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Uganda

SCIENCE, TECHNOLOGY & INNOVATION POLICY REVIEW

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Preface

The Science, Technology and Innovation Policy (STIP) Review of Uganda was prepared on the request of the Ministry of Science, Technology and Innovation of Uganda.

Ugandan development aspirations require that its national science, technology and innovation (STI) plans and programmes make an effective contribution to its social and economic development. Strengthening national innovation performance is required to improve the competitiveness of Ugandan firms and industries competing in the global economy. Furthermore, like all other countries, Uganda is facing the challenges of Agenda 2030 for Sustainable Development and its 17 Sustainable Development Goals (SDGs). Here, as well, technology and innovation are increasingly important factors of success.

The Review has three fundamental goals. Its first goal is to offer Uganda an assessment of activities and institutions that make up its STI ecosystem. The second goal is to draw attention to the main STI policy challenges and enhance institutional capacity for policy design and deliver through capacity building activities. Special attention has been placed on the agriculture and information and communication technologies (ICTs). The third goal is to provide recommendations for strengthening STI policies and propose measures that may improve national technological capacities and encourage innovation.

During visits to Uganda, the STIP Review team held 60 interviews and meetings with representatives of government agencies, research institutes, universities, chambers of commerce and businesses. A draft of this document was presented and discussed at a series of national workshops held in Kampala between 9 and 12 December 2019, with the participation of more than 100 experts and national STI stakeholders. The feedback and suggestions provided have been considered in the preparation of this review.

This review would not have been possible without the cooperation of the Ministry of Science, Technology and Innovation of Uganda and, in particular, Honourable Minister Dr. Elioda Tumwesigye and Permanent Secretary David O. Obong. A special appreciation is owed to the Ministry STIP team, led by Assistant Commissioner Jennifer Muwuliza. Gratitude is also extended to all participants in the national workshop and to the persons and entities, too numerous to list, that generously contributed their comments and ideas. Special thanks go out to colleagues at UNESCO, and from UNDP and UNIDO in Kampala, collaborating and assisting on the Review and related activities.

While national partners, counterparts and experts in Uganda may have advised on its content, they may not necessarily concur with the entirety of the STIP Review's analysis and recommendations. The data cited in the Review is established by UNCTAD research staff. The assessments, opinions and conclusions expressed in this document are entirely those of the UNCTAD secretariat.

Abbreviations

AI	Artificial intelligence
ASDSIP	Agricultural Sector Development Strategy and Investment Plan 2010/11-2014/15
ASSP	Agriculture Sector Strategic Plan 2015/16-2019/20
ATIS	The Alliance for Trade in Information and Technology Services
BBL	Billions of barrels
BPO	Business process outsourcing
Btu	British thermal unit
BTVET	Business, Technical, Vocational, Education and Training
CNDPF	Comprehensive National Development Planning Framework
COMESA	Common Market for Eastern and Southern Africa
CRISPR	Clustered regularly interspaced short palindromic repeats
CURAD	Consortium for Enhancing University Responsiveness to Agribusiness Development
EAC	East African Community
EU	European Union
FTBIC	Food Technology and Business Incubation Centre
GCF	Green Climate Fund
GCI	Global Competitiveness Index
GDP	Gross domestic product
GEM	Global Entrepreneurship Monitor
GERD	Gross domestic expenditure on research and development
GGDS	Uganda Green Growth Development Strategy 2017/18-2030/31
GII	Global Innovation Index
GPS	Global Positioning System
GSM	Global System for Mobile Communications
ICT	Information and communication technology
IMF	International Monetary Fund
INSEAD	Institut Européen d'Administration des Affaires
IP	Intellectual property
IPRs	Intellectual property rights
ISO	International Organization for Standardization
ITC	International Trade Centre
ITU	International Telecommunication Union
IUCT	Uganda Institute of Information and Communication Technology
LDC	Least Developed Countries
LED	Light-emitting diode
MAAIF	Ministry of Agriculture, Animal Industries and Fisheries
MGLSD	Ministry of Gender Labour and Social Development
MIIC	Makerere Innovation and Incubation Center
NDP II	Second National Development Plan 2015/15-2019/20
NGO	Non-governmental organization
NIF	National Innovation Fund
NITA	National Information Technology Authority
NRI	Networked Readiness Index

