafety measures to guarantee the protection of biological resources and ensure their sustainable use, to protect human health, and to minimize the adverse socioeconomic impacts of biotechnology.

Implementation of regulations relating to standards is affected by various constraints, including lack of testing facilities, technical expertise and institutional coordination. The major challenges include the lack of a national accreditation body with facilities for testing, limited capacity of BOBS, and incoherence in and outdated regulations. Owing to the absence of a national accreditation body with an equipped laboratory, samples have to be sent to accreditation agencies in Mauritius, South Africa or the United Kingdom. This is costly for companies and for the country as a whole, and affects the introduction and diffusion of new technologies in the economy. Also, the lack of a national accreditation body is likely to affect Botswana's participation in the African Continental Free Trade Area and other regional trade areas such as the Common Market for Eastern and Southern Africa (COMESA). The weak capacity of BOBS is due to a limited budget and scarcity of skilled personnel in various technical aspects of standards-setting, quality assessment, monitoring and accreditation.

Building the capacity of BOBS should be at the core of efforts to strengthen the national system of innovation. In this regard, it is recommended that a comprehensive assessment of the country's existing technical standards be undertaken to identify specific policy and institutional deficits. Such an assessment would inform the design of a national programme for strengthening technical standards, BOBS and national policies.

4.4 Policy monitoring and evaluation

Effective M&E that enables reflection and learning is a critical element of STI policy design, implementation, assessment and refinement that strengthens the policymaking process. It is a process by which stakeholders assess whether and how STI policies and programmes are developed and implemented to achieve specific national goals. Policy M&E involves appraising specific policy measures and instruments, gauging the level of stakeholder engagement in policy design and implementation, and evaluating outcomes of policy implementation. It is supposed to be embedded in policy implementation plans and practices. Weaknesses in M&E practice can make a difference in performance and outcomes.

The NRSTI Policy and most other policy frameworks lack M&E provisions, making it difficult to assess their effectiveness. The fact-finding mission for this review found that there is a National Monitoring and Evaluation Strategy (NMES) which all government agencies are required to use. However, there was also consensus that the 2011 NRSTI Policy and related implicit policies such as those for ICT, human resource development, trade, investment and IPRs, are not being effectively implemented because of weak M&E capacity in various departments and in the Government as a whole. This is partly due to low policymaking capabilities, and a lack of resources – both budgetary and human skills – for M&E. In addition, poor institutional coordination and oversight as well as a lack of policy accountability mechanisms involving legislative bodies and the Auditor General are impediments to effective STI policy implementation. This should be remedied by developing M&E capabilities and effective M&E systems across all government entities as a priority for strengthening the country's efforts towards achieving Vision 2036. The development of a draft M&E framework for STI by the DRST is a vital first step for strengthening M&E in STI.

Various institutions, such as the National Strategy Office (NSO), have been established. The NSO, located in the Office of the President, is the overarching implementation coordination unit for effective policy implementation. Despite this initiative, there are persistent challenges to M&E and policy implementation in Botswana, as M&E has not yet been institutionalized across the Government.

Given that STI is cross-sectoral, STI policymaking and implementation are complex processes. They require systemic and holistic interventions and coherence across sectors and NSI institutions, as well as stronger institutional mechanisms. Moreover, the policymaking process must be dynamic because of the rapid developments in science, research, technologies and innovation activities. **Accordingly, it is important to consider creating a reconfigured and strengthened DRST (or possibly a dedicated ministry for STI) with clear mandates and adequate resources and authority for intersectoral coordination, and ensuring that STI are mainstreamed into all sectors of the economy.**

4.5 Synthesis and recommendations

Botswana has a wide range of explicit and implicit policies and related measures for STI that should be reviewed and better coordinated to improve coherence and effectiveness. The 2011 NRSTI Policy is the main framework for STI, and is relatively good, although it has clear weaknesses in terms of its heavy emphasis on R&D without enough focus on innovation and technology. It includes wide ranging institutional arrangements for strengthening the country's NSI. Some key institutions for implementing the NRSTI Policy are planned, but have yet to be established. They include the Botswana National Research, Development and Innovation Coordinating Council, the National Research Fund and the Directorate for Research, Science, Technology and Innovation (DRSTI).

The NRSTI Policy Implementation Plan (adopted in 2012) is unknown to most stakeholders, and implementation has been weak. This is attributed to the absence of adequate institutional arrangements, weak capacity of the DRST, limited financial allocations for STI, lack of an effective M&E framework (which DRST is seeking to address by recently releasing a draft M&E framework), the slow and partial implementation of key measures, and weak policy accountability mechanisms.

To address these deficits, and strengthen the NRSTI Policy and the NSI in general, the following short-, medium- and long-term actions are recommended.

Short-term actions (within 1 year):

Establish a high-level committee for NRSTI Policy implementation. An inter-agency committee comprising the DRST, research departments of the various sectoral ministries, universities, the chamber of commerce, representatives of civil society, the BDIH and other key actors should be established to work out modalities for operationalizing the creation of the Botswana National Research, Development and Innovation Coordinating Council and the National Research Fund, and upgrading the DRST to become the Directorate for Research, Science, Technology and Innovation.[27] The committee would review the 2012 NRSTI Policy Implementation Plan to identify specific short-term (1-2 years) measures or actions to be instituted in order to implement those provisions of the 2011 NRSTI Policy that focus on the establishment of new institutions and/or strengthening the DRST. It would also develop a clear strategy for resource mobilization and funding of STI in Botswana.

Strengthen parliamentary engagement in STI policy. To ensure that the country allocates adequate and sustainable funding for STI through annual national budgets, it is crucial to secure the engagement of the National Assembly, which is responsible for approving budgets and enacting legislation to implement policy. It is a key institutional actor in the processes of budgeting and determining the allocation of resources to national development priorities. Currently, it is not actively engaged in STI policymaking processes in the country. It is important to establish a strong parliamentary committee for STI, which would help to ensure that adequate funding is allocated to research and innovation, and that the Government implements the NRSTI Policy effectively. The DRST should work with appropriate offices or organs of the National Assembly to develop a programme for strengthening parliamentary engagement in STI. Such a programme should involve establishing a parliamentary portfolio committee on STI.

[27] According to communications with the DRST, an advisory committee has been established. However, it may not include all of the relevant actors identified here.

Medium-term actions (1-2 years):

Revise the NRSTI Policy. In revising the current NRSTI Policy, its focus on and coverage of innovation and technology development considerations need to be strengthened. The current policy framework is framed narrowly around the promotion of R&D, taking a linear approach to STI. It should cover various innovation policy instruments such as those relating to technology areas, public procurement for innovation, technology foresight and assessment, use of IP protection and fostering public-private sector partnerships in STI. There is also a need to expand the policy scope to focus on science-for-policy, with an emphasis on measures and guidelines for the procurement and use of science (scientific evidence) in public policies. The DSRT (reconstituted and strengthened into a directorate) should establish a consultative policy process to revise the 2011 NRSTI Policy. The private sector, civil society and political parties should be involved in the process to ensure that its outcomes are widely owned by stakeholders in the country.

Design an implementation plan and M&E framework for the revised NRSTI Policy. To ensure that the revised NRSTI Policy is effectively implemented, a comprehensive plan with an M&E component will be crucial. The DSRT (reconstituted and strengthened into a fully-fledged directorate), under the leadership of the proposed Botswana National Research, Development and Innovation Coordinating Council, will need to ensure against a long time lag between the revision of the RSTI Policy and the preparation and adoption of the implementation plan having an integrated M&E component.

Strengthen the use of implicit STI policy instruments. Botswana has a range of implicit STI policy measures that should be used (or invoked) to promote research and innovation. One such measure is the Public Procurement Act. As stated earlier, public procurement can be a critical innovation policy instrument if it is well aligned with the NRSTI Policy and is designed to be innovation-enhancing procurement (IEP). Therefore, Botswana's procurement regulations should be revised to include IEP provision. Such provisions should provide for the DRST to be represented on tendering board(s) or committees, the training of staff of the Public Procurement Authority and the DRST in IEP, and policy learning from countries such as Sweden that make effective use of public procurement as an innovation policy instrument.

Ensure policy coherence across key economic policy areas that enable the building of RSTI capabilities and their application in the economy. This includes, in particular, coherence across industrial policy, procurement policies and RSTI policy, but extends also to FDI and trade policy. This should be an objective of policymaking going forward, in order to adopt a whole-of-government approach to policy design and implementation, integrating greater communication and information-sharing across ministries, departments and agencies. Over time, this would contribute to breaking down silos and reducing fragmentation in the NSI, which currently undermine the type of integrated approach needed for STI policy.

Long-term actions (3-5 years):

Within 3-5 years of its establishment, review the institutional performance of the Directorate for Research, Science, Technology and Innovation (following upgrading of the DRST, as proposed). Such a review of its performance (and that of the NIS as whole) would help determine whether the Directorate is an effective institutional mechanism for STI in the country.

Consider the option of establishing a fully-fledged ministry dedicated to STI. Conduct a comprehensive institutional study on the feasibility and desirability of establishing a fully-fledged ministry for STI. Such a study would need to be informed by best practices and lessons from countries that already have such ministries. Issues to consider in the study would be the nature of its specific remit, whether it would help to strengthen the NSI (particularly in terms of strengthening institutional coordination across sectors), and the cost implications of having such a ministry.

Part II STI for Overcoming Sustainable Development Challenges

Introduction

Botswana's Vision 2036 envisages that transformation across its four pillars will be achieved by investments in R&D and innovation, and by accelerating the pace of technical and scientific advancement (Vision 2036: 4). This implies that R&D, both new and more established technologies and innovations, will need to be harnessed across multiple industries and sectors to achieve transformation. Part II of this STIP Review examines the opportunities for harnessing STI for transformation and for overcoming the challenges to attaining the SDGs. It is structured to correspond to different SDGs. Using new technologies is a critical element in harnessing STI considering the rapid increase in technological changes and the need for all countries to harness digitalization and frontier technologies to accelerate development.

Chapter 5. Harnessing new technologies for Botswana's economic transformation

Botswana is looking to harness digital technologies for its economic transformation, much like the rest of the world, and has started to adopt several frontier technologies. There are several advantages to building capacity to harness digital technologies and frontier technologies more widely. The country is actively investing in digitalization across diverse economic sectors, extending far beyond communications that was a key focus in the 1990s, to include the diffusion of computers, the Internet and mobile telephones. It is hoped that digitalization will allow technological leapfrogging and bring multiple benefits in terms of improved communications, increased efficiency, higher productivity, improved access to export markets, better government services and other services of many kinds (e.g. in education, health, retail and travel), empowerment of MSMEs and young entrepreneurs and the building of dynamic digital start-ups that could grow into tech giants (e.g. unicorns) similar to some small tech start-ups that grew in other countries. As a result of the Covid-19 pandemic, the need for people to use digital platforms to make life easier under pandemic restrictions prompted policymakers to give greater priority to the deployment of ICTs.

Some forms of leapfrogging are relatively easy, for example adopting digital communications technologies such as mobile phones to bypass fixed line telephones. Indeed, many countries are making progress in providing better access to mobile phones, computers and the Internet. However, even these more basic achievements require large investments in digital infrastructure to enable broad access at rapid speeds and at affordable prices. And, apart from the high costs involved, it requires good implementation capabilities. **However, more sophisticated levels of leapfrogging such as applying digital technologies to build productive capacity and gain competitive advantages in production over other countries is harder to achieve.** Nevertheless, some frontier technologies can still be adopted and applied widely to improve efficiency and productivity, and provide better service delivery across sectors. Since most countries are doing this today, it has become a dynamic race where progress is needed to avoid falling behind.

Botswana has embraced the digital revolution at the highest levels of policymaking, and has invested heavily in digital infrastructure and other complementary infrastructure, such as energy supply needed to harness its benefits. However, providing affordable access to Internet services, particularly high-speed broadband, and making them universally available, is particularly challenging for a country like Botswana due to its small and dispersed population and landlocked situation, which entail higher infrastructure costs and prices per person. In cities and towns, there remains an issue of affordability of mobile phones and Internet access for poorer households and many MSMEs that have low productivity, low earnings and limited cash flow. Botswana has, nevertheless, made good progress in improving its digital infrastructure (UNCTAD, 2021b) through substantial investments. Data centres are becoming central components of these efforts and could potentially play an important role in realizing Botswana's aspirations to become a digital economy. In 2021, Botswana Fibre Networks announced its plans to build a data centre in Gaborone.

However, progress in digital transformation (i.e. the adoption and use of digital communications technologies across the economy and society) requires that advances be made in multiple areas. These include digital infrastructure, digital literacy and skills, digital financial services and identification, digital innovation and entrepreneurship, and digital platforms. These are five pillars that the World Bank includes in its digital assessment methodology.

UNCTAD's E-commerce Enabler and Assessment Framework lists eight key policy areas for harnessing e-commerce for development: ICT infrastructure and telecom services; logistics and trade facilitation; the legal and regulatory environment; electronic payments; skills development and talent building; awareness-raising, including consumer awareness; and e-procurement (UNCTAD, 2021b). Digital transformation thus calls for addressing far more than infrastructure issues alone, although infrastructure remains a critical element.

5.1 The state of digital development in Botswana

Digital transformation requires a solid foundation of critical infrastructure, which includes fast, reliable and affordable Internet services, and access to electricity. On the Network Readiness Index, which provides an indication of how well developed the digital infrastructure network is in a country, Botswana had a relatively low ranking of 102 in 2021, down from 99 in 2020. This placed it ahead of Namibia, Zambia and Zimbabwe, but behind South Africa and Mauritius (table 13). Given its many constraints, improving digital readiness may be harder in Botswana than in South Africa, but it still needs to be done.

Table 13

Network Readiness Index of Botswana and selected countries, 2021

	2021 ranking	Technology	People	Governance	Impact
Botswana	102	91	99	101	115
Malaysia	38	37	39	40	38
Mauritius	71	79	87	58	72
Nambia	109	104	102	104	116
Singapore	7	8	9	12	1
South Africa	70	63	70	51	103
Zambia	112	114	106	99	120
Zimbabwe	122	113	114	116	129

Source: Portulans Institute (https://portulansinstitute.org/).

Access to mobile phones and the Internet is relatively high in Botswana compared to other African countries, including Mauritius and South Africa (table 14). Indeed, Botswana has one of the highest mobile penetration rates in Africa, with 163 subscriptions per 100 people. However, fixed line telephone penetration is very low. This is typical in African countries where many people have forgone fixed line telephony and leapfrogged into mobile telephony. While the majority of households have Internet access (63 per cent) and use the Internet (64 per cent), many still lack such access. These numbers are similar to regional leaders.

There appears to be an energy divide between rural and urban areas: only 26 per cent of the rural population has access to electricity, compared with 92 per cent in urban areas. The low rate of access in the rural areas constitutes a major challenge to improving the ICT infrastructure and connectivity. In rural areas, network coverage is weaker than in urban areas.