NSI	National system of innovation
NSSF	National Social Security Fund
NSTP	National Science, Technology and Innovation Plan
OWC	Operation Wealth Creation
PIBID	Presidential Initiative on Banana Industrial Development
RASA	Real Agricultural Solutions for Africa
RCDF	Rural Communications Development Fund
RCIP	Regional Communication Infrastructure Program
SDGs	Sustainable Development Goals
SSA	Sub-Saharan African region
STEM	Science, technology, engineering, and mathematics
STI	Science, technology and innovation
STIP	Science, technology and innovation policy
TALEN	Transcription activator-like effector nuclease
TFP	Total factor productivity
TNA	Technology needs assessment
UBOS	Uganda Bureau of Statistics
UCC	Uganda Communications Commission
UDB	Uganda Development Bank Limited
UETCL	Uganda Electricity Transmission Company Ltd.
UIRI	Uganda Industrial Research Institute
UNBS	Uganda National Bureau of Standards
UNCST	Uganda National Council for Science and Technology
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNHCR	United Nations High Commissioner for Refugees
UNIDO	United Nations Industrial Development Organization
URSB	Uganda Registration Services Bureau
US	United States of America
USAID	United States Agency for International Development
WEF	World Economic Forum
WFP	World Food Programme
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
YLP	Youth Livelihoods Programme

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Key messages

- To meet the challenges confronting the country and enable Vision 2040, Ugandan development stakeholders will need a revitalized effort to deploy science, technology and innovation (STI) as catalysts of transformational economic development which will address the challenges of inclusiveness and environmental sustainability.
- In spite of a record of strong growth and a healthy attitude toward entrepreneurship and entrepreneurial risk that provides fertile ground for innovation, structural transformation processes in Uganda have been stalling in the last decade.
- Per capita growth, productivity levels and export diversification have slowed, indicating that technology and innovation are not contributing to growth. Therefore, a strong STI policy and competent implementation is urgently needed in order to catalyze technology-led growth and development.
- The future STI policy and its implementation will need to:
    - Develop a common and nation-wide understanding of the primacy of innovation in STI processes, the entrepreneurial nature of innovation and the need for a well-functioning national system of innovation (NSI);
    - Involve the private sector and its innovative entrepreneurs in policy design and implementation, and recognize their potential in affecting transformational development beyond acting merely as financiers;
    - Eradicate institutional silos that hinder communication and cooperation in policy implementation;
    - Engage in a broad public dialogue with diverse sectors of Ugandan society; and
    - Evolve a monitoring and evaluation culture that will provide factual feedback on policy implementation and strengthen institutional policy-learning and evidence-based policymaking.
- The Sustainable Development Goals (SDGs) and Agenda 2030 are well established in the Ugandan policy domain.
- Green and off-grid technologies have an important role to play in resolving Uganda's energy deficit.
- Policies for adaptation to climate change are very pertinent for rural communities due to their inherent economic fragility.
- The Ministry of Science, Technology and Innovation (MOSTI) will need to significantly develop its competencies and linkages with other stakeholders in order to mobilize the Ugandan NSI and lead national STI efforts.
- Technology transfer processes in Uganda are focused on scientific and technological research. The country will need to shift towards the innovation end of STI processes to generate meaningful impact.
- The state of the business environment in Uganda, while matching regional averages, will need significant improvements if Vision 2040 and its aspirations are to be achieved through STI-led development.
- Improving key framework conditions requires increased attention from policymakers. Broadband data access is expensive. Inadequate access to modern forms of energy and weaknesses in transport and logistics are a hurdle to the deployment of technology and to innovative business activity. There is a need to better match the competencies of vocational school and university graduates to the needs of firms, sectors and industries. Finally, access to finance is insufficient for innovative firms and entrepreneurs.
- Support for innovation for sustainability in the form of social entrepreneurship, funded as impact investment, may prove to be an important policy action.
- Innovation is the key for transforming and modernizing agriculture in Uganda. Transforming agriculture necessarily means farmers and firms moving up the value chain. The interaction between agriculture and information and communication technologies (ICTs) provides tangible opportunities for technological upgrading. It will guide policymakers to take a holistic approach to innovation policy and encourage closer coordination between these two sectors.
- ICTs play a key role in innovation by creating business opportunities, supporting the modernization of the economic system, reducing poverty, and generating opportunities for social and economic inclusion. Their impact on transformational development in Uganda, however, is insufficient and must be strengthened.

Summary

To meet the challenges and enable Vision 2040, Ugandan STI policymakers will need to revitalize their STI Strategy, guided by the following key concepts:

- *The Ugandan sense of diversity in oneness*. Diversity is productive when expressed with a corresponding sense of unity. Diverse languages, cultures, and ethnicities, all confident of their Ugandan identity, provide a strong foundation for learning, absorbing knowledge and adapting technologies, in support of national development and societal goals.
- *The Ugandan capacity for communication*. A key challenge for complex STI policy processes is the capability of stakeholders and beneficiaries to formulate and voice ambitions and concerns during all phases of policy development and implementation. Government agencies and institutions will need to improve their communications capacities and processes internally, and with the private sector, as well as among the broader population.
- *The Ugandan entrepreneurial energy.* The Ugandan entrepreneur is an energetic and creative character, habitually adapting to changing circumstances, improvising and innovating. Policymakers will undoubtedly recognize the potential and role of innovation-led entrepreneurship as the key factor of change in commerce and industry.