Table 14

Key ICT indicators in Botswana and selected countries, 2020

Key indicators ICT (2020)	Botswana	Namibia	Mauritius	South Africa	Zambia	Africa (average)	World
Fixed-telephone sub. per 100 inhab.	6	6	38	4	0	0.7	11.6
Mobile-celluar sub. per 100 inhab.	163	114	150	162	104	83.7	107
Active mobile-broadband per 100 inhab.	95	69	98	111	56	38.7	77.3
At least 3G coverage (% of population)	97	89	99	100	94	78.3	93.6
Mobile-celluar coverage	98	100	99	100	98	89.5	96.7
Individuals using the Internet (%)	64	41	65	70	20	29.5	59.1
Households with a computer (%) [1]	28	21	49	23	8		
Households with Internet access (%) [2]	63	9	73	63	18	20	61.5
International bandwith per Internet user (kbit/s) [3]	48	18	176	27	31	22.7	156.8
Fixed broadband sub. Per 100 inhab	11	3	25	2	0	0.6	15.8
Fixed-broadband sub.by speed tiers, % distribution							
Up to 256 kbit/s to 2 Mbit/s	5	3	17	0	22		
Up to 2 to 10Mbit/s	2	89	0	34	77		
Equal to or above 10 Mbit/s	9	3	82	65	0		
Total fixed broadband subscriptions	259 525	71 963	323 200	1 303 057	82 317		
population /(million)	2.352	2.541	1.266	59.31	18.38		
Total fixed broadband subscriptions per million	110 342	27 967	255 292	21 970	4 479		

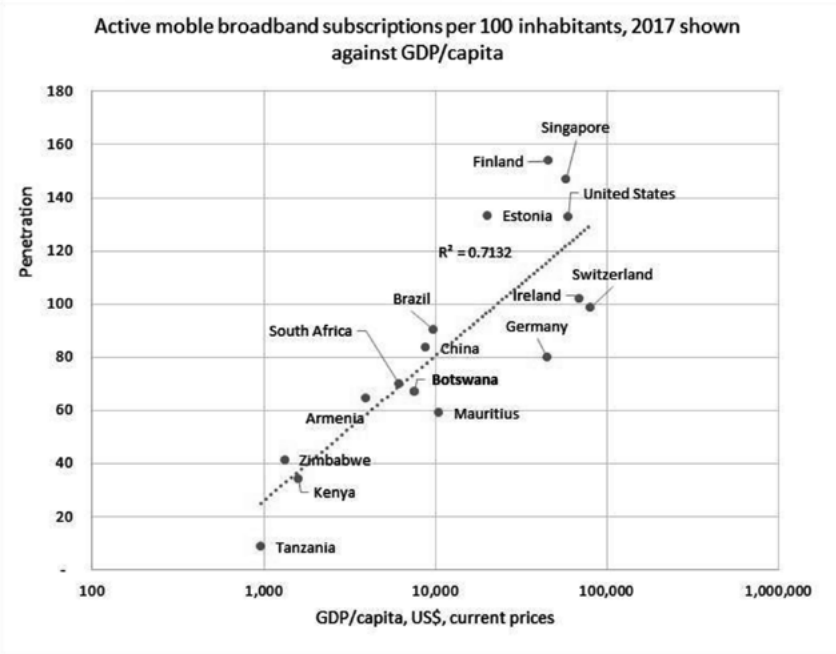
Source: https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx, ITU.

Notes: [1] Data in Namibia is for 2013, in South Africa for 2019, and in Zambia for 2018; [2] Data in Namibia is for 2013, in South Africa for 2019, and in Zambia for 2018; [3] Data in Namibia is for 2018.

Botswana is very close to achieving the level of broadband penetration that would be expected relative to its income level (figure 21). Its penetration rate is close to that of South Africa, which is a strong performer among African countries.

Figure 21

Active broadband penetration rate in Botswana and selected countries, 2017

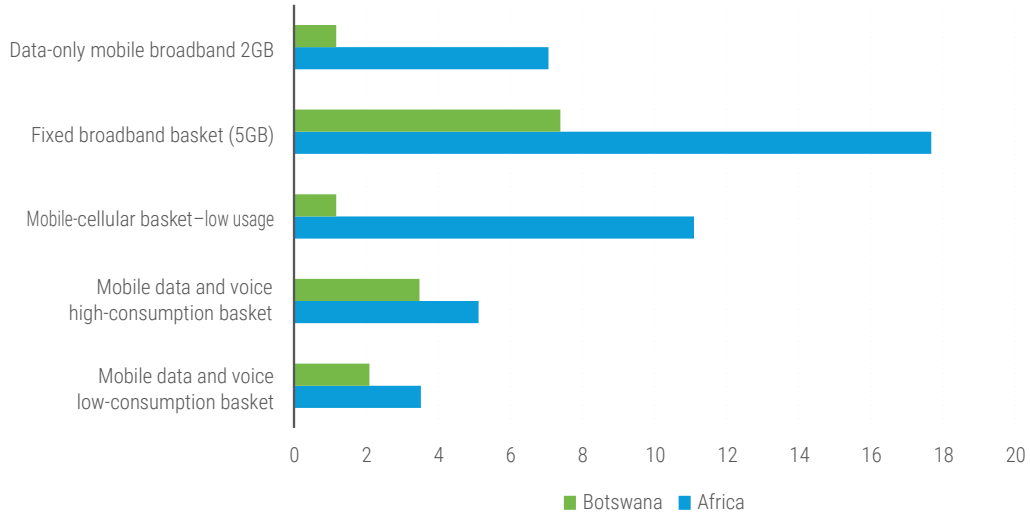


Source: UNCTAD (2021b) based on data from the World Bank and the ITU.

In Botswana, there are major deficiencies related to Internet speed, service quality and price. Respondents during the many meetings while preparing this review pointed to serious deficiencies in the quality of Internet services. This was partly due to failures in energy supply and Internet service in many government offices. Figure 22 provides data on the cost of Internet services as a percentage of monthly gross national income (GNI) per capita. The cost of Internet services in some cases meets the Broadband Commission for Sustainable Development's target of a maximum of 2 per cent of GNI per capita, but mobile data and especially fast broadband are still expensive and above this threshold. Even though the price of 1 gigabyte (GB) of broadband fell in 2020, it still remains high (table 15). There has been a steady decline in prices (table 16), reportedly as a result of concerted action through a series of government measures to drive prices down (UNCTAD, 2021b). However, affordability of fast Internet service remains a serious issue that appears to be related to the cost of providing services and the small population size to absorb those costs.

Figure 22

Affordability of Internet services of Botswana and average for Africa, 2021
(Price as a percentage of monthly GNI per capita)



Source: https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/IPB.aspx.

Table 15

Cost of 1 gigabyte of broadband in selected countries, 2018–2020
(Dollars)

	2018	2019	2020
Botswana	8.84	8.85	8.06
Malaysia	7.19	3.62	5.86
Mauritius	5.94	5.96	4.9
Nambia	11.02	8.57	6.62
South Africa	10.41	10.37	5.68
Zambia	4.2	3.9	2.67
Zimbabwe	15.0	15.0	n.a

Source: https://a4ai.org/extra/baskets/A4AI/2020/mobile_broadband_pricing_gni.

Table 16

Cost of 1 gigabyte of broadband in selected countries, 2015–2020
(Percentage of GNI per capita, dollars)

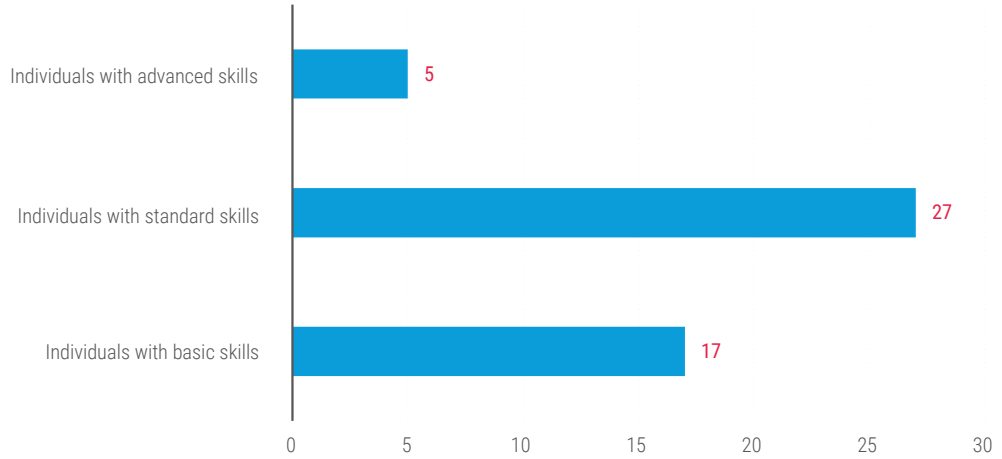
	2015	2016	2017	2018	2019	2020
Botswana	5.74	5.11	2.19	1.56	1.37	1.44
Malaysia	1.19	0.82	1.07	0.89	0.41	0.65
Mauritius	1.12	1.06	1.01	0.7	0.59	0.54
Nambia	2.69	3.49	4.66	2.88	1.96	1.99
South Africa	2.48	2.35	2.5	2.3	2.17	1.41
Zambia	14.94	12.25	12.25	3.88	3.27	3.65
Zimbabwe	n.a	44.68	32.97	19.78	10.06	n.a

Source: https://a4ai.org/extra/baskets/A4AI/2020/mobile_broadband_pricing_gni.

Strong digital skills across industry, and indeed the whole of society, are critical to achieving the country's aspirations for digital transformation and must be upgraded through the education and training system. The data available indicate that digital skills are low: only about 17 per cent of individuals have basic digital skills, 27 per cent have standard digital skills, and 5 per cent have advanced digital skills (such as coding) (figure 23). The shares of the population with basic digital skills and standard skills are very low compared to the average for developing countries (46 per cent and 39 per cent respectively), which, on average, are themselves lagging significantly behind those of developed countries (65 per cent and 49 per cent respectively) (UNCTAD, 2021c, figure 8).

Figure 23

Digital skills in Botswana, 2014
(Percentage of the population)



Source: ITU Digital Development Dashboard (2021).

Note: Basic skills: the highest value among the following four computer-based activities: copying or moving a file or folder; using copy and paste tools to duplicate or move information within a document; sending e-mails with attached files; and transferring files between a computer and other devices. Standard skills: the highest value among the following four computer-based activities: using basic arithmetic formula in a spreadsheet; connecting and installing new devices; creating electronic presentations with presentation software; and finding, downloading, installing and configuring software. Advanced skills: the highest value for writing a computer program using a specialized programming language.

Improving digital literacy broadly is essential, which means that schools and universities in Botswana need to adapt their curricula to educate students on digital technologies. Digital education needs to be integrated into the educational system, from basic through to higher education. The country can build on the initial progress it made during the Covid-19 pandemic in integrating e-education tools into these systems.

As mentioned previously, Botswana aspires to diversify its economy through the development of a digital economy. Digital businesses offer great potential for generating not only jobs and economic growth, but also locally relevant solutions in an increasingly digitalized context. A digital economy includes a vibrant digital entrepreneurship ecosystem. However, although Botswana has a growing number of digital businesses, digitalization is being driven more by large-tech firms, many of which are foreign digital multinational corporations, rather than local firms. There have been some initial attempts to establish partnerships with foreign firms. For instance, in 2017 the Botswana Police Service signed a memorandum of understanding (MoU) with Huawei to deploy CCTV surveillance cameras through the Safe City project, and in 2021, Huawei Technologies Botswana launched the Huawei ICT Academy in partnership with Botho University. In 2022 Lenovo partnered with

the University of Botswana to set up a Digital Entrepreneurship Pod that is expected to serve as a co-creation platform where existing and aspiring entrepreneurs are empowered with digital tools and skills within an ecosystem that enables creativity and innovation aimed at making a socioeconomic impact.

5.2 Application of digital technologies in Botswana

Digital technologies are diffusing across Botswana, and are being increasingly adopted in new sectors, although the rate of uptake is reportedly slow. Some examples of digital technologies currently being applied in Botswana are in the areas of e-commerce, e-government, e-payments and e-education as discussed below.

E-commerce

E-commerce is not widely adopted in Botswana, mainly due to the lack of secure methods of online payment, the potential for scams and unfair business practices. According to an ICT survey by Statistics Botswana (released in 2017 and based on data from 2014), half the country's Internet users choose not to shop online due to a lack of trust, and only 4.6 per cent of the population are regular online shoppers. The Government has taken steps to facilitate and regulate electronic transactions. In April 2014, it passed the Electronic Communications and Transactions Bill, and in October 2021 it launched its National E-Commerce Strategy, which puts e-commerce and the digital economy at the forefront of efforts to ensure the flow of digitalized content and information, goods, services and data. The first Botswana e-commerce platform, Skymart, was launched in 2012. Although e-commerce offers considerable potential, especially for MSMEs, few businesses currently use e-commerce platforms to sell their products, and the number of local e-commerce websites is still limited. Many SMMEs apparently do not understand their potential value. Group discussions with SMMEs revealed that they lack basic ICT skills, do not have access to the Internet and lack knowledge of ICT tools. They also lack the financial means to buy ICT tools for their businesses (UNCTAD, 2021b).

Table 17 provides insight into the e-commerce market in Botswana. Services are offered by several local firms in retail, travel, banking and postal services, for example. Retailers appear to be actively pursuing e-commerce clients. Foreign e-commerce sites are also available, although there are no data on how actively they are being used to buy goods from abroad.

Table 17
E-commerce platforms used in Botswana

E-Commerce Category	Botswana	Foreign, Botswana-based	Foreign
Online travel, ticketing, etc.	Air Botswana	Qatar Airways (Qatar), South African Express (South African), Ethiopian Airlines (Airlines).	
E-retailer	Lion tutoring (e-learning), My Foodness (food delivery service), Bidfood (food products), Skymart. bw (technological fashion and beauty products), Sefalana Holdings (grocery store), Shop360 (music, tickets, electronics, clothing and accessories), Lovebosh (fashion store), Mr. Veg (fruit and vegetables), Botswana craft (arts and crafts), G4G IT (fashion, electronics, sportswear, etc.), Webmart (website development), Dichi Media (digital marketing agency), Mpotsa (information), BUYBDUB (local and indigenous products)		AliExpress (China), Amazon (United States), Aramex (Shop and Ship, United Arab Emirates)
E-marketplace		Bidorbuy (South Africa)	Alibaba (China), Amazon (USA)
Online portals classifed	HRMC (jobs), BotswanaPost (Postal Services)	Pnet (South Africa)	eBay (USA)
E-banking services	FNB, Barclays, Stanbic, Standard Chartered.		

Source: UNCTAD (2021b).

E-Government and e-payments

The use of e-services, especially e-payments to pay for water and electricity services, mobile money transfers and e-filings of tax returns, is common in Botswana. In 2017, the Water Utilities Corporation launched a self-service platform that enables customers to access its services through cell phones. Customers enter their customer contract number and pay their bills using any bank card (Bant et al., 2021). In June 2018, WUC introduced WUCapp, an application for

smartphones through which customers can pay water bills, check their account balance, view their monthly consumption totals, submit meter readings, and report pipe bursts or leakages (Bante et al., 2021). In 2013, the Botswana Power Corporation introduced the options for online and mobile payments of electricity bills. Other online services, such as fault and complaint reporting, can be filed through the website (Bante et al., 2021). As an additional channel for filing income tax returns, the app, mtax, has been available since September 2019.

The Government of Botswana launched its E-Government Strategy in 2012, with the aim of improving the provision of services through technology. This has since been superseded by the SmartBots digital transformation strategy.

E-education during Covid-19

Covid-19 led to the rapid deployment of e-education initiatives to prevent the complete loss of education services to students. The lockdown imposed by the Government to mitigate the effects of the Covid-19 pandemic in March 2020 presented multiple challenges to Botswana's education system. Tertiary education institutions responded by increasing online programmes to ensure continuity of lessons.

Nationally, initiatives to promote e-Education were reported to be under development in 2021 by the Ministry of Basic Education and the Ministry of Tertiary Education, Research and Technology.[28] The objective is to promote cost-effective access to education and training, enhance learner access to lifelong learning, leverage technology-enabled learning, and increase enrolment and success in tertiary education. In addition, the establishment of a National Open Educational Resource Centre has been proposed to increase access to educational resources for teacher training and e-content development, and to enhance access to databases for research and innovation.

Digital finance and Fintech

Fintech is yet to fully launch in Botswana, but there is potential for it to provide financial services to people who do not have bank accounts. Electronic payments have already been launched by some mobile telephone firms, and some e-banking services have been established by banks such as FNB, Barclays, Stanbic and Standard Chartered Bank (see table 17 above). Some commercial banks have joined with mobile money service providers for the provision of electronic money services. In its Banking Supervision Annual Report 2018, the Bank of Botswana indicated that Fintech is a necessary agent for financial development, noting that it has great potential to deliver economic benefits by enhancing competition and lowering the cost of operations (BOB, 2018). Fintech services are critical to financial inclusion as they play an essential role in helping to meet the needs of underserved and unbanked populations, especially as they offer reduced fees. However, it would be prudent for the Bank of Botswana to consider potential regulatory issues related to Fintech.

Digital entrepreneurs and start-ups

There is little information available on the status of digital start-ups, although designers of apps of various kinds have been trying to find a market for their products in Botswana. Several of them interviewed for this review reported that it is difficult to find a market, as large buyers are mainly in government entities, and are often reluctant to buy products from small start-ups without a track record or established reputation. The most important incubator in Botswana, the BDIH, is taking on digital innovation as part of its role, and will need to consider how it can provide effective support for digital start-ups.

[28] https://allafrica.com/stories/202105280466.html.

5.3 SmartBots and digital transformation policies

The SmartBots Digital Transformation Strategy of 2020 is the main initiative to drive digital transformation in Botswana, which it is hoped will accelerate wider transformation to a knowledge-based and innovation-driven economy. The strategy outlines a whole-of-government approach, and aims to make rapid progress in four areas: accelerated digital connectivity nationwide, moving government services online, leveraging smart technologies to address food security, and transforming the education sector. It has many different projects across Botswana, with support from the highest levels of government, including a SmartBots office planned to be established in the Office of the President. The former MOTE took on responsibilities for part of the strategy related to the digital transformation of higher education, helping establish the Botswana Research and Education Network. The BDIH is responsible for implementing part of SmartBots. In addition, the Botswana Communication Regulatory Authority and Botswana Fibre Networks play important roles in the country's digital transformation. However, the role of the Ministry of Communications, Knowledge and Technology in implementing SmartBots should be clarified in light of the Government's restructuring.

The policy framework for digital transformation includes several laws, regulations and plans that have been established over the past 25 years and continues to be developed. The strategy incorporates and builds on earlier policies and regulations related to digital transformation (as discussed in chapter 4). UNCTAD (2021b) argues that, for recently enacted legislation and regulations, enforcement measures will need to be developed, and additional areas will be needed to support e-commerce. Data management is becoming more critical with digitalization, and the desirability of pursuing open data policies to promote sharing of data for the public good (specifically for research, but more generally as well) will need to be balanced with the need to ensure the effective protection of data and privacy of personal data. Regulation of data to make that which is useful for the public good in Botswana (and beyond) available publicly may require further consideration. This is a high priority global issue that all countries should work to address nationally, regionally and internationally.[29]

5.4 Application of frontier technologies in Botswana

Frontier technologies (i.e. recent, new or emerging, as opposed to more mature, technologies) are developing rapidly worldwide, and are having considerable impacts in the firms, industries and societies of countries where they have been adopted for use.[30] These impacts have great development benefits, but also significant potential downsides if they outpace the ability of societies to adapt (UNCTAD, 2021b). It is advisable to prepare for the transformational impacts of these technologies across countries, as is expected in coming decades. **Countries that fail to adequately prepare when beginning to build their technological capabilities will witness growing technology gaps with the technology leaders, which will be reflected in growing development divides.** There are already significant productivity gaps emerging in developed countries between firms actively adopting these technologies and those not adopting them. Frontier technologies include many different kinds of technologies. The most important ones already in use, include artificial intelligence (AI), the Internet of things (IoT), Big Data, blockchains, 5G, 3D printing, robotics, drones, gene editing, nanotechnology and solar photovoltaics (PV).[31]**It is important for developing countries like Botswana to build the capabilities to examine the effects of these technologies and their potential implications,**

[29] On the issues of data management and cross-border data flows, see the *Digital Economy Report 2021* (UNCTAD, 2021a).

[30] See UNCTAD (2021c) for an in-depth look at the different impacts of the main group of frontier technologies.

[31] The terminologies of Fourth Industrial Revolution (4IR) and Industry 4 technologies are often used interchangeably to refer to many frontier technologies.

and develop the technological skills and know-how needed to effectively adopt them and put in place safeguards that may be prudent to prevent their potential negative impacts. There may be opportunities created for many process innovations and the rapid adoption of frontier technologies to increase productivity in the next decade in Botswana. Both firms, and society more broadly, will need to be ready for their adoption in coming years.

Botswana ranks low in the Frontier Technologies Readiness Index, and the review found little information on the application of frontier technologies. More research would be useful to understand progress in this respect, and generate data to help policymakers understand the current situation. Botswana does not seem to be adequately prepared to cope with the possible impacts from the diffusion of some frontier technologies. It ranks 111 on UNCTAD's Frontier Technologies Readiness Index, which falls in the lower middle range of rankings across countries (see UNCTAD, 2021c). This is the ninth highest rank in sub-Saharan Africa behind South Africa, Mauritius, Namibia, Gabon, Cape Verde, Ghana, Kenya and Eswatini, but higher than neighbours Zambia and Zimbabwe. Although available information indicates that the adoption of frontier technologies in Botswana appears to be limited, there are indications that this has been growing in recent years. Several illustrative cases are described below.

Efforts are under way to introduce additive manufacturing in Botswana.[32] This was initiated by a project launched in mid-2019, with the University of Botswana as project coordinator and partnering with the South African Central University of Technology's Centre for Rapid Prototyping and Manufacturing and the BITRI. The Southern African Innovation Support initiative provided the initial funding. This project, which supports manufacturing of innovative patient-specific implants and medical products, and additive manufacturing of and cutting/positioning guides through state-of-the-art technology platforms, recently kicked off with an official launch in Gaborone. BITRI set up a printing laboratory (additive manufacturing) in 2020 which allows 3D printing of artefacts from plastics or related materials. The focus on health-related applications points to the importance of adapting the training of health practitioners to enable them to successfully use 4IR technologies.

There may be uses for blockchain technology, but it is still at an embryonic stage, with limited awareness beyond some academics and a small group who reportedly trade in crypto currencies. Blockchain technology presents considerable potential for global commodity value chains by enhancing transparency, traceability and reliability, which can result in reduced costs, and greater efficiency and profitability. The application of blockchain technology in core sectors of the Botswanan economy, such as the diamond and beef industries, is currently under scrutiny. In the diamond sector, it has potential applications in the areas of provenance, supply chain traceability, involvement of third-parties in the verification process, and reliability of transactions to meet best international practices. Similarly, in the beef industry, blockchain technology could address the strict traceability requirements of international markets. The Satoshi Centre, founded in 2014 as a platform to create awareness of blockchain technology in Botswana, supports entrepreneurs in Botswana to use blockchain technology to solve "African problems".

The Ministry of Agriculture plans to promote the adoption of frontier technologies in agriculture as part of the SmartBots strategy, in order to improve agricultural performance and environmental management. It reportedly plans to launch new activities focusing on the use of digital technologies, AI and drones. As part of SmartBots, the Lobu Small Stock Project aims to incorporate smart technologies in production, management, precision livestock farming and environmental management at Lobu farm (see chapter 6).

[32] In additive manufacturing objects are produced by depositing, joining or solidifying under computer control several layers of materials such as plastics, liquids or metal powder.

5.5 Recommendations

Continue to pursue the digital transformation strategy for the country with a whole-of-government approach, identifying and leveraging the competencies of relevant bodies, setting realistic time frames, considering high priority activities for funding and means of financing to support digital transformation. This would involve simultaneous action in different elements of the digital ecosystem, including infrastructure, skills, digital entrepreneurs and e-government.

In particular:

- Build digital literacy and strengthen digital skills. Key stakeholders, especially education and training providers at all levels (basic education, TVETs and universities) need to develop programmes that address the current gaps in digital skills. Education and training organizations need to be better resourced in terms of ICTs (e.g. computer equipment and affordable Internet access). This should be accompanied by targeted efforts to expand career opportunities in the digital space, such as those in software, content development services, animation and digital design.
- Facilitate access to and raise awareness about digital tools among SMMEs and start-ups. Additional support to the digital ecosystem includes investing in early-stage start-ups, and assisting enterprise support organizations, including incubators and accelerators, to deliver quality services to these enterprises. ICT-related investments need to be strategically targeted in order to build digital platforms and offer innovative digital services.

Consider undertaking data collection and assessment to determine the status of frontier technologies in Botswana, and improve local readiness for the adoption frontier technologies. To make evidence-informed strategic decisions and prioritize key frontier technologies in Botswana, it would be useful to conduct a fully-fledged readiness assessment related to the adoption and application of frontier technologies. This assessment would include a survey of relevant stakeholders. Statistics Botswana should be well positioned to drive new data collection in this area. At the same time, continue to improve indigenous knowledge systems and documentation of traditional knowledge.

Consider implementing measures to support the adoption of frontier technologies that potentially have beneficial uses in the country to foster progress towards sustainable development. And prepare for their adoption and diffusion by anticipating and acting to leverage potential benefits and mitigate any downside risks. Some of the frontier technologies could be widely used in Botswana, as elsewhere. In these cases, where any downside risks are manageable, the Government should promote their adoption and use. Botswana is already moving in this direction, but should adopt an organized approach, perhaps by establishing a multistakeholder working group on frontier technologies representing relevant public bodies, academia, the private sector and civil society. Another option would be for a high-level interministerial body on RSTI to be established to oversee the working group, or for the working group to report its findings to that body.

Build relevant foresight capacity and conduct technology assessments of frontier technologies. Also, develop specific policies and strategies for key frontier technologies, such as AI, to ensure that it maximizes the benefits and reduces the risks of adoption for local use. Frontier technologies can be socially and economically disruptive, and thus it is important that countries like Botswana put in place governance mechanisms (norms, rules and agencies) to regulate their development and application. Accordingly, Botswana should institute regimes to govern frontier technologies so as to harness them for societal advancement and transition to sustainable development. Such actions will also ensure that the country conforms to international norms (some of them still in the making) such as UNESCO's Recommendation on Ethics of AI.[33]

[33] See https://unesdoc.unesco.org/ark:/48223/pf0000380455.

Chapter 6. Transforming agriculture for food and nutritional security

6.1 Overview

In the context of a global food crisis, policymakers in Botswana will need to focus much more on agriculture and food security. This is important for multiple reasons. Until the discovery of diamonds, Botswana's agricultural sector was the main engine of economic growth and employment. As the contribution of tourism, mining, and other sources of revenue to Botswana's GDP rose, that of agriculture declined. However, given impending local and global food challenges, the agriculture's contribution to food security in Botswana is set to grow, and with it, the potential for agricultural R&D to boost productivity and food security. Moreover, agriculture is critical to providing multiple socioeconomic benefits, including employment creation, poverty reduction by supporting smallholder subsistence farmers, promoting manufacturing by developing agroprocessing, supporting rural development where poverty can be the most severe, and redressing trade imbalances by reducing food imports through import-substitution.

Botswana's agricultural sector is thus an important part of the economy and, given many years of its poor performance, the sector is in urgent need of transformation. Research, technology and innovation in agriculture is key to attaining Botswana's Vision 2036 and SDG 2 (Zero Hunger).

Although agriculture accounts for only 2 per cent of GDP, it is vital to livelihoods and employment creation for many rural households. Traditional small-scale crop farming is dominated by cereal production, but productivity is relatively low due to droughts, poor irrigation systems and poor soils. Commonly produced crops include sorghum, pulses, maize and millet, as well as beans, groundnuts and sunflowers (World Bank, 2020).

Livestock production, especially cattle farming, accounts for about 80 per cent of agricultural GDP. In 2020, it was estimated that Botswana had 2.1 million heads of cattle, and a similar number of small stock, mainly sheep and goats. Over 90 per cent of the beef produced is exported to the European Union, Asia and other markets due to its high quality. Botswana has stringent disease control measures and a relatively strong vaccination production and supply system. In contrast to beef production, dairy farming is relatively underdeveloped, and Botswana imports about 70 per cent of its dairy products (particularly milk) from neighbouring countries, particularly South Africa.[34]

Aquaculture is relatively underdeveloped, for a number for reasons, including water scarcity, low investment in disease surveillance and management, and a relatively weak extension system to support fish farmers. Botswana imports most of the fish and fish products it consumes, which is about 4,000 tons of fish per year, but it produces only 300 tons locally. Recognizing the high potential of fish farming to contribute to food and nutritional security, in 2017, a fully-fledged Aquaculture Division was established in the Ministry of Agriculture to promote the development of a viable and sustainable aquaculture industry, and as a way of diversifying the economy.[35]

Botswana's agricultural policies are articulated in the National Policy on Agricultural Development. The overall goal of the policy is to improve food security at both household and national levels, and to conserve scarce agricultural and land resources for the future. This policy goal aligns with Vision 2036 and with principles of sustainable development in general, including SDG 2. It recognizes that

[34] See: https://www.trade.gov/country-commercial-guides/botswana-agricultural-sectors.

[35] See: https://www.trade.gov/country-commercial-guides/botswana-agricultural-sectors.

agricultural transformation and transition to food and nutritional security depend on investments in STI (Government of Botswana, 1991).

There are various national plans and programmes for implementing the National Policy for Agricultural Development. They include the Arable Land Development Project (ALDEP), the Integrated Support Programme for Arable Agriculture Development (ISPAAD) of 2008, the Livestock Management and Infrastructure Development (LIMID) of 2007, and the National Master Plan for Dairy Development (NAMPAADD) of 2002. Following a review of ALDEP, ISPAAD aimed to improve arable farming and increase production. Under the two programmes, investments in R&D have focused on improving the germplasm of indigenous livestock, developing new range management techniques and systems, and improving range resource management, utilization and conservation.[36]

NAMPAADD focuses on transforming agriculture by means of improved technologies, and efficient use and management of land and water resources. It aims to reform small-scale farming by introducing modern agricultural and commercially orientated practices. Areas of investment include digitalization of agriculture, development of new high-yield varieties and improving traditional cereals, as well as building physical infrastructure to make farm inputs accessible to rural parts of the country, and developing irrigation and sustainable water management systems to reduce overreliance on rain-fed farming.

6.2 Current state of research and innovation in agriculture

There is scant information on the state of agricultural research and innovation in Botswana. R&D and innovation activities are fragmented across the various institutions, with limited coordination. Most universities have projects on agricultural R&D, although almost half of such R&D is conducted by the Department of Agricultural Research (DAR), now being integrated into NARDI.

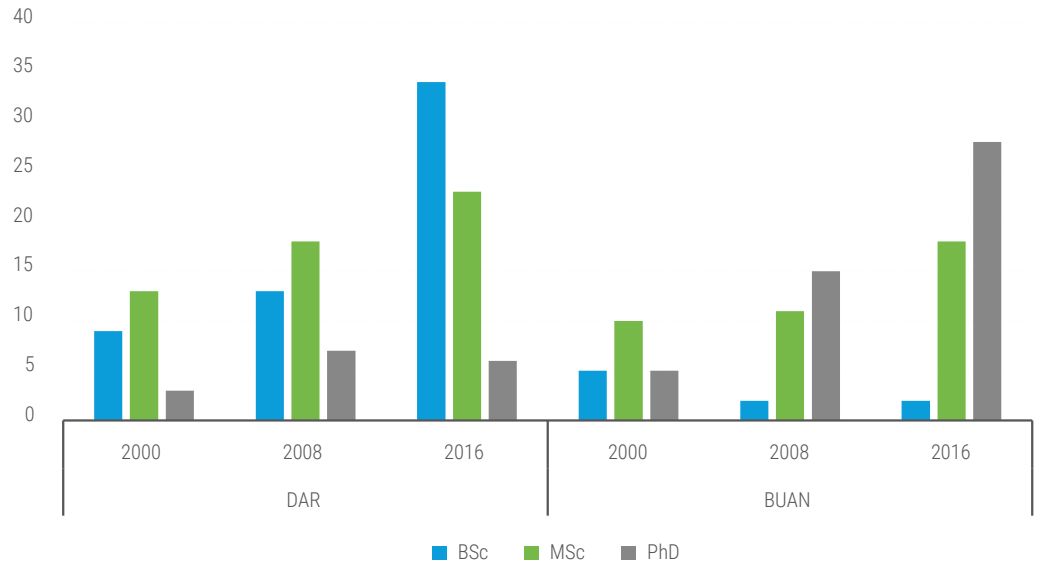
The Botswana University on Agriculture and Natural Resources (BUAN) is responsible for providing training in agricultural programmes from diploma to degree level, including doctoral degrees. However, besides the DAR and BUAN, there are not many dedicated R&D institutions for agriculture in the private sector; the public sector remains the predominant funder for such R&D. **The Department of Agricultural Research (under the Ministry of Agriculture) and the BUAN are the two major institutions driving agricultural research.** The proportion of time staff spend on research activities has been rising since 2000 (figure 24). In the year 2000, there were only three full-time researchers at PhD level at the DAR, rising to seven in 2008 before falling to 6 by 2016.

There has been a steady increase in full-time-equivalent agricultural science researchers at the PhD level in BUAN, from 5 in 2000 to 15 in 2008 and reaching 28 by 2016 (figure 24). In DAR there is a predominance of researchers at bachelor's degree level, followed by those with a master's degree. In contrast, at BUAN the growth in PhD holders has outstripped the other two qualification levels. While the growth in prominence of BUAN has meant more PhD holders in agricultural R&D, many academic researchers tend to conduct academic research that is not necessarily associated with new product development. The challenge in Botswana is the existence of only a few training programmes at master's level, with admissions heavily skewed towards late career professionals (40–50 year-olds) instead of a younger age group (20–30 year-olds). This makes it difficult for Botswana to tap into its younger brainpower. A university like BUAN can only realistically admit a total of five PHD students annually.