The priority objective for STI policy in Uganda should be the energizing of transformational economic development while addressing concerns about the social inclusiveness and environmental sustainability.

A holistic approach to STI policy design and implementation will be needed. Mainstreaming STI policy will require high-level and broad public dialogue. Exploiting potential synergies will require unconstrained collaboration between public and private stakeholders, sectors and industries, civil society organizations and the public. The adoption of a national systems of innovation (NSI) framework for policy design and implementation is a prerequisite for achieving transformational impact.

Renewing transformational process in the economy with STI-led development

Following a period of strong growth, transformational processes have stalled since 2010. The decline in the Global Innovation Index and ranking of Uganda confirms this development. A combination of practical and policy factors has presented significant challenges to policymakers.

Growth rates need to be restored as innovative firms, sectors and industries are more likely to succeed in growing economies. However, a high population growth is weakening development results. While debt-to-GDP ratios at 42 per cent are not high, debt servicing is costly, because Uganda pays high interest rates of over 15 per cent on borrowing in international debt markets. Regular budget deficits also take their toll on national value creation.

Trade diversification processes have slowed and reversed, signaling a risk of deindustrializing and a threat to the country's modest industrial manufacturing sector. The industry and manufacturing sector struggles with a challenging business environment. Uganda's landlocked geography presents considerable challenges, while trade is hindered by an underdeveloped transport and logistics infrastructure. The fact that low-productivity agriculture is the major employer, while services generate the most value addition is, in itself, an obstacle to development and innovation.

Transformational change in Uganda faces three significant challenges. The first is the need to enable technology-led development in agriculture and industry, through interactions with ICTs. The second challenge for structural transformation is to increase investment in private sector firms and industries. The third is to manage Uganda's population growth towards positive development outcomes.

Innovation for sustainable development

The policy frameworks for addressing the SDGs and the 2030 Agenda for Sustainable Development are well established in the Ugandan policy domain. There is a high level of coherence and vertical alignment.

However, the appreciation of the role of STI is uneven across policies, indicating that they have been developed with insufficient coordination.

Technology Needs Assessments (TNA) should focus on the inclusive development components of the SDGs and on slowing and reversing the deterioration of Uganda's natural environment. For example, policies for adaptation to climate change are highly pertinent for rural communities due to their inherent economic fragility. Conversely, Uganda's contribution to greenhouse gas emissions and the country's direct impact on climate change is negligible and likely to remain so in the medium term, and therefore STI for adaptation rather than mitigation should be prioritized. Nevertheless, green energy technologies can play an important development role. Expectations of development windfalls from the petrochemical sector, and commensurate policy attention, however, can inadvertently redirect interest away from developing alternative and renewable energy production and distribution.

Frontier technologies and their use in promoting an inclusive and sustainable development agenda are, fundamentally, a policy decision. Given an understanding of their potential, support for their roll-out in innovative products and services that address critical social needs is a policy must. Here, support for innovation, in the form of social entrepreneurship and impact investment, may necessarily lead to sustainable action.

Technology transfer processes require greater policy support in order for Uganda to realize its development aspirations and commitments to Agenda 2030. Institutions mandated to engage in technology transfer processes in Uganda are focused on the scientific and technological aspects. So far, investments in research on technology transfer, embedded in products and services, have not managed to achieve notable commercial results in the national market.

Policy perspectives, challenges and initiatives

Policy work done from the early- to mid- 2000s has produced the requisite policy and strategy documents. Awareness of STI for sustainable and inclusive development is present and increasing. However, these seem to have insufficient impact on development on the ground. There are multiple reasons for this outcome.

A primary issue is the need to develop a common understanding of the primacy of innovation in the STI process, including the acceptance that innovation mostly occurs in firms driven by entrepreneurs and is validated in markets. A new, innovation-focused mindset will need to be instilled in the newly created institutions, as well as in those already in place.

Policies and policy elements addressing STI, under the purview of the Ministry of Science, Technology and Innovation (MOSTI) and other public institutions, do not adequately involve entrepreneurs, firms and industries, and do not recognize their role in STI processes. Similarly, research and development (R&D) and technology transfer policies focus on research results, instead of enabling commercial or public service outcomes as primary objectives.