[36] See: https://www.trade.gov/country-commercial-guides/botswana-agricultural-sectors.

Figure 24

Number of researchers in agriculture by level of education in DAR and BUAN, 2000–2016



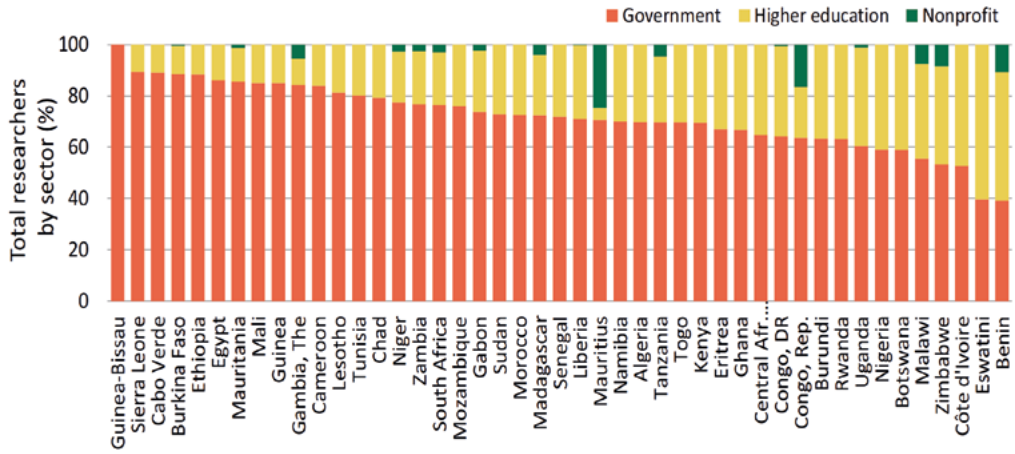
Source: Flaherty et al. (2018).

An area of relative success is the diversity of research institutions in agricultural R&D. Botswana compares well with other countries in Africa in terms of growth of research in academic and government institutions (figure 25).

Figure 25

Agricultural researchers by type of institution, Botswana and other African countries

(Percentage)



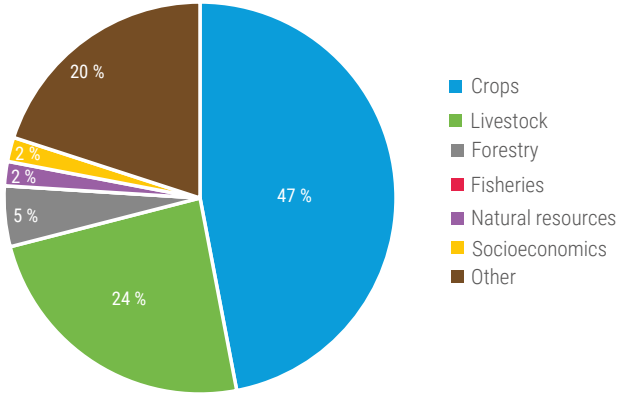
Source: Stads et al. (2021).

Most researchers (47 per cent) are engaged in research on crops, with 18 per cent focusing on cereals, and 10 per cent each on pulses and horticultural crops (figure 26). Livestock, which is Botswana's most productive agricultural subsector, accounts for 24 per cent of researchers in agriculture. What is apparent in figure 26 is the absence of researchers in fisheries. This is a sector

that could use more research, as Botswana produces only 300 tons of fish locally and imports about 4,000 tons annually. Another area that requires greater attention is agroprocessing, which holds the potential for increasing value-added production locally and diversifying within existing value chains (Flaherty et al, 2018).

Figure 26

Percentage of agricultural researchers by area of research focus

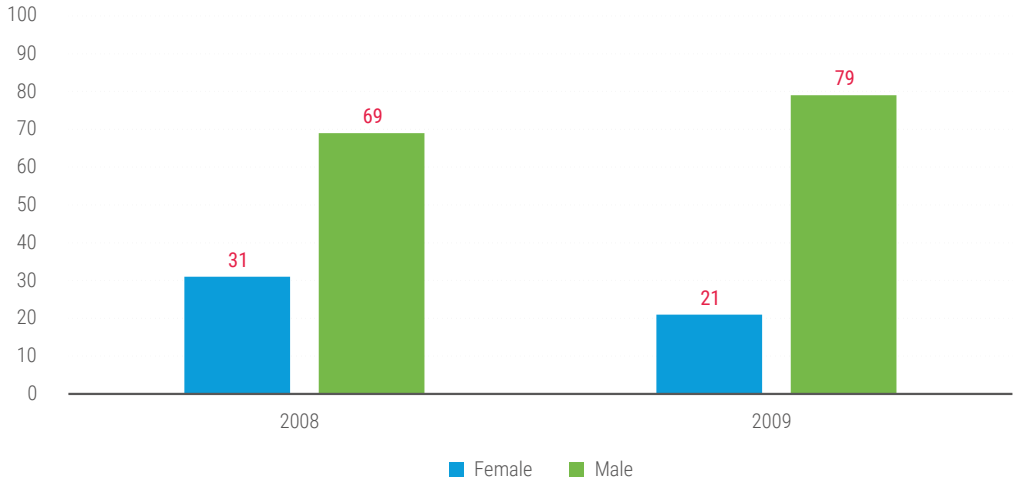


Source: Flaherty et al. (2018).

There appears to be a heavy bias in favour of men in agricultural R&D (figure 27). More efforts are required to raise the share of women researchers.

Figure 27

Share of women and men in total agriculture research staff (DAR and BUAN), 2008–2009
(Percentage)



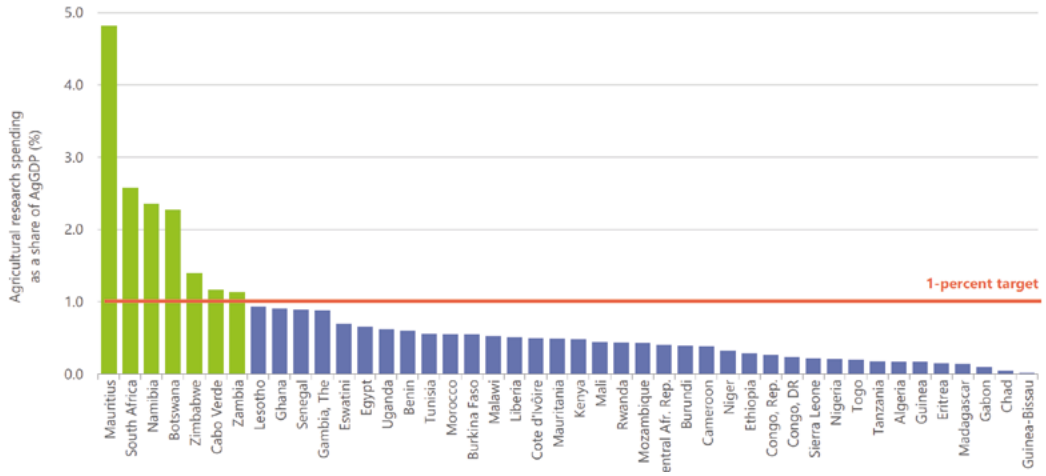
Source: Flaherty et al (2018).

Botswana invests significant amounts in agriculture research. However, there remains a significant gap between actual investment and the desirable level: in 2016, the amount spent was BWP 83 million, which was BWP 58 million short of the attainable investment target of BWP 141 million (Flaherty et al., 2018).

Botswana, Cabo Verde, Mauritius, Namibia, South Africa, Zambia and Zimbabwe are the only African countries with agricultural R&D spending that is greater than the minimum target for Africa of 1 per cent of agricultural GDP (figure 28). Nevertheless, it needs to further increase its agricultural R&D spending.

Figure 28

Share of agricultural R&D in agricultural GDP in African countries
(Percentage)



Source: Stads et al. (2021).

A notable area of innovation in Botswana is the Botswana Animal Identification and Traceability Scheme (BAITS). An ICT-based method of tracing livestock, including elements of ownership, movement, animal slaughter and areas of production, BAITS, was introduced in 2001 in response to concerns in overseas markets of traceability of Botswana's beef. It has since been improved to include electronic permits and linking of bolus and analogue ear tags.[37] Some of the challenges faced by the use of bolus are possible lack of sustainability due to extreme dependence on the Government, delays in updating of the central database with data from field offices, problems associated with recycling, lack of visual identifiability of the cattle and extreme resource demands (Modisa, undated).

6.3 Institutional actors

The Ministry of Agriculture is the apex public institution responsible for agricultural transformation in Botswana. It is responsible for developing and coordinating the implementation of agricultural policies covering R&D, technology development and extension services.

[37] A bolus is an implant in the rumen of an animal that can be used to release medicines, or to track different parameters in real time for prevention and herd management purposes.

Table 18
Institutional actors in the agricultural sector

Organization	Functions
Department of Animal Production	Ensures competitiveness of the livestock sector, and skills and technologies transfer relating to various animal science disciplines.
Department of Crop Production	Promotes competitiveness of the arable sector, and assists farmers in upgrading their technology applications.
Department of Agribusiness Promotion	Promotes a commercialized, diversified, sustainable and competitive agricultural sector.
Department of Veterinary Services	Provides animal and public health services in aid of prevention and control of nationally and economically important animal diseases.
Department of Agricultural Research, Statistics and Policy Development	Coordinates policy R&D and M&E of agricultural programmes. Also provides statistical information services to support a competitive and sustainable agricultural sector.
National Development Bank (NDB)	Provides financial products and services across the agricultural value chain through partnerships for development.
Botswana Meat Commission (BMC)	Purchases and slaughters livestock, and processes and sells meat and other animal products in the interests of the livestock industry.
Botswana Agricultural Marketing Board (BAMB)	Provides a market for locally grown scheduled crops such as cereals, pulses (beans) and oilseeds while ensuring availability of adequate supplies for sale to customers at affordable prices.
Botswana Vaccine Institute (BVI)	Development of livestock vaccines and diagnostic tools, and administering vaccination programmes. BVI is a major developer and exporter of foot and mouth vaccines.
National Agricultural Research and Development Institute (NARDI)	NARDI is the outcome of a merger of the Department of Agricultural Research (DAR), Botswana National Veterinary Laboratory (BNVL) and National Food Technology Research Centre (NFTRC). It is mandated to engage in needs-based research, innovation and technology transfer.

6.4 Challenges and priorities

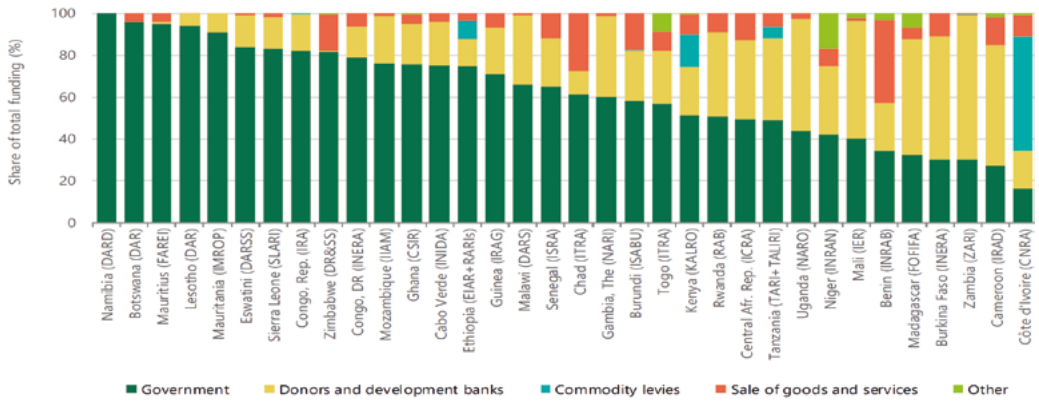
Botswana's agricultural sector faces many challenges to its food security. Given the country's largely arid to semi-arid climate, crop farming is confined to only a small area of about 2,500– 3,800 sq. km. on the eastern and northern margins of the country, and, owing to the low and erratic rainfall, crop yields (particularly cereals) tend to be poor. Besides water scarcity and perennial droughts, other impediments to food security include poor infrastructure, poor soils, animal and plant diseases and pests, a relatively weak extension system, low uptake of modern technologies, limited engagement of the private sector and weak institutional coordination of the various departments and parastatals under the Ministry of Agriculture (World Bank, 2020 and Bahta et al., 2017).

Botswana's chronic water shortages are a major contributor to food insecurity and poverty. They frustrate both subsistence and irrigated farming in most parts of the country, resulting in significant segments of the population facing food insecurity. Research in water smart technologies and water-resistant crops is urgently needed to boost production and reduce extreme poverty, particularly in rural areas.

Funding for agricultural R&D emanates mostly from government sources as does most training (figure 29). This means that R&D sustainability is largely determined by the strength of the Government's fiscal position, making it vulnerable to declines in government finances.

Figure 29

Share of different funding sources in total agricultural R&D funding in Botswana and other African countries
(Percentage)



Source: Stads et al. (2021).

Owing to the poor performance of the agricultural sector, the National Policy on Agricultural Development changed its goal from food self-sufficiency to food security in 1991, with a focus on access to food at affordable prices, irrespective of source and origin. This policy shift led to the removal of trade-restricting border measures in the grain industry, leading to increases in food imports. Currently, the country imports about 90 per cent of its national food supply (Government of Botswana, 1991).

Weak institutional linkages within and between the Ministry of Agriculture and other ministries, particularly the Ministry of Education and Skills Development and the DRST, and weak synergies among the various university programmes for agricultural R&D and innovation, continue to deny the country the opportunity to target its scarce human and financial resources to STI priority areas that would transform agriculture to boost food and nutritional security.

The lack of inter-agency coordination of most public agricultural R&D agencies that are under separate ministries or administrative units, leads to duplication of research efforts and wasted resources. While some stakeholders believe that the DAR's performance would be improved if it were turned into a parastatal body, a proposal to that effect in 2011 was rejected by the Ministry of Agriculture.

Related to weak institutional linkages is the lack of a comprehensive national agricultural research and innovation strategy or plan. There is no approved national plan setting specific research and innovation priorities in agriculture. Consequently, various institutions determine their own research priorities, which are largely influenced by sources of funding. A clear picture of the status of agricultural R&D is not possible because there are many small initiatives scattered across the institutional terrain.

However, there is considerable potential for the agricultural sector to contribute more to Botswana's economic diversification and industrial transformation. Botswana could diversify crop production and increase agroprocessing of cereals such as millet and sorghum for domestic and external markets. Millet and sorghum are drought-resistant crops with high potential for small-scale agroprocessing, but so far they are the focus of only very few scalable R&D activities. Although BUAN plans to focus on these cereals in its long-term research plans, there is no indication of a budgetary allocation for this.

The NDP 11 mid-term review identifies climate-smart agriculture as a priority for future investments. In line with existing national policy, food imports will continue to play an important role in ensuring national food security. To address low levels of crop production, the Government is reviewing its Integrated Support Programme for Arable Agriculture Development (ISPAAD) to examine its impact on productivity, contribution to value addition in agriculture and cost-effectiveness (MOFED, 2018).

The Ministry of Agriculture appreciates the potential of frontier technologies to provide technological solutions for agricultural transformation. Accordingly, it plans to launch new activities focusing on the use of digital technologies, AI and drones in agriculture, for example using drones for irrigation and seed distribution.

Smart Botswana plans to implement activities to improve agricultural production through 4IR. An example is the Lubu Small Stock Project. Lubu Farm will be remodelled and upgraded to incorporate smart technologies in production, management, precision livestock farming, environmental management, farmer capacity- building and training, animal health and welfare monitoring, sustainability and competitiveness of the farm, information management systems and farm sustainability (Smart Botswana, undated: 6).

In biotechnology, the University of Botswana, the BIUST and BUAN offer undergraduate and postgraduate courses on various aspects of the technology. The University of Botswana's Department of Biological Sciences is collaborating with Pfizer's Vaccine Development Institute in the United States, and locally with the Botswana Vaccine Institute (BVI) and the Botswana National Veterinary Laboratory (BNVL) to develop vaccines for cattle lumpy skin disease (Batlang et al., 2014).

6.5 Recommendations

Develop a national agricultural/food research and innovation strategic plan to harness STI in transforming Botswana's agricultural sector so as to achieve food and nutritional security goals (SDG 2). A national agricultural research and innovation strategic plan that incorporates food and nutritional security considerations and establishes agricultural research and innovation priorities would provide clear directions for RSTI in agriculture.

Strengthen the agricultural innovation system by bringing together the relevant actors to systematically foster agriculture and food security, recognizing the nexus of agriculture/food with water and energy, and health and the environment. Education also has a role to play in providing appropriately skilled personnel. It would be beneficial to consider the food/agriculture innovation system as an organizing mechanism.

Encourage collaboration between BUAN and NARDI as the two most important agricultural research groups. Their activities appear to be complementary with focused expertise in agriculture and food. Incentives should be considered to encourage their collaboration on research, field tests and education and training.

Private sector investment in agricultural R&D is lagging significantly in Botswana. Policymakers should consider ways to incentivize the private sector to invest in agricultural R&D, including training.

Chapter 7. Health and well-being

Good health and well-being are necessary for economic development as envisioned in Vision 2036, while also fulfilling SDG 3, but they have been compromised by major pandemics in recent years. HIV/AIDS and Covid-19 are prominent global pandemics that have posed significant local socioeconomic, political and fiscal challenges. National health is given high priority in Botswana, with health-related R&D accounting for the largest sectoral area of investment (see chapter 2). Nonetheless, building STI capacity to effectively address pandemics needs to be given greater priority. To tackle lifestyle and non-communicable diseases, Botswana has a pluralistic and comprehensive health-care system comprising public and private institutions while traditional medical practices are also present. At the apex of its health-care services, Botswana has three referral hospitals, followed by several district hospitals, primary hospitals, clinics, health posts and mobile health stops (MoH, 2011).

Botswana has a comprehensive policy framework for health-care provision, underlined by the National Health Policy (MoH, 2011). The policy outlines governance arrangements for health-care services, recognizes the need for a multisectoral approach encompassing the public, private and non-governmental sectors, as well as indigenous medical practices. The Essential Health Service Plan details promotional, preventative, curative and rehabilitative interventions to guide how health-care services may be provided at various levels (primary, secondary and tertiary) (MoH, 2010). The Medicines and Related Substances Act of 2013 establishes the Botswana Medicines Regulatory Authority to regulate medical devices, cosmetics and medicines.

Botswana has an E-Health Strategy to leverage health-care technology. It establishes e-health services for health-care services delivery, governance arrangements and resource mobilization. The strategy has resulted in implementation of a Digital Communication Platform in several hospitals to provide health education and raise patients' awareness about health matters while in waiting rooms. The strategy also leverages ICT connectivity through the Integrated Patient Management System (IPMS), which has been implemented in 28 hospitals and 23 clinics (MoHW, 2020).

The following are some indicators of health and wellness in Botswana:

- Ninety-six per cent of the population live within an eight-kilometre radius of a health-care facility.
- The doctor-to-patient ratio is 5.27 per 10,000 (i.e. lower than the World Health Organization's recommended 10 per 10,000 of the population).
- Life expectancy is 68 years for women and 64 years for men.
- In 2018, at the time of the mid-term review of NDP 11, 20.3 per cent of adults lived with HIV/AIDS, an improvement from 25 per cent in 2013.
- An important measure in mitigating the prevalence of HIV/AIDS in Botswana was the 2016 Treat All Policy adopted by the Government to offer anti-retroviral treatment to all HIV/AIDS carriers.
- The tuberculosis (TB) notification rate declined from 280 per 100,000 in 2015 to 218 per 100,000 in 2017. Even though this is below the Government's 260 per 100,000 target, the 9 per cent mortality rate amongst TB patients remains high.
- The maternal mortality rate fell from 156.6 deaths per 100,000 live births in 2016 to 143.2 per 100,000 live births in 2017. However, this is higher than the target of 105 deaths per 100,000 set in 2017 (MOFED, 2020).

7.1 Challenges from Covid-19 and other pandemics

The effect of Covid-19 spread far beyond the health sector to create a national economic crisis. The pandemic led to restrictions on movements of people, negatively affecting tourism, which is the second highest foreign exchange earner for the economy. The huge domestic economic and social shocks created by Covid-19 had negative effects on mining, manufacturing, tourism, personal services and other sectors (UNDP, 2020).

Botswana recognizes the importance of building national capabilities, including STI capabilities to manage pandemics such as HIV/AIDS and Covid-19, as a matter of national importance. HIV/AIDS and Covid-19 are Botswana's most serious pandemics since it gained independence. After its first case of HIV/AIDS was discovered in 1985, the country became the worst affected in the world: high morbidity, absenteeism and productivity loss were felt across the entire economy and all communities (Greener et al., 2000). Over time, Botswana has built national capabilities to respond to HIV/AIDS, which were leveraged to also address health challenges created by Covid-19 in 2020. Botswana's response included building coalitions with private and non-governmental organizations, along with other public policy interventions, such as introducing mask mandates, contact tracing, restrictions on travel, economic support measures, creating a multidisciplinary National Covid-19 Task Team, and rapid adoption of health technologies developed internationally and transferred to Botswana, most notably vaccines.

To combat the Covid-19 pandemic, data collection and information-sharing were prioritized, digital technologies utilized and local scientific capacity leveraged. The Ministry of Health collaborated with stakeholders to develop a publicly available online dashboard for monitoring progress on Covid-19 vaccinations and infection rates, and launched online registration for movement permits to facilitate movements for individuals, businesses and government employees in essential services. Data were collected for tracing new variants. to Digital means were also established for online vaccination registrations, and the Ministry implemented a vaccine stock management system at facility, district and national levels.[38] Controversial issues of data sharing versus data protection had to be dealt with.

7.2 Challenges in E-Health

The e-Health Strategy of Botswana has multiple goals. They include increased access to timely, accurate and complete reporting on health system activities and outcomes; enhanced quality, safety, efficiency and effectiveness of clinical services; efficient patient management practices, including monitoring, and affordable health-care provisions for communities (MoHW, 2020).

According to the mid-term review of NDP 11, Botswana's challenges in e-Health include the following:

- Inadequacy of data collection by health-care providers in the public, private and non-governmental sectors. To address this challenge, the mid-term review recommended closely coordinating the M&E systems of the health facilities in all three sectors. As the public sector has several levels of health care, there is an urgent need to address this challenge.
- Lack of data for national disease surveillance.
- Shortcomings in national ICT infrastructure.
- Constant changes in leadership that hinder a sustained momentum of e-health implementation.

[38] See: https://www.go2itech.org/2021/05/i-tech-develops-covid-19-vaccine-registry-in-botswana/.

- Fragmented information systems at the facility level (i.e. referral, district, primary, clinics and mobile health stops) and by sector (private and public).
- Limited human resource capabilities such as health informatics specialists, biostatisticians, monitoring and evaluation, epidemiologists and data technicians.
- Non-implementation of an Information Age Council announced in the 2018 National Broadband Strategy to provide oversight of national ICT implementation.

7.3 Research and innovation status and trends

Botswana's per capita publications on health and well-being are among the highest in Africa, at 784.8 per million inhabitants compared with research-intensive jurisdictions such as Kenya, with 294.8 per million inhabitants. The number of R&D personnel per million inhabitants is 570, which is higher than in other sub-Saharan African countries, and second only to Kenya's 1,029 (table 19). While the country's relatively low population may partly explain this outcome, it suggests that sufficient attention is being paid to R&D training in health (Juma et al., 2021).

Table 19

Health R&D indicators for Botswana and other selected countries

	GDP per capita (US$ 2016)	Number of publications per million inhabitants	Total R&D personnel per million inhabitants	GERD as a percentage of GDP
Botswana	6 924	784.8	570	0.57
Kenya	1 455	294.79	1 029	0.79
Uganda	580	198.85	42	0.17
Zimbabwe	1 270	166.23	129	0.28

Source: Juma et al. (2021).

While information on ongoing health research in Botswana is scanty, there are various important collaborations in innovation in the country's health-care system. Notable among these are the Botswana Harvard AIDS Institute Partnership, which monitors regional changes in HIV/AIDS, HIV/AIDS isolation and cultures. In late 2021 researchers at the Partnership laboratory helped identify the Covid-19 Omicron variant.

7.4 Institutional actors

Botswana's health-care system includes public, private and non-governmental institutions (table 20). The Ministry of Health oversees health-care delivery, policy leadership and oversight (MoH, 2011).

Table 20

Health sector institutional actors

Institutional actors	Functions
Department of Policy Planning, Monitoring and Evaluation	Provides health policy planning, research and information management services to other departments.
Management Information Systems	Oversees building of the information technology infrastructure, and M&E of the Ministry of Health's ICT projects.
Health Policy Planning Department	Coordinates formulation, review and dissemination of health policies and strategies.
Department of Monitoring and Evaluation	Oversees establishing and coordinating national health-care services' M&E systems.
Traditional healers	Custodians of traditional medicine.
Botswana Health Professionals Council (BHPC)	Sets standards for training and monitoring of adherence to set standards of practice.
Botswana Medical Regulatory Agency (BOMRA)	Regulates health-care sector professionals, and ensures that the medicines used conform with quality, safety and efficacy standards.
Sir Ketumile Masire Teaching Hospital	A University of Botswana faculty for medical education, research and clinical services.
Institutions of Health and Sciences (IHS)	These are college-level institutions owned and run by the MoH, affiliated to the University of Botswana, and accredited through the Botswana Qualifications Authority. They offer courses in nursing and other health-care programmes, pharmacy technicians, general nursing, community health nursing, and midwifery.
Botswana Harvard AIDS Institute Partnership	A research collaboration between the Ministry of Health, and the Harvard Chan School of Public Health. It undertakes research and training in HIV/AIDS, and capacity-building in areas of clinical and basic science, epidemiology, socio-behavioural science and community-based bioclinical research relating to the HIV/AIDS epidemic, emerging public health challenges in Botswana as well as in sub-Saharan Africa and globally.
The Africa Comprehensive HIV/AIDS Partnerships (ACHAP)	A partnership between Harvard University and the Government of Botswana, it is funded by the United States President's Emergency Plan for AIDS Relief. Its mandate is capacity-building in Botswana to respond to HIV/AIDS. It also provides consultancies and technical support to other African countries.
The Botswana Baylor's Children Clinical Centre of Excellence (Botswana Baylor)	A public-private partnership between the Government and Baylor College of Medicine's Baylor International Pediatric AIDS Initiative, it provides medical services for children, adolescents and young adults.

7.5 STI challenges and opportunities in health care

Health-care research in Botswana has the advantage of the existence of collaborative arrangements with well-funded institutions with international exposure. This gives Botswana the opportunity to be at the frontier of global research. A major challenge is the weak coordination between these institutions, the Ministry of Health and the DRST. Furthermore, studies carried out in Botswana at the behest of global collaborative arrangements tend to prioritize donor requirements, including the IP requirements of those institutions.

The e-Health Strategy offers great opportunities to enhance health-care delivery in Botswana. Matters that need to be addressed include inadequate leadership and the governance structures responsible for digitization in general, including in e-health. In part, these are due to the high turnover of political leadership, particularly ministers (through cabinet reshuffles), permanent secretaries and senior ministry staff. This is accentuated by fragmentation of Botswana's multilayered systems of health care: referral, district and primary care. Also multiple visions of what e-Health should entail have delayed realization of the potential opportunities it offers. In addition, there has been suboptimal implementation of the Internet-of-things (IoT) concept due to limited use of mobile technology and low capacity of mobile networks.

7.6 Recommendations

Continue building national capacity for managing pandemics, based on learning from the HIV/AIDS and Covid-19 pandemics, to respond to future pandemics and regional disease outbreaks, which are expected to be more frequent. Covid-19 showed that the cost of unpreparedness is extremely high. Building national capacities will help protect future health, prosperity and well-being.

Consider how to optimize the advantages of digitalization and digital technologies in the health sector. This is delicate, as health information is sensitive and privacy of health data is a major public concern. A national data policy should address this issue. Using AI and big data in health will also be facilitated by digitizing health information.

In order to promote an e-health system in Botswana, and reap the benefits of related technologies, the country needs to increase investment in infrastructure and last-mile Internet connectivity to provide Internet access to all parts of the country. While the Universal Access Service Fund is an important instrument for enhancing connectivity, there needs to be increased investment in health care.

Botswana's e-health readiness requires realistic investments, as existing facilities demonstrate different levels of readiness for e-health. For example, older facilities should be upgraded for improved e-health readiness, and more training provided to equip health-care professionals with basic skills.

Chapter 8. Inclusive growth and social development

While Botswana has enjoyed sustained economic growth, this was mainly due to the consistent contributions of a highly capital-intensive mining sector (Acemoglu et al., 2001)**.** Worryingly, poverty and inequality remain high for a middle-income country (UNDP 2021). STI to address inequality (including gender inequality) and support more inclusive economic development could therefore make an important contribution to progress towards the achievement of SDGs 5 and 8.

8.1 Women and girls in STEM: Status and challenges

There is a shortage of young women and girls in the science, technology, engineering and mathematics (STEM) disciplines in Botswana – partly due to a lack of role models in those disciplines – as well as in politics and business. Girls also have disproportionate social obligations that force them to drop out of school. Furthermore, Botswana does not have a national policy to prepare young people for STEM disciplines. Most initiatives are activity based, lacking in both coordination and resource mobilization strategies (Koketso, 2015; also see chapter 1 and figure 8).

However, some institutions champion STEM education. Notable examples are the Women in STEM (WiS) initiative and the Organization for Women in Science in the Developing World (OWSD).[39] WiS focus areas seek to empower women in STEM disciplines, involve men in resource-sharing, and engender project collaborations through training, events and collaborative activities. The main partners in WiS are the BIUST and the Development in Africa with Radio Astronomy (DARA) Programme. DARA is a joint UK-South Africa Newton Fund human capital development project that aims to develop high tech skills using radio astronomy in several African countries. OWSD, affiliated with UNESCO, is a multidisciplinary institution with a global reach that provides science research and training opportunities for women in developing countries.

8.2 Youth employment

While youth comprise the single largest demographic group in Botswana, youth unemployment is a critical policy challenge. Many factors contribute to youth unemployment, including:

- Unfavourable geographical location: urban youth are more likely to find jobs than rural youth.
- Education: the better educated are more likely to find jobs than the less educated.
- Jobless growth: Botswana's growing economy is unable to create new jobs at a rate comparable with the growh rate.
- Capacity constraints: young people's businesses are not competitive due to multiple shortcomings, including skills and financing.
- Gender: young women are less likely to find jobs than young men (Diraditsile, 2020; Diraditsile and Nthomang, 2015; Gaetsewe, 2019).

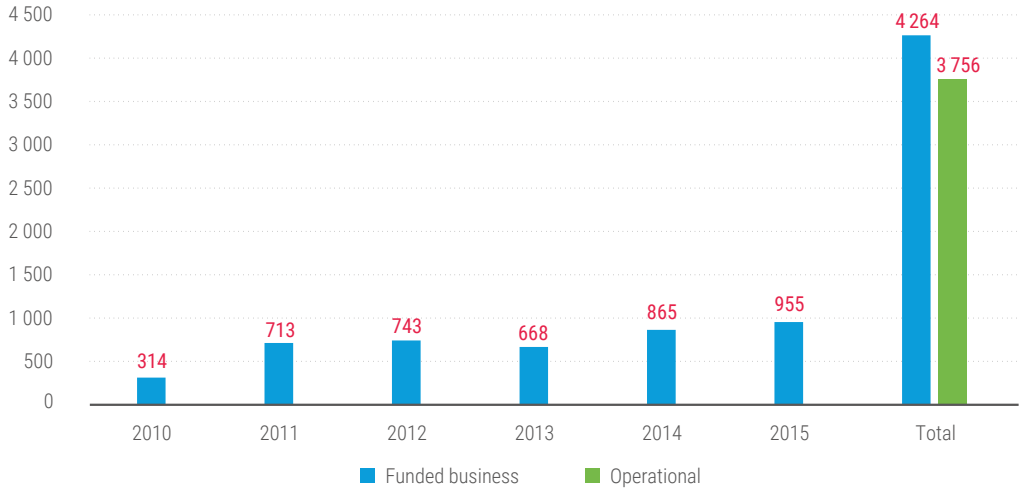
The Government has some policies and initiatives aimed at addressing this problem, including the Youth Policy of 1996 (revised in 2010), the Out of School Youth Grant (2001), the Youth Development Fund (2009), the Youth Empowerment Scheme (2012), the National Internship Programme (2009), the Botswana National Service Programme (2014) and the Graduate Volunteer Scheme (2015).

[39] Source: https://owsd.net/news/news-events/new-national-chapter-owsd-established-botswana (accessed 18 Sept. 2022).