Policies often operate in institutional silos with insufficient inter-institutional interaction. This is despite the broad acceptance that, due to the complexity of Uganda's development challenge, it is impossible for any single ministry to implement its sector policies on its own.

Finally, the policies themselves have modest monitoring and evaluation (M&E) provisions. A highly functional national policy M&E system is crucial for providing information and feedback for policy learning. M&E requires high quality data, and the Innovation Surveys of 2014 and 2016 were a step in the right direction. However, there must be regularity in the way these are conducted, and the process and application of the methodologies will need periodical reassessment. Here, the interaction between policymakers and statisticians will be the key to developing high-quality data. Finally, it is crucial to accept that evaluation is a learning process, not a system of punishment.

Several policy initiatives are ongoing. To respond to the needs of financing innovation, MOSTI has announced the creation of a National Innovation Fund as an essential instrument for STI policy implementation. Best practices should apply, and due consideration should be given to the notion that policy design and policy implementation through funding of STI activities should rest in separate public agencies or institutions.

The policy instrument of creating and supporting industrial parks and business parks has been increasingly used in developing countries. For a number of years, the Uganda Industrial Research Institute (UIRI) has been at the forefront of the national effort to create and manage industrial parks in the country. As a result, incubation and acceleration activities have emerged in Uganda and have already produced success stories. Regardless of whether they are in the public or private sector, these activities deserve the full support and heightened attention of policymakers and public agencies that are a part of the innovation system.

From its own institutional perspective, MOSTI will need to evaluate its internal organization in the near term, having acquired factual feedback on its initial years of operation. Activating virtuous policy learning cycles requires data on STI for evidence-based policy design and implementation. The Uganda National Council for Science and Technology (UNCST) may play a critical role with its experience and statistical competencies as well as institutional memory, given its historical role in the development of STI policy in Uganda.

Framework conditions and business environment

Key framework conditions for innovation-led development include accessible and affordable ICTs (prices in Uganda are relatively high), accessible and affordable energy, effective and efficient transport and logistic infrastructure, and access to finance. An important cross-sector policy effort awaits MOSTI in establishing the dual roles that firms and industries in these sectors play: as commercial ventures with responsibilities to owners, and development stakeholders – and enablers – of broader societal processes. This can only be done by embracing an NSI framework for STI policy and developing outreach, as well as a culture of collaboration, with all relevant ministries, agencies, regulators, industries, and citizens as consumers.

A key factor for innovation is the business environment. Innovation-led firms and entrepreneurs are additionally sensitive to challenging business environments as they, by the nature of their endeavour, deal with greater levels of uncertainty. The state of the current business environment in Uganda, while matching regional averages, may not serve to achieve its development or STI aspirations. Success stories may be seen as accomplishments in spite of grave challenges, rather than outcomes of programmatic support from STI policy.

The interaction between the private sector and policymakers needs to become more fluid and meaningful. The tax treatment of startups and nascent firms is a particular concern. A more accommodating tax environment for innovative startups and nascent firms, in particularly addressing their low R&D spending, is greatly needed. Uganda will need to increase spending on R&D. However, increasing R&D activities should largely come as a result of growing demand from firms and industries, rather than from academic research developed in a vacuum.

The education sector in Uganda is itself constrained by many challenges, among which, a lack of qualified education professionals, and curricula that do not match the needs of students, nor of sectors and industries, are critical. Ideally, university and tertiary education would develop closer coordination with sectors and industries to produce adequate numbers of science, technology, engineering and mathematics (STEM) graduates with innovation mindsets, as well as the competency and confidence to step easily into professional life upon graduation.

The National Intellectual Property Policy provides policy clarity on the issue of intellectual property rights (IPRs) and highlights several key challenges, among which are enforcement IPRs and the commercialization of intellectual property (IP). However, implementing IP policy requires the development of human and financial capacity. At the same time, policymakers should not lose sight of the value of the knowledge commons, open access and public licenses. Preservation and commercialization using IPRs can be contradictory objectives for traditional knowledge and genetic resources. Therefore, some strategic thinking about how to pursue these two important goals would be warranted.

Agriculture

Innovation is the key to transforming and modernizing agriculture in Uganda. Transforming agriculture necessarily means moving up the value chain. However, productivity growth in the agricultural sector has made no progress since 1970 and growth has been based on expansion of cultivated land. Smallholdings

and customary tenure present serious obstacles to the development of commercial agriculture. The agricultural extension system has limited resources and impact. Adding to this, climate change is increasing the vulnerability of rural communities whose main economic activity is agriculture.

While spending on R&D in agriculture has been increasing, the lack of productivity growth indicates that there are major lab-to-field challenges. A key concern is insufficient linkages among various institutions and research agencies in the Ugandan agricultural innovation system. Without coordinated action on common objectives, human capacity and funding is dispersed and fragmented, and this results in sub-optimal outcomes. While non-traditional exports are growing, coffee still has major unrealized export potential and presents opportunities to move up the value chain. A lack of strategy on creating domestic demand and a consumer base for exemplary Ugandan agriculture products presents a missed opportunity for innovation.

In the Ugandan context, the interaction between agriculture and ICTs provides real and tangible solutions and opportunities, and guides policymakers towards taking a holistic approach to innovation policy.

Information and communication technologies industry

ICTs play a key role in innovation by creating business opportunities, supporting the modernization of the economic system, reducing poverty, and generating opportunities for social and economic inclusion. Mobile phones are also a starting point for digital literacy. Therefore, affordable and accessible mobile networks and services are a key element for STI-led development.

While Uganda has a plethora of public, academic and private ICT stakeholders, their impact on the transformative processes in the Ugandan economy is marginal. To move forward, a policy audit is advisable, treating the Ministry of ICT, the Uganda Communications Commission (UCC) and the National Information Technology Authority (NITA), with MOSTI as a key partner, as a single policy domain. The objective would be to identify points of collaboration and synergies that directly benefit the most people in terms of access and affordability.

By improving financial inclusion, particularly for women and vulnerable or underserved populations, fintech, which is a cross-sector between finance and ICTs, has significant impact on social development. From an innovation perspective, enabling fintech is an opportune move, as the required mobile infrastructure and technologies are already in place. Well-formulated policies addressing consumer protection, competition, data privacy, and skills and competencies among entrepreneurs, technologists and regulators, will determine the commercial success of Fintech, as well as its societal contribution.

Part I

STI policy and innovation in Uganda

1. Introduction

The Science, Technology and Innovation Policy (STIP) Review of Uganda was conducted by UNCTAD at the request of the Ministry of Science, Technology and Innovation (MOSTI). The analysis in the Review is based on interviews of STI stakeholders held during several UNCTAD missions in 2018 and 2019, as well as on quantitative data acquired from national and international sources.

Uganda will build on robust growth during the last 35 years and seize development opportunities in the oil and gas sector, tourism, minerals and ICT industries.

Uganda has had a robust development trajectory during the last 35 years. It has benefited from favourable natural resources and a relatively stable policy environment. The National Vision Statement of Uganda – Vision 2040 – states its ambition is to achieve "… a transformed Ugandan society from a peasant to a modern and prosperous country within 30 years." Opportunities identified in Vision 2040 include the oil and gas sector, tourism, minerals and ICT industries. It cites several conditions that favour growth and development, such as an abundant labour force, and Uganda's central geographical location, facilitating trade, abundant water resources, and advantageous agricultural conditions. The potential for industrialization is vast, though it is dependent on the right framework conditions. These include general infrastructure (energy, transport, water, oil and gas, and ICTs), leveraging science, technology, and innovation (STI), managing land and urban development, nurturing the national human resource base, and the provision of peace and security.

Focusing on innovation will energize transformational processes.

Several specific challenges present themselves to STI policymakers. The first is to increase support for the innovation side of the STI realm. The second is to develop coherence, coordination and directionality among the diverse policies that make up the STI policy complex. The third is to improve capacity to implement, evaluate and revise policy in successive policy cycles. The fourth is to generate genuine transformational development in increasing industrial output. This requires shifting an increasing proportion of agricultural output out of subsistence production, up the value chain and into industrial production. It also requires support for the development of manufacturing and related industries, as well as the development of a services sector with strong linkages to both agriculture and industry. Finally, the fifth key challenge is to deeply involve the private sector, and its firms and entrepreneurs, as the core generator of innovation, employment and economic value.

To meet the nations' development challenges and enable Vision 2040, Uganda will need a revitalized effort to deploy science, technology and innovation (STI) as catalysts of profound economic and social transformations.

The STIP Review proposes that, at the strategic level, the political leadership launch a national Innovation New Deal that could be inspired by three features permeating Ugandan society:

- *The Ugandan sense of diversity in oneness*. Diversity is productive when expressed with a corresponding sense of unity. Diverse languages, cultures, and ethnicities, confident in their Ugandan identity, provide a strong foundation for learning, absorbing knowledge and adapting technologies, in support of national development and societal goals.
- *The Ugandan capacity for communication*. A key challenge for complex STI policy processes is the capability of stakeholders and beneficiaries to formulate and voice ambitions and concerns during all phases of policy development and implementation. Government agencies and institutions will need to improve their communications capacities internally, as well as with the private sector and all citizens.
- *The Ugandan entrepreneurial energy.* The Ugandan entrepreneur is an energetic and creative character, habitually adapting to changing circumstances, improvising and innovating. Policymakers will undoubtedly recognize the potential and role of innovation-led entrepreneurship as the key factor of change in commerce and industry.