The Youth Development Fund (YDF) targets 18–25-year-old youth in Botswana by funding their business concepts. Half of that funding is a grant and the remainder consists of an interest-free loan. Figure 30 shows the number of surviving YDF-funded projects during the period (2010–2015). Of the total of 4,264 funded projects between 2010 and 2015, only 3,756 were still operational in 2015 – a success rate of 88 per cent.

Figure 30

Performance of the Youth Development Fund, 2010–2015
(Number of projects)



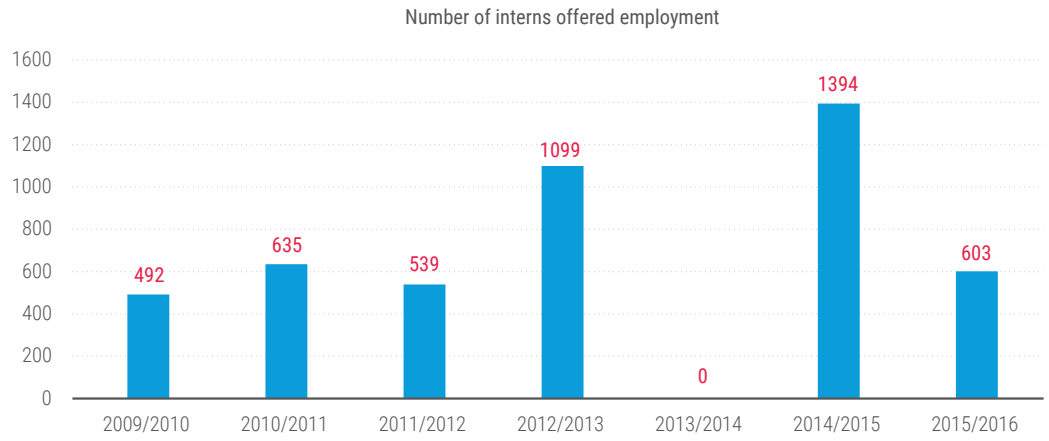
Source: MOFED (2017).

The Young Farmer Fund (YFF) provides financial subsidies to aspiring young farmers (18–25-year-old). Applicants must demonstrate that they have the relevant training and they need to prepare a fundable proposal. It is administered by the Citizen Entrepreneurial Development Agency, and targets diploma and degree holders.

To equip youth with on-the-job skills, the Graduate Volunteer Scheme (GVS) of 2015 targets unemployed graduates. An amount of 600 Botswanan Pula is available to recipients to cover meal expenses. Figure 31 demonstrates the performance of the GVS from 2009 to 2016.

Figure 31

Number of interns offered employment under the Graduate Volunteer Scheme, 2009–2016



Source: MOFED (2017).

Youth unemployment schemes have a number of deficiencies, including a lack of affirmative action. Without deliberately targeting vulnerabilities like disability or gender, such schemes are unlikely to succeed. In addition, they suffer from a shortage of qualified, experienced staff in ministries, lack of impact assessments and lack of commitment by some project managers (Diraditsile, 2020).

8.3 People with disabilities and the elderly

People with disabilities and the elderly face particular challenges, such as mobility issues, and political and economic exclusion, which require targeted policy interventions. While Botswana has not adopted a legal framework to address the needs of people with disabilities, the National Policy on Care for People with Disability recognizes the need to protect the rights of such people, and recommends a multisectoral approach (Republic of Botswana, 1996).

According to the Botswana Multitopic Household Survey Report of 2015–16, a total of 56,555 individuals, or about 3 per cent of the population, reported living with some form of disability. Of these, 4.7 per cent were women and 3.7 per cent were men (Statistics Botswana, 2018).

In 2016–2017, a Disability Cash Grant (DCG) was launched. This monthly cash transfer aims to enhance the well-being of people living with disabilities by catering to their special needs, cushioning families, especially care-givers, from the effects of poverty, and enhancing their social and economic inclusiveness. Since its introduction, access to the DCG has been growing steadily. By 2018–2019, 6,583 of the 7,282 registered beneficiaries (or 90 per cent) were able to access the service (table 21)(MOFED, 2020).

Table 21

Performance of social protection programmes during NDP 11

	2016-17 (Baseline)		2017-18		2018-19	
Programme/ Service	Registered beneficiaries	Supported beneficiaries	Registered beneficiaries	Supported beneficiaries	Registered beneficiaries	Supported beneficiaries
Destitute Persons	35 366	35 366	36 513	36 513	37 934	37 934
Community Home-Based-Care (CHBC)	1 313	1 313	1 262	1 262	1 218	1 218
Old-Age Pensioners (OAPs)	108 499	95 649	109 454	103 726	116 884	110 896
Disability Cash Transfers (DCT)	5 528	4 709	6 231	5 386	7 282	6 583
World War II Veterans (WWIIV)	1 735	1 569	1 486	1 396	1 375	1 349

Source: MOFED (2020).

Institutional arrangements for people with disabilities involve both governmental and non-governmental organizations. The Coordinating Office for People with Disabilities (COPD) in the Office of the President coordinates national policy measures for them. The Department of Social Support in the Ministry of Local Government and Rural Development provides social protection services, including for people with disabilities. The Botswana Council for the Disabled (BCD) is the umbrella body for NGOs that provide services for people living with disability.

Botswana's retirees are entitled to claim retirement benefits through their respective pension schemes. The Botswana Public Officers' Pensions Fund (BPOPF) provides pensions for civil servants and other public officers, while the Old Age Pension (OAP) Scheme is a non-contributary scheme available to all citizens from 65 years of age onwards. There is also a World War II Veterans Scheme. In 2016–2017, 108,499 beneficiaries were registered under the OAP, with 95,649 accessing the programme – an access rate of 88 per cent (table 20). By the year 2018–2019, the programme supported 110,896 pensioners out of 116,884 registered beneficiaries, representing an access rate of 90 per cent (MOFED, 2020). Similarly, for World War II Veterans, in 2016–2017, 1,569 of the 1,735 registered beneficiaries accessed the scheme, which is a 90 per cent access rate. By 2018–2019, 1,349 of the registered 1,375 accessed the programme which translates to a 98 per cent access rate.

8.4 STI Opportunities and challenges

Social science research into poverty, livelihoods and rural development has matured, led by the BIDPA and the University of Botswana. Both institutions should consider how science and technology may further assist in reducing poverty and improving livelihoods as a matter of priority.

Another initiative, Smart Switch has potential to improve the efficiency of service delivery. It provides cash transfer and wage payment transfers to destitute people, HIV/AIDS sufferers, and unbanked populations, reducing the burden on them to access services. The system interfaces with the national civil registration system which administers the national identity card (Hulela, 2012).

Technology can also improve the coordination of schemes, as exemplified by the Single Social Registry (SSR). The SSR was conceived to assess implementation of social protection programmes in Botswana. It will consolidate social protection information in a single database by allowing district councils to directly upload information about programmes (MOFED, 2020b).

A major challenge is the pervasive lack of reliable, usable data in Botswana, which renders M&E difficult, and policy decisions cannot be based on objective data.

8.5 Recommendations

Formulate a national strategy for promoting STEM disciplines and increase access to STEM disciplines amongst young women and girls. The Government and the private sector need to improve the visibility of women role models at various levels of learning.

Increase the capacity of the Single Social Registry to improve the efficiency of Botswana's social welfare programmes through more investments in ICT infrastructure. And providing training to council staff in basic ICT operations to manage the SSR databases in local authorities will contribute to successful implementation.

Continue to explore the capacity of digital technologies to deliver services to people with disabilities, the elderly and the underprivileged. An example is the Pula Card, a Visa-accredited automated prepaid card which caters to unbanked citizens, particularly those living in rural areas.[40]

[40] Source: https://www.gov.bw/allowances/pula-card (accessed 18 Sept. 2022).

Chapter 9. Sustainable tourism

Tourism is Botswana's second largest foreign exchange earner after diamonds. It contributes both directly and indirectly to the economy, including through building allied infrastructure such as hotels, motels and airstrips, and has established backward linkages such as retail businesses that supply the hospitality industry (Stone et al., 2017). Prior to the effects on tourism of Covid19, Botswana's tourism sector was experiencing growth in important indicators, although its share in GDP declined steadily, from 3.6 per cent in 2012, to 3.4 per cent in 2014 and 3.3 per cent in 2016, before rising to 3.5 per cent in 2018 (table 22). The gross number of tourist arrivals grew by 13 per cent, from 161,000 in 2012 to 183,000 in 2018 over the period 2012–2018. Spending per tourist remained fairly stable prior to the Covid-19 outbreak. Innovation should mitigate the impact of Covid-19 on tourism through the promotion of e-tourism products, such as virtual tours of Botswana's tourist destinations. This would be an ecologically sustainable way of promoting tourism, although its financial viability is untested.

Table 22

Tourism sector indicators for Botswana, 2012–2018

Indicator	2012	2014	2016	2018
Number of tourists	1 610 000	1 970 000	1 710 000	1 830 000
Receipts (millions of dollars)	515.6	529.3	505	584.2
Share in GNP (percentage)	3.6	3.4	3.3	3.5
Average spending per tourist (dollars)	319	269	295	319

Source: https://knoema.com/atlas/Botswana/topics/Tourism (accessed 18 Sept. 2022).

According to the mid-term review of NDP 11, important policy challenges to tourism are:

- Ensuring ecological sustainability;
- Diversifying the tourism product;
- Engaging more citizens in the sector; and
- Extending infrastructure development to enhance the tourism product (MOFED, 2020a).

During NDP 10, (2009-2016) Botswana aggressively attempted to diversify its tourism product, adding several events to the tourism calendar. These included the Khawa Dune Challenge and Cultural Festival, Toyota 1000 Desert Race, the Makgadikgadi Epic and Race for Rhinos. ICT initiatives aimed at diversifying the tourism product included Virtual Botswana Travel and Tourism Expo, Virtual International Tourism Bourse and the Botswana Live Virtual Tours Campaign (MFDP, 2013).

9.1 Research and innovation in tourism: Status and trends

An important player in Botswana's tourism sector is the Okavango Research Institute (ORI). A faculty of the University of Botswana, it specializes in research on tourism and ecology, particularly in the Okavango Delta, encompassing studies on ecological vulnerability and livelihoods. The ORI provides the tourism sector in Botswana with information for evidence-based decision-making.[41]

Recognizing the critical opportunities offered by ICTs, the Botswana Communications Regulatory Authority promoted increased investment in ICTs in the tourism sector. In 2013, it studied the quality of service of tourism and hospitality establishments in the country. The resulting Guidelines on Minimum Requirements on Internet Connectivity in the Hospitality Industry now set the standard for Internet connectivity in the sector (BOCRA, 2014).

9.2 Institutional actors

Organizations in the public, private and non-governmental sectors are engaged in Botswana's tourism sector.[42] The Ministry of Environment and Tourism oversees tourism development, protection of natural resources, conservation and promotion of a sustainable environment.

Table 23
Institutional actors in the tourism sector

Institution/department or parastatal	Functions
Department of Tourism	Manages and promotes tourism development in Botswana. This includes policy formulation, M&E, and strategies to ensure sustainable tourism.
Department of Wildlife and National Parks	Manages Botswana's fisheries and wildlife in line with global standards.
Department of National Museum and Monuments	Protects, promotes and preserves Botswana's cultural heritage for sustainable utilization, and collects research data.
Botswana Tourism Organization	A statutory organization marketing Botswana's tourism internationally, and domestically, licenses tourist operators and grades tourism facilities.
The Okavango Research Institute	A University of Botswana faculty that researches wetlands and adjacent drylands and generates scientific knowledge about the Okavango Delta.[a]
Hospitality and Tourism Association of Botswana	The umbrella body for hospitality and tourism businesses in Botswana, it enforces codes of conduct among members, which include hotels, air services, travel operators and safari lodges.[b]
Statistics Botswana	Collects and disseminates statistics and coordinates the National Statistics System. It plays a key role in the compilation of the Tourism Statistics Annual Report in collaboration with the Ministry of Labour and Home Affairs.[c]

Source: https://cms1.gov.bw/ministries/ministry-environment-natural-resources-conservation-and-tourism.

Notes: [a] See https://www.ori.ub.bw/about-ori); [b] see https://www.hatab.bw; [c] see https://www.statsbots.org.bw.

9.3 STI challenges and opportunities

[41] Source: https://www.ori.ub.bw (accessed 12 Dec. 2021).

[42] See: https://cms1.gov.bw/ministries/ministry-environment-natural-resources-conservation-and-tourism.

Tourism-related STI challenges arise from the need for information-sharing between tourists and tourism operators. They include:

- Lack of relevant marketing tools by communities, resulting in lost opportunities for tourism-related development.
- Need to improve connectivity to tourist destinations to enable tourists to stay connected with their places of origin when in Botswana.
- Diversification of the tourist product through enhanced use of ICTs.
- Inadequate tourism data, as most data are predominantly produced for arrivals, and seldom show the amounts of money spent on tourism activities.
- Lack of information on domestic tourism, leading to undercounting of the contribution of tourism to GDP, employment and other economic indicators.
- Inadequate infrastructure including air transport, ICTs and road infrastructure networks. Air Botswana remains the only domestic scheduled airline.
- Low citizen participation in the tourism value chain.
- Overdependence on international tourists for tourist receipts (Stone, 2014; Mbaiwa, 2004).
- Misappropriation and mismanagement of funds by communities engaged in tourism projects, especially community-based (tourism) trusts, due to the lack of appropriate skills for financial management (Mbaiwa, 2004, cited in Stone et al., 2017).

9.4 Recommendations

Tourism marketing should focus on creativity based on strong design skills. Marketing tourism destinations cannot be limited to traditional presentations of Botswana's selling points concerning pricing, peace and tranquility, or the abundance of wildlife. Creativity in designing stimulating advertisements and other online material is key. Design is an important technical skill related to engineering that is often overlooked.

To reach all demographics, particularly younger people, Botswana needs to fully exploit the use of ICTs and social media. Mobile phones, rather than computers, have become critical technological instruments for tourism promotion. Therefore Botswana Tourism Organization (BTO) should collaborate with universities to market Botswana as a destination through mobile devices. The rise of mobile technologies does not necessarily supplant computers. Interoperability is needed between marketing and ICT systems, which can be promoted by the BTO, Hospitality and Tourism Association of Botswana and other stakeholders.

Aggressively pursuing e-tourism also needs to consider promoting environmental awareness and conservation. E-tourism should help mitigate negative ecological impacts in Botswana. This requires good software engineering and design skills.

Chapter 10. Sustainable and inclusive mining and industrialization

As Botswana's mining sector matures, the urgency to industrialize the economy has grown. The mining sector has historically underpinned economic growth and contributed heavily to GDP (table 24). However, while mining remains the greatest source of export revenue for Botswana, its contribution to GDP continues to decline relative to non-mining GDP.

Table 24
Contribution of mining to the economy, 2016–2018

	Diamonds	Copper	Coal	Soda Ash	Other mining & prospecting	Total	Share of GDP
2016	31,300	882	336	1,169	1,288	34,913	20.5%
2017	28,673	33	472	826	1,303	31,262	17.4%
2018	28,301	41	555	803	1,402	31,066	16.4%

Source: Ministry of Finance (2020a).

Manufacturing is important for industrialization, and enhanced manufacturing capacity will contribute to economic diversification and export diversification. Botswana has several policies and strategies aimed at promoting industrialization. Foremost among these is the Industrial Development Policy (see chapter 4) and the National Industrial Upgrading and Manufacturing Programme (IUMP). The IUMP supports industrialization of agro- and food-processing, processing of minerals, production of chemicals and pharmaceuticals, leather and leather products, machinery, and machinery and equipment. It also supports fisheries and services, among others.

However, industrialization has been slow for several reasons. These include low productivity and the high cost of local production, which impede competitiveness. Botswana's regulatory framework also stifles industrialization. Besides the continued existence of legal monopolies in fairly competitive sectors, there is a lack of competitive neutrality, which hinders competition and innovation.

10.1 Research and innovation in mining: Status and trends

Interviews with key stakeholders and some documentary evidence revealed that technological innovation in Botswana's mining industry takes place mostly through imported solutions. As an illustration, some of the key factors contributing to Debswana's competitiveness, include its enablement of integrated operations, predictive maintenance, autonomous operations, planning and implementing transformation of the workforce of the future.[43] In 2020, the company launched its Strategic Plan 2020–2024 (Debswana, 2020). One of the plan's six strategic leverage areas is to gain a technological edge, which aims to make the company "an innovative driver for new technology in the diamond mining and processing space". Interviews during the preparation of the Botswana STI Foresight Report conducted by UNCTAD in Botswana as part of the STIP Review project revealed that Debswana is aggressively adopting frontier technologies, including the use of smart drills, software analytics, data analytics and machine learning.

[43] Debswana Diamond Company (Pty) Limited (Debswana) was established in 1969 and is one of the world›s foremost diamond producers by value and volume. Debswana is an equal partnership between the Government of the Republic of Botswana and the De Beers Group of Companies.

10.2 Institutional actors

The Ministry of Minerals and Energy (MME) has the overall responsibility for promotion, oversight and coordination of policy design and implementation in the areas of mineral development and regulation of mining activities. This includes promoting the production and use of environmentally sound technologies, such as renewable technologies, and overall promotion of sustainable energy sources in Botswana.

Table 25
Institutional actors in the mining sector

Institution	Functions
Department of Mines	Licenses and monitors adherence to licensing conditions by holders of prospecting licences.
Botswana Geoscience Institute	Its mandate is to strengthen capacity for research and innovation in geosciences, and to provide specialized services in geoscientific services.
Debswana Diamond Company	Debswana is one of the largest diamond miners in the world.
Minerals Development Company of Botswana	A mining investment holding company that is mandated to hold and develop all of Botswana's current and future mining interests. Its purpose is to optimize returns to Government from its equity stakes in the mining industry, in a socially and environmentally responsible manner.
Okavango Diamond Company	A wholly government-owned private diamond marketing company.
Botswana Chamber of Mines	An umbrella body for all mining bodies in Botswana, it carries out policy advocacy, and is regularly consulted by the Government in matters related to mining.
Botswana International Trade Centre	Promoting and attracting FDI, and managing the Botswana Brand.
Business Botswana	An association of employers, it focuses on promotion of private sector interests and lobbying. It co-chairs the High-Level Consultative Conference with the President of Botswana.
Ministry of Trade and Industry	Described in chapter 4.
Local Enterprise Authority	Described in chapter 4.
Competition and Consumer Authority	Described in chapter 4.
Botswana Bureau of Standards	Described in chapter 4.
Economic Diversification Unit	An organ of the Ministry of Investment, Trade and Industry, it is responsible for coordinating sources of economic growth, including ensuring that Botswana becomes self-sufficient in producing goods locally.
Companies and Intellectual Property Authority	Described in chapter 4.

10.3 Challenges and opportunities for STI in mining

While Botswana's mining economy has reached maturity, research in the sector is scant or undertaken only within companies. Innovations in mining seldom originate locally. Machinery is imported as there is no local manufacturing capacity for mining equipment.

Botswana lacks institutions of higher learning in mining. Diamond mining has reached maturity. Coal faces a global backlash resulting from an emphasis on green energy In order to diversify within the mining sector, Botswana may still focus on applications in digital sciences, and the Internet of things in mining, and on the provision of services for emerging mining economies in southern Africa, such as Angola.

Many of Botswana's mining companies are joint ventures between local companies and foreign partners. Technological innovations are adopted internally by importing those of joint venture partners. When there are possibilities for adopting and applying new technologies, those partners get first consideration, thus stifling local innovations.

10.4 Recommendations

The Government and mining companies should build Botswana's technological innovation capacities in mining. As noted, currently most technologies that are adopted relate to imported solutions, which undermines the development of local innovation.

To improve safety of personnel and productivity in the mining sector, mining companies should aggressively pursue adopting frontier technologies in mining, such as sensors and autonomous vehicles (driverless cars). For instance, driverless vehicles can sense fatigue in the driver and automatically adopt safety measures.

As Botswana advances with its goal to become a regional diamond centre, it should consider adopting blockchain technologies for diamond traceability, as buyers increasingly demand certainty as to the origins of such diamonds. Blockchain technology offers possibilities for providing such certainty by documenting the origins of such high-value resources.

Chapter 11. STI for environmental sustainability

11.1 Environmental issues and challenges in Botswana: An overview

Botswana's commitment to environmental sustainability, in general, and to sustainable management of natural resources in particular, is well expressed in Vision 2036 and various policies and related legislation. One of the four pillars of Vision 2036 aims at achieving a Sustainable Environment. This pillar includes ecosystem functions and services, sustainable utilization of natural resources, water security, energy security, sustainable land use and management, sustainable human settlements, climate resilience and disaster risk reduction and pollution and waste. This aspiration is well aligned with environment-related SDGs, concerning for example resource management, access to and quality of water, sustainable cities, responsible consumption and others and is entrenched in the National Development Plan.

The secretariat of the Convention on Biodiversity finds Botswana to be richly endowed with diverse natural resources, particularly around the Okavango Delta. The country has a species richness index of between 9.3 and 15.[44] Plant varieties are estimated to be between 2,150 and 3,000. Of these, 15 are endemic to the country and 43 are on the Red List of threatened species compiled by the International Union for Conservation of Nature (IUCN). The country has 157 species of mammals, as well as birds such as Lesser Flamingos. It has the largest remaining populations of the African wild dog (Lycaon pictus) and the largest remaining population of the African elephant (Loxodonta Africana). However, many of the animal and bird species are threatened due to habitat loss (DEA, 2016)

Botswana ranks extremely high on the biodiversity indicator in the Environmental Performance Index (EPI), which ranks countries on 32 performance indicators. The other indicators show Botswana performing at an average to poor level, with an overall ranking of 103 out of 180 countries (table 26).

Table 26

Botswana's ranking in the Environmental Performance Index, by indicator, 2020

	Ranking out of 180 countries
Overall EPI ranking	103
Environmental health	158
Air quality	168
Sanitation and drinking water	136
Heavy metals	125
Waste management	130
Ecosystem vitality	48
Biodiversity	1
Ecosystem services	31
Climate change	128
Pollution emissions	72
Agriculture	178
Water resources	106

Source: Yale Centre for Environmental Law & Policy, at https://envirocenter.yale.edu/2020-environmental-performance-index (accessed 6 July 2022).

[44] Source: https://www.cbd.int/countries/profile/?country=bw (accessed 18 Sept. 2022).

Botswana's National Biodiversity Strategy and Action Plan of 2016 provides a comprehensive assessment of the state of biodiversity and threats to species survival. One of its strategic thrusts is to develop policies and regulatory instruments for promoting conservation and sustainable use of the country's biodiversity (DEA, 2016: 32). The strategy does not have any specific targets and goals on STI, and how STI could contribute to the conservation and sustainable use of biodiversity.

Climate change is another environmental priority area for Botswana. The country is vulnerable to climate variability, and to climate change and its impacts. Its greenhouse gas (GHG) emissions are about 5 per cent, compared to an average of 4 per cent for Africa. In 2019, it was ranked 94 out of 181 countries in the Notre Dame Global Adaptation Initiative Index (ND-GAIN), which summarizes a country's vulnerability to climate change and other global challenges. Climatic change poses major challenges to farmers, such as water shortage, and exposes households to food insecurity. Due to frequent droughts, there is high livestock and wildlife mortality. This affects both agriculture and tourism, undermining economic growth and human welfare (World Bank, 2020).

Over 80 per cent of Botswana's source of electricity is coal. The power expansion plan for 2020–2040 envisages an increase in local electricity production from various sources. Reliance on coal-based electricity is a major source of GHG emissions in Botswana. In 2015, the Government of Botswana, in its nationally determined contributions (NDC), made a voluntary commitment to reduce total atmospheric GHG emissions by 15 per cent in 2030, against a 2010 base year.[45] However, Botswana's GHG emissions from coal have increased over the past 15 years. This excludes emissions from land use, land-use change and forestry. Its atmospheric emissions increased by almost 72 per cent between 2000 and 2015. The energy sector was the major source of emissions during this period (World Bank, 2020).

To respond to the challenge posed by climate change, the Government of Botswana adopted a National Climate Change Response Policy in 2019, which prioritizes several STI interventions for climate change adaptation. They include:

- Conducting R&D and use of technologies for improved water harvesting, use and irrigation;
- Promoting the use of indigenous knowledge and traditional forest management;
- Conducting research and promoting ICT for early warning systems;
- Promoting the use of climate clean technologies for water supply; and
- Promoting research on technology needs assessments, and investing in innovation for clean technologies.

While Botswana does not have an environmental research and innovation strategy, the National Climate Change Strategy for Botswana includes innovation and R&D (Government of Botswana and UNDP, 2018). However, priorities for research and innovation to achieve environmental sustainability are spread across various natural resource management and environmental policies, such as the National Climate Change Response Policy.

[45] NDCs embody efforts by each country to reduce national emissions and adapt to the impacts of climate change. The Paris Agreement (Article 4, paragraph 2) requires each Party to prepare, communicate and maintain successive NDCs that it intends to achieve.

11.2 Institutional actors

The Ministry of Environment and Tourism (MET) is the principal State agency for coordinating development and implementation of policies and programmes aimed at environmental sustainability. MET has eight departments, a parastatal and one autonomous agency (table 27).

Table 27
Institutional actors for environmental sustainability

Institution	Functions
Department of Environmental Affairs	Promotes environment-related projects for conservation and protection of the environment.
Department of Meteorological Services	Provides weather and climate information and related services for informed decision-making for sustainable development.
Department of Waste Management and Pollution Control	Prevents and controls pollution of the environment through formulation of waste management policies. Also regulates and monitors the waste sector.
Department of National Museum and Monuments	See table 23 in Chapter 9.
Department of Tourism	See table 23 in Chapter 9.
Department of Forestry and Range Resources	Charged with the conservation, protection and management of vegetation resources in Botswana and to ensure that these resources are used sustainably for the benefit of the present and future generations.
Department of Wildlife and National Parks	See table 23 in Chapter 9.
Botswana Tourism Organization	See table 23 in Chapter 9.
Forest Conservation Botswana	Administers the Tropical Forest Conservation Fund on behalf of the Ministry of Environment and Tourism, and promotes, conserves and maintains Botswana's forests.
Kalahari Conservation Society	Environmental NGO that promotes research about Botswana's wildlife resources and their conservation.

Source: Government of Botswana, website, at: https://www.gov.bw/ministries/ministry-environment-natural-resources-conservation-and-tourism.

11.3 Transition to environmental sustainability: Challenges and opportunities

There are several institutional, financial and policy challenges to a research and innovation-based transition to environmental sustainability in Botswana. Institutional challenges pertain to weak coordination between the Ministry of Environment and Tourism and the DRST, and between these agencies and other actors like NGOs.

Botswana's investments in environmental research and innovation are relatively low. Although there are no current data, some studies (e.g. Spada et al., 2019) conclude that less than 5 per cent of the total GERD is devoted to environmental R&D. The National Biodiversity Strategy and Action Plan identifies a heavy reliance on external funding as a challenge, compounded by increasing competition for domestic funding (DEA, 2016).

There are several political, policy and STI opportunities to spur the country's transition to environmental sustainability. For instance, the Parliamentary Portfolio Committee on Environment, Wildlife and Tourism as well as various NGOs are active in environmental governance, including making persistent demands on the Government of Botswana to provide frequent environmental reports. Statistics Botswana has since integrated environmental reporting in its programmes, providing environmental statistics on a quarterly basis.

Botswana's abundance of sun and wind offers an opportunity to diversify sources of energy in order to help make the transition from coal-based electricity supply and thus reduce GHG emissions. However, turning the country's electricity supply from an overreliance on coal-based sources to renewable ones will require increased investments in research and innovation, focusing, in particular, on appropriate infrastructure and other cleaner technologies.

11.4 Recommendations

The transition to environmental sustainability as envisaged in Vision 2036 and various national policies, strategies and regulations cannot be realized without making strategic investments in STI. Specific actions are needed to invest in STI-enabled pathways to environmental sustainability.

The Government should ensure alignment and coherence between STI and environmental policy measures. The review of the RSTI Policy of 2011 should include specific environmental sustainability goals and policy actions that focus on research and innovation to address high priority current and future environmental challenges. Those challenges include climate change, water scarcity, loss of biological diversity, land degradation and desertification, waste management and other priority areas of natural resource management.

A national environmental research and innovation investment plan with clearly articulated and sequenced priorities should be developed through an inter-agency mechanism. The plan should indicate specific STI projects for implementation over the medium to long term by various institutions, including universities, NGOs and research institutes.

Chapter 12. International cooperation and partnerships in STI

Partnerships or cooperation in STI are critical for developing Botswana's NIS and helping the country to leverage new scientific and technological opportunities to address its social, economic and environmental challenges. Such partnerships should enable the country to tap into the global pool of scientific and technical knowledge, engage in policy learning, leverage international funding for domestic research and innovation, exploit economies of scale from regional and international networks of research, and build local scientific and technical capabilities. Partnerships are recognized and emphasized as a means for achieving the SDGs. Specifically, SDG 17 is about building enduring partnerships to achieve sustainable development. It has provisions on partnerships for research and innovation, as well as for technology exchange and transfer.

Vision 2036 and the NRSTI Policy explicitly recognize that international cooperation and partnerships between the public and private sectors are key to achieving the country's transition to a knowledge-based and innovation-driven sustainable economy. Objective 4.4.5 of the NRSTI Policy aims to "…promote the establishment of collaborations, partnerships and linkages among stakeholders, private sector and international science, research and development community." Botswana has entered into various STI partnerships, and participates in several international and regional STI programmes. It is also signatory to a number of bilateral STI cooperation agreements with countries around the world.

12.1 Bilateral STI partnerships

Botswana has several bilateral STI cooperation agreements with countries around the world, of which the most active is with South Africa. In August 2005, Botswana and South Africa signed an Agreement for Scientific and Technological Cooperation, which aims, overall, to provide a formal framework for structured bilateral STI cooperation in areas of mutual interest. Under the agreement, the two countries have committed to strengthening cooperation between their "respective government agencies, enterprises, research institutions, universities and other research and development organizations." To this end, a Joint Committee on S&T was established, with representatives from the Department of Science and Innovation (DSI) and the DRST.

Under the agreement, some of Botswana's institutions have been collaborating with their South African counterparts on a variety of projects covering different areas or technology such as the Square Kilometer Array (SKA), indigenous/traditional knowledge systems, biotechnology, and nanotechnology and material sciences. Most of the collaborative projects involve capacity-building with an emphasis on developing skills of Botswana's researchers and students. However, there is scant information on specific outcomes of these collaborations.

In April 2005, Botswana entered into a formal bilateral STI cooperation agreement with Mozambique to cooperate in a variety of fields or areas, including the following: ICT, scientific research and innovation, technology development, development of human resources, exchange of experts in S&T-related areas, and technology transfer. Several meetings of the Joint Committee for STI cooperation were held between 2005 and 2008 to identify specific projects for cooperation. However, so far, no specific projects have been designed and implemented, and the memorandum of understanding (MoU) is largely dormant. This is attributed to a lack of dedicated resources and weak institutional capacities of both parties. It suggests that STI cooperation with Mozambique should be reviewed.

In 2019, Botswana and Zimbabwe signed an MoU for cooperation in STI, aimed at facilitating the exchange of scientific and technological information and expertise, development of joint training programmes or projects for STI policy, skills development and transfer, and promotion of private sector participation in STI. A Joint Implementation Committee comprising representatives of the Ministry of Tertiary Education, Research, Science and Technology (MOTE) and Zimbabwe's Ministry of Higher and Tertiary Education, and Science and Technology Development was established to oversee implementation of the MoU. However, because of the Covid-19 pandemic, and perhaps because of weak institutional capacities of both parties, no concrete projects have been designed and implemented so far.

Botswana is currently exploring bilateral STI cooperation with China, India and Turkey. Various exploratory meetings with these countries have been held over the past three years or so. For example, with Turkey, discussions are under way between the MOTE and the Scientific and Technological Research Council of Turkey to finalize an MoU that would facilitate cooperation in research and innovation in mining, vocational training in specialized areas, exchange of scientific and technical expertise, joint scientific workshops, and conferences for information exchange among scientists.

12.2 Regional cooperation in the context of SADC

Botswana ratified the Treaty Establishing the Southern African Development Community (SADC Treaty) and the 2008 SADC Protocol on Science, Technology and Innovation. It also adopted the 2015 SADC Industrialization Strategy and Roadmap (2015–2065) and the SADC Cyber Infrastructure Framework. Article 21(d) of the SADC Treaty makes explicit reference to SADC member countries cooperating in S&T for regional development and integration. The objective of the Protocol on Science, Technology and Innovation is "to foster co-operation and promote the development, transfer and mastery of science, technology and innovation" among member States.