A national systems of innovation perspective is key for success.

In its discussion, this review will apply a *National Systems of Innovation* (NSI) approach. The aim is to assess the overall functioning of Uganda's innovation system and to recommend STI policies and actions that would enhance its performance and positively impact growth and development with consideration for the challenges of inclusiveness and sustainability. An NSI perspective will

enable Uganda to engage the 2030 Agenda for sustainable development as a vehicle for its own transformational development. An NSI is the sum of linkages, relationships, and information and knowledge flows among STI stakeholders. When these are pervasive, extensive, and of high quality, they will enable innovators in the private and public sectors, in academia and among the populace, to test their competencies and create wealth and welfare. Annex 1 provides several commonly used definitions of innovation systems.

2. The economic context for STI

2.1 Macroeconomic conditions

STI policies, and innovative firms, sectors and industries, are all more likely to succeed in growing economies.

Macroeconomic conditions provide a foundation for broader economic policy and certainly for STI policy development and implementation. Economic growth offers a context that is positive for innovation by opening opportunities for investment from innovative firms and entrepreneurs, as well as public organizations.

The average growth rate during the 1987-2017 period was 6.5 per cent.

For many years Uganda has been experiencing robust real GDP growth, with higher rates than the African average and similar to East Africa. The average growth rate during the 1987-2017 period was 6.5 per cent.[1] Recent substantial growth volatility and the slowing of GDP per capita growth, however, suggest that the macroeconomic environment presents more challenges than opportunities for innovation.

However, population growth is weakening growth results.

In per capita terms the growth results are not as impressive. When compared with developments in Kenya, Rwanda, and Tanzania, Uganda has experienced a significant growth slowdown since 2010 (see figure 2.1), indicating the acute demographic pressures that the country is exposed to (see figure 2.2). The population increased from 24 to 35 million during 2002-2014 and is expected to be above 80 million in 2040 (World Bank, 2018).

Inflation rates and exchange rates that are sustainable, stable and predictable reduce uncertainty for innovators.

The annual inflation rate in Uganda has been moving between 2 and 8 per cent since 2013, with reduced volatility compared to previous periods. While averaging about 6 per cent during the last 20 years, it has seen extreme peaks of over 15 per cent in 2011 and deflation of 0.3 per cent in 2002. The Bank of Uganda (BoU) lending rate is currently 10 per cent after a steady decline from a recent peak of 17 per cent in early 2016. Prior to this, BoU's interest rates hovered around 12 per cent following a decline from peak rates of 23 per cent in early 2012. Commercial bank prime lending rates are double or more than BoU's lending rate and are generally unsuitable and unavailable for investment in innovation-led firms or industries that, by the very nature of their operations, engage heightened levels of risk and uncertainty.

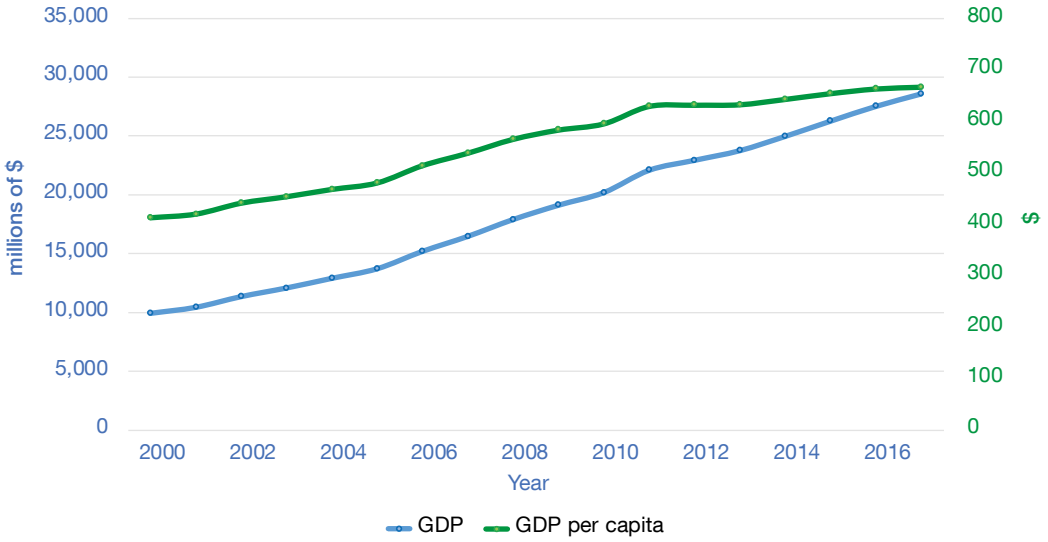
After a period of relative stability between 1999 and 2009, the Ugandan Shilling (USh) has been steadily losing value in exchange with the dollar at a rate of about 8 per cent per year. The steady depreciation reflects Uganda's persistent trade deficit and demand for imported goods with comparably low export earnings. Stable exchange rate movements, regardless of direction, enable foresight and planning by firms and industries.[2]

Trade openness stimulates innovation in firms and industries to improve their competitiveness. However, Uganda's underdeveloped transport and logistic infrastructure and its landlocked geographical situation present serious challenges.

With imports of about $7.6 billion and exports of about $4.5 billion of goods and services in 2017 (43 per cent of GDP), Uganda trades relatively more than Ethiopia and Kenya, but less than Rwanda. Uganda is a member of the World Trade Organization (WTO), the Common Market for Eastern and Southern Africa, known as COMESA, and the East African Community (EAC). Its main export is coffee, accounting for 19 per cent of all exports, while its imports are fairly diversified, with petroleum products the largest single import. The trade deficit in 2017 was about $2 billion, and has been worsening steadily since 2005 until 2011, after which followed some improvement. Box 2.1 provides a number of trade indicators.

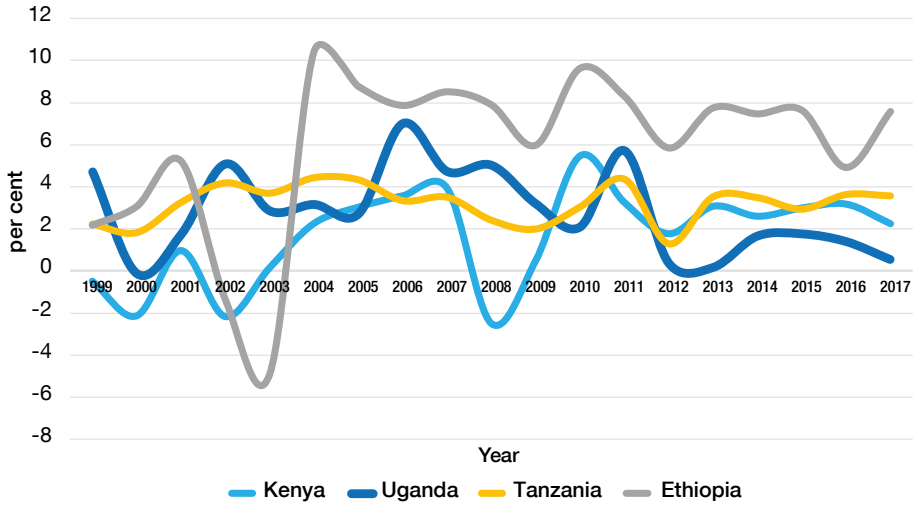
Uganda is a landlocked country and its under-developed infrastructure, including roads, port

Figure 2.1: GDP and GDP per capita, 2000-2017 (constant 2010 $)



Source: databank.worldbank.org

Figure 2.2: Annual GDP growth rate per capita: Uganda and comparators (constant $ 2010)



Source: databank.worldbank.org

facilities, railway networks and carriage stock, presents major obstacles to trade. Its fragmented and largely informal economy, focused on household consumption, does not lend itself to increasing exports, and should not be expected to do so on its own without development support that includes strong trade and trade facilitation. This support should incorporate targeted developments in infrastructure and finance, industrial and agricultural policy, and a well-formulated and implemented STI policy.

2.2 Sector balance and structural transformation

The sector structure of the Ugandan economy, whereby low-productivity agriculture is the major employer, while services generate the most value addition, is a major developmental and innovation challenge.

STI policy development and implementation will need to address the specific sector balance in the national economy. The current sector composition in Uganda amounts to value added of 47 per cent of

GDP that is produced in the services sector, 25 per cent in agriculture and 20 per cent in industry.[3] This structure, together with its large informal sector, presents a serious challenge for STI policy that aims to increase technological capabilities and absorption, and improve innovation outcomes in the overall economy. A key concern is that manufacturing – in other words industry without the construction, energy and minerals sectors – represents only about 9 per cent value added of GDP.

A holistic approach to STI policy is therefore needed, to exploit potential synergies between sectors and industries.

Often, STI policies will address industrial manufacturing as the primary sector under consideration. Technological upgrading is often thought to be most effective in industrial manufacturing because of prior knowledge and competitive pressures. Incentives for technological upgrading can be focused through fiscal tools, developing clusters, co-funding R&D, support for technology transfer targeted at market-driven innovation challenges, and investing in augmenting specific human capacities.