However, various stakeholders in the country, including those in STI policy circles and foreign relations circles, are unfamiliar with the SADC Protocol. Moreover, Botswana has not developed an explicit strategy or plan for domestic implementation of the Protocol. Neither does the DRST (and the Government in general) have a dedicated budgetary allocation for its implementation.

Botswana participates in several programmatic initiatives in the SADC region, such as the Southern African Innovation Support (SAIS) programme and STI policy training workshops. It has been a participant in the SAIS programme funded by the Government of Finland, which aimed to strengthen national and regional innovation systems in selected SADC countries. The BDIH has been the implementing/coordinating agency on behalf of the Government. Some of the main initiatives launched and/or implemented in or by Botswana under SAIS include:

- RLabs projects, which provide training with a focus on ICT, entrepreneurship and community innovation;
- The Demand-Driven Supply-Chain Business Incubation Model project, which has supported selected innovative mining companies to develop components for the mining technology supply chain and develop new entrepreneurial ventures;
- Innovation Cafés hosted by the BDIH, which seeks to raise public awareness and understanding of SME innovation and competitiveness, IP protection in Botswana, design-led innovation and innovations in water conservation.

Botswana has also been participating in SADC training courses on STI policy. In 2020 and 2021, the SADC Secretariat organized at least two training workshops on STI policy capacity-building in which DRST officials participated. Such workshops are critical for strengthening the country's (and the DRST's) capabilities for STI policymaking. Going forward, DRST needs to develop a strategy for effectively using SADC and other STI policy courses to build its own capabilities.

Participation in the African Union

- **Botswana participates in various STI policy processes and programmes of the African Union and United Nations agencies.** Within the African Union, Botswana participates in the Specialized Technical Committee on Education, Science and Technology, and the Committee of Presidents championing resource mobilization for African Education, Science, Technology and Innovation. Such participation normally involves presenting general statements on the status of STI in the country and seeking to influence African Union programmes and policies on STI. However Botswana's participation in the Union's STI programmes and activities lacks a strategy; it is ad hoc, and not informed by national needs or priorities.
- **Botswana has been involved in the African Science, Technology and Innovation Indicators (ASTII) Initiative of the African Union Development Agency (AUDA-NEPAD)**.[46] Under this initiative, it conducted R&D and innovation surveys for 2013–2014 with technical and financial support provided by NEPAD. Officials from the DRST and Statistics Botswana participated in ASTII training courses/workshops. MOTE published the R&D survey report in 2017, but there has been no follow-up since then.

12.3 Engagement of the private sector in STI

Botswana's Vision 2036, the EDD Strategy and the NRSTI Policy recognize the private sector as a key player in the NSI, and that its engagement in STI should be strengthened. In its NRSTI Policy, the Government commits to "induce private sector participation in research, science and technology through funding of research and development, support of human resource and infrastructure development, intellectual property protection, technology transfer and business incubation, marketing, commercialization and industrialization."[47]

The Government's target of allocating at least 2 per cent of GDP in R&D by 2016, in partnership with the private sector, remains unfulfilled. This is partly because of extremely low private sector R&D and low public investment, and because the National Research Fund is not yet established (see section 2.2). The DRST does not have a clear strategy to mobilize private sector investment, and is not providing any incentives at present, but is working to improve private sector engagement. **In July 2021, it published a draft version of a Private Sector Engagement Strategy in Research, Science, Technology and Innovation 2021–2026.** The proposed strategy "seeks to reconfigure, realign and strengthen public-private partnership in the development of research, science, technology and innovation in Botswana." However, the draft contains only general statements of intent and lacks coherence with the NRSTI Policy. It does not clearly articulate specific objectives

[46] AUDA-NEPAD was established in 2018, when the African Union's Heads of State decided to transform the NEPAD Planning and Coordination Agency into the African Union Development Agency-NEPAD (AUDA-NEPAD).

[47] Government of Botswana (2011), *National Policy on Research Science Technology and Innovation*, p. 7 para 5.2.2.

for funding private sector R&D, supporting private companies to engage in commercialization of their technologies or strengthening university-industry linkages. Its vision and mission are general and vague. In March 2021, the DRST organized a stakeholders' meeting/workshop to discuss the draft and obtain inputs from various organizations. It is not clear whether the private sector was adequately represented. It is also unclear whether there has been an external review of the draft by experts on issues pertaining to strengthening private sector R&D and innovation, and different policy instruments such as R&D tax credits. Such a review could help to make it useful, implementable and aligned with the NRSTI Policy and Vision 2036.

12.4 Challenges to STI cooperation and partnerships

There are at least two challenges to Botswana's efforts at building enduring STI partnerships and engaging in international cooperation in STI. The first relates to the lack of an explicit strategy for such partnerships and cooperation. While the country participates in a wide range of international and regional STI processes and programmes, and has established some bilateral STI cooperation agreements (as outlined above), it is not easy to determine their performance in the absence of a clear national strategy and/or plan. The DRST does not have a strategy on how to deal in a cohesive manner with the international and national dimensions of STI policy, and leverage different partnerships to harness STI for national objectives including strengthening the NSI.

Second, the DRST lacks in-house human and budgetary resources to help manage international STI cooperation and partnerships with the private sector. In terms of human resources, there are no personnel with skills and experience in science diplomacy who are dedicated to forging and coordinating partnerships or engagements with other countries. Moreover, the Department does not have sufficient funds to coordinate international STI cooperation activities, and effectively participate in related STI meetings of the United Nations, the African Union, SADC and other major international actors. Also, because of limited budgetary allocations and shortage of personnel, the DRST is not able to effectively coordinate and provide leadership to numerous STI collaborative projects involving local and foreign researchers.

12.5 Recommendations

Botswana needs to enhance its engagement in SADC, the African Union, the United Nations and other international STI initiatives. It should strategically leverage international STI cooperation or partnerships to help grow its NIS and harness STI for sustainable development.

To do so, the following actions are recommended:

- A revised NRSTI policy should contain explicit decisions or measures that commit the Government to investing new and additional resources in international STI cooperation and partnerships**.** A budget line dedicated to promoting international STI cooperation should be included in annual financial allocations to the DRST or the ministry responsible for STI and approved by Parliament.
- The DRST should establish a department or unit within its organizational structure that would be responsible for coordinating international cooperation and resource mobilization. Such a department or unit should be provided with appropriately skilled personnel, equipment and funds.
- The DRST and the Ministry of Foreign Affairs should jointly support some of their personnel to take short training courses and participate in workshops on science and innovation diplomacy. This would help to build skills and literacy in STI diplomacy

and strengthen the country's capacity for international STI cooperation. Science and innovation diplomacy courses are offered by a variety of institutions, including The World Academy of Sciences (TWAS, formerly The Third World Academy of Sciences) and the United Nations (for example, UNCTAD and UNESCO).

- The DRST should design a comprehensive strategic plan for international STI cooperation and partnerships, with clear principles for choosing and investing in specific structured partnerships. This would enable the DRST to focus on collaborative projects and international engagements that could help strengthen the NIS.

Chapter 13. Synthesis and summary of recommendation

13.1 Synthesis of findings

Botswana has great potential for using RSTI for sustainable development, and has made some progress in building national capacity and capabilities, but it is performing well below potential and progress is too slow. This is an opportune time to review the state of its national systems of innovation, the policy frameworks for RSTI and the national RSTI policy in the context of growing national and global challenges. Botswana has important strengths that it has built since independence, starting as a very poor country with low RSTI capacity and facing many development challenges. The Government began focusing on building RSTI capacity as a specific objective only in the 1990s. It has gone through two processes, first designing a national S&T policy, which it issued in 1998, followed by the NRSTI policy in 2011. This STI Policy Review finds that it is time to update the 2011 policy to reflect the current context, with a more balanced focus on the areas of science, R&D, technology and innovation, and to remedy several deficiencies. Until now, the policies have focused heavily on scientific research; they have not linked S&T to innovation and production in a way that could create more significant economic, social and environmental impacts.

In order to build the national RSTI capacity needed to enable the transformation of Botswana from a natural-resource-based economy to a knowledge-based and innovation-driven one that also promotes sustainable development, reforms are proposed in eight key areas: (1) institutional reforms to improve governance of the NSI; (2) improving management of the research system, and establishing national RSTI priorities; (3) improving linkages and collaboration among all actors in the NSI, including the Government, academia and research, industry and others; (4) increasing public and private investment in RSTI, and developing new financing mechanisms; (5) revising the National RSTI Policy of 2011 for a more balanced focus on R&D, technology and innovation, and adding missing elements, for example in governance, monitoring and evaluation or articulation with the private sector; (6) building appropriate human resources; (7) ensuring policy coherence across key policies, and making more proactive use of policy tools (both explicit and implicit ones) to provide improved incentives and support to innovation; and (8) improving institutional capacity in STI policy, including policy design and implementation, M&E and related tools such as foresight and technology assessments. Specific areas covered in Part II of this review largely correspond to sustainable development challenges broadly in line with the SDGs. They highlight the need to harness STI for supporting transformation in Botswana across multiple sectors through transformative innovation policies. Progress will be necessary across different areas simultaneously. In particular, reform of STI governance represents a key element that merits immediate attention, as it could open up progress in multiple areas.

To remedy the weaknesses identified will require multiple policy interventions, and, above all, improved implementation of STI policies and programmes. This STI Policy Review found that many stakeholders are aware that the NSI is not functioning effectively, and that reforms are needed. Implementation has been disappointingly slow and partial since the national S&T policy was issued in 1998, and represents a major hindrance to transformation in Botswana. Improving implementation should therefore be made a top national priority and addressed as a matter of urgency. This can be achieved through the following actions:

1. Create stronger mechanisms for institutional governance (upgrading the institutional status of the DRST and providing it with adequate technical and managerial human resources, finances and skills) and establishing an effective high-level intergovernmental, multistakeholder committee;

2. Increase Parliament's engagement in STI;
3. Revise the RSTI policy and increase general awareness of the new policy;
4. Improve M&E, indicators and data systems for STI;
5. Make R&D more demand-driven and better connected to local industry and societal challenges; and
6. Strengthen engagement with and support to the private sector for its STI activities.

Enshrining a new RSTI policy in legislation, and re-establishing a target for the share of GERD in GDP (see section 2.2) should also be considered.

Policymaking processes for the design and implementation of policies and programmes need to be reformed. This would require high-level leadership and support for reform and changes to business-as-usual modes of working: from designing and implementing policies and programmes in isolated silos without discussion and information-sharing to collaboration in the design and implementation of key policies across government with more of a whole-of-government approach. Adopting innovative measures to promote M&E and improved collaboration and implementation should be considered, such as periodic M&E discussions on policy implementation across major policies. For STI, the proposed high-level committee should enable substantive discussions across ministries, research, industry, civil society and other stakeholders to encourage collaboration and partnerships.

Working to address the constraints identified in this review will allow Botswana to move from its current STI trajectory to one in which STI contributes substantially to the country's successful transformation as outlined in Vision 2036. This would correspond to the scenario of a thriving Botswana in the STI foresight exercise. Continuing with business as usual in the future will mean a slow and uncertain transformation represented by less optimistic scenarios. Botswana's policymakers should consider implementing reforms that will move Botswana towards a thriving scenario.

13.2 Summary of recommendations

Education and skills

1. Build a critical mass of technical skills for the R&D system and the economy, including at the master's and PhD levels (Chapter 2).

Institutional governance of NSI and STI

2. Improve institutional coordination of the STI system by upgrading the DRST to a Directorate for Research, Science, Technology and Innovation (DRSTI). This includes providing it with adequate staff and funding, investing in capacity-building, developing a strong M&E system, and enabling collection of STI indicators as well as an effective data management system (Chapter 3).

In the short term (within 1 year):

3. Establish a high-level committee for NRSTI Policy implementation (Chapter 4).
4. Strengthen parliamentary engagement in STI policy (Chapter 4).

In the long term (3–5 years):

5. Review the institutional performance of the proposed Directorate for Research, Science, Technology and Innovation (DRSTI) within 3–5 years of its establishment (Chapter 4).
6. Consider the option of establishing a fully-fledged ministry dedicated to STI (Chapter 4).

Foresight and technology assessment capacity

7. Build national capacity for undertaking STI foresight on a continuing basis as a tool for strategic planning and for adopting more forward-looking policy processes (Chapter 3).

8. Build relevant foresight capacity with respect to developments in frontier technologies, and conduct assessments of those technologies; develop specific policies and strategies for key frontier technologies such as AI to ensure that benefits are maximized and risks reduced (Chapter 5).

Establish STI priorities

9. Identify national priorities for R&D and technology for a national research agenda for the future, and guide future investments in RSTI and education/skills development. Accordingly, build on the STI foresight exercise and Botswana STI Foresight Report undertaken as part of this STI Policy Review (Chapter 3).

Financing for RSTI

10. Explore innovative ways of increasing financing for R&D, technology and innovation by assessing the operation and effectiveness of the Botswana Innovation Fund (BIF) and increase its size; design incentives to encourage the private sector to invest in R&D, develop new sources of financing such as business angels, venture capital and development bank financing of innovation, and impose a mineral levy on diamonds (Chapter 2).

National RSTI policy and supporting measures

11. Adopt a balanced approach to RSTI policy by extending the focus beyond R&D to include technology and technology transfer (both within Botswana and from abroad) and innovation with the aim of contributing to sustainable development and the goals of Vision 2036 (Chapter 3).

12. Revise the NRSTI Policy, and design an implementation plan and M&E framework for the revised policy (Chapter 4).

13. Ensure policy coherence across key economic policy areas, and strengthen the use of implicit STI policy frameworks (Chapter 4).

The R&D system, research commercialization, and data collection and management

14. Take measures to improve management of the research system, including establishing a national research fund, a national research council or similar body, and a mechanism to ensure that ministries, departments and agencies, universities and research institutes collect and report data on R&D programmes and projects to the DRST (Chapter 3).

15. Improve the commercialization and use of research to overcome sustainable development challenges by strengthening the focus on demand-driven research. This will involve supporting key actors in the "commercialization ecosystem", establishing a strong data/information network for easy access by researchers and users of innovation, including the design of a national policy on data that encourages open science and open data, ensures data protection, and recognizes the growing importance of data as a potential economic resource for creating value; and improve the usefulness of the IPR system (Chapter 3).

Support to private-sector firms and entrepreneurs

16. Nurture private-sector firms and entrepreneurs, and promote commercial innovation through enhanced policy support for start-ups, new technology-based firms, entrepreneurs and firms that are seeking to access knowledge and expertise, adopt technologies and innovate. Engagement with the private sector on STI policy should be strengthened (Chapter 3).

STI indicators and M&E

17. Improve data on STI through regular R&D and innovation surveys as a basic element of the M&E framework for STI (Chapter 2).

Digital transformation

18. Continue to pursue the digital transformation strategy of the country with a whole-of-government approach, identifying and leveraging the competencies of relevant bodies (including the MCKT), setting realistic time frames, considering high priority activities for funding and means of financing to support digital transformation (Chapter 5).
19. Build digital literacy and strengthen digital skills (Chapter 5).
20. Facilitate access to, and raise awareness about, the value of digital tools among SMMEs (Chapter 5).

Frontier technologies

21. Consider undertaking data collection and assessment to determine the status of frontier technologies in Botswana, and improve local readiness for the adoption frontier technologies (Chapter 5).
22. Consider implementing measures to support the adoption of frontier technologies that potentially have beneficial uses in the country, particularly in terms of accelerating progress towards sustainable development; and prepare for their adoption and diffusion by anticipating and acting to leverage potential benefits and mitigate any downside risks (Chapter 5).

International cooperation and partnerships in STI

23. Revise the NRSTI policy to include explicit decisions or measures that commit the Government to investing new and additional resources in international STI cooperation or partnerships (Chapter 12).
24. The DRST should establish a department or unit within its organizational structure that will be responsible for coordinating international cooperation and resources mobilization (Chapter 12).
25. The DRST and the Ministry of Foreign Affairs should jointly support some of their personnel to take short training courses and participate in workshops on science and innovation diplomacy (Chapter 12).
26. The DRST should design a comprehensive strategic plan for international STI cooperation and partnerships (Chapter 12).

Sectors and SDG-related sustainable development challenges

27. Take actions to harness STI for transforming sectors and achieving the SDGs, including in agriculture, health, tourism and mining, as well as for environmental sustainability and inclusive growth and social development (various sector and SDG chapters).

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