However, in Uganda's case, this approach could lead to narrow policies with limited impact, considering the size of the manufacturing sector in industry and the overall economy (see figures 2.3 and 2.4). Therefore, a more holistic approach may be needed, whereby opportunities and synergies are sought between and among agriculture, services and industrial activities. Key opportunities discussed in the Review include the linking of digital services with the agriculture sector and the accelerated moving of the agriculture economy into the sphere of manufacturing and industry.

The adoption of a National Systems of Innovation (NSI) framework for policy design and implementation is a prerequisite for achieving transformational impact.

Adopting an NSI framework for formulating and implementing policy presents a significant challenge that will require institutional arrangements among

Box 2.1: The Ugandan economy: International trade

International merchandise trade

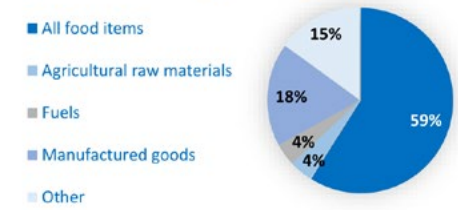
(millions of $)	2010	2015	2017
Merchandise exports	1,619	2,267	2,901
Merchandise imports	4,664	5,528	5,596
Merchandise trade balance	-3,046	-3,261	-2,694

International trade in services

(millions of $)	2010	2015	2017
Service exports	1,304	2,044	1,609[e]
Service imports	1,803	2,379	2,043[e]
Service trade balance	-449	-335	-434[e]

[e] Estimate

Export structure by product group in 2017

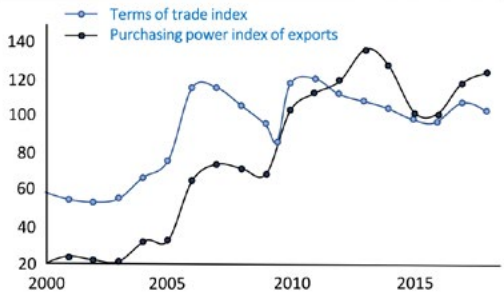


Services exports by main category

(as a % of total services	2010	2015	2017
Transport	3.2	6.6	9.5
Travel	60.1	50.0	57.0
Other services	36.6	43.4	33.4

Top five partners, exports in 2017

Trade indices



Source: UNCTAD. https://bit.ly/38xaUV3

national STI stakeholders that are unprecedented in their complexity. As a minimum, STI policy will need to appreciate and absorb key elements of national agriculture, industrial and services strategies. Policy will also need to reflect on directions taken with regard to national development of physical and trade-related infrastructure, ICTs, finance and human capital, i.e., education at all levels, including tertiary levels and vocational and technical training. It will require a deep adoption of an NSI framework perspective on policy development and implementation. Substantive efforts to enlarge the scope of horizontal communication and cooperation between key stakeholders and STI policy beneficiaries, such as firms, sectors and industries, as well as the general public and representatives of public interests in poverty reduction, environmental sustainability and other key challenges as expressed in Agenda 2030 and the SDGs, will also be needed.

Structural transformation processes in Uganda will need to be stimulated to acquire a new dynamism and will depend critically on the deployment of a more intense and consistent STI policy effort.

Structural transformation processes in Uganda have been modest since mid-2008. Structural transformation can be defined as the movement of labour and other productive resources from economic activities of low-productivity to high-productivity (UNCTAD, 2016). Alternatively, structural transformation may be seen as the reallocation of economic activity, expressed as their share in GDP, across three broad sectors: agriculture, industry, and services (Herrendorf et al., 2013).[4] The shedding of agriculture's share, in favour of industry and services, is usually seen as a positive transformation if matched with cumulative growth of all three sectors. In practice, structural transformation happens when economic development is driven by the appearance and growth of knowledge- and technology-led firms, industries and public services.

In countries where structural transformation is weak, policymakers may choose to review and redefine their STI policies, and their capacities for implementation. During the last decade, transformational processes and structural change in the Ugandan economy have been modest. In the last 20 years, agriculture has shed a few percentage points of its share in GDP to services (see figure 2.5). Since 2008 however, agriculture seems to have regained some share from industry. In addition, productivity levels, measured as GDP output per employed (see figure 2.6), were growing modestly but have entered a period of slow growth since 2010. This indicates that the changes in labour composition are among various low-productivity activities, such as self-employment in agriculture or self-employment in services or artisanal manufacturing, often called entrepreneurship out of necessity. A transformational growth in

Figure 2.3: Industry and manufacturing in Uganda, 1999-2017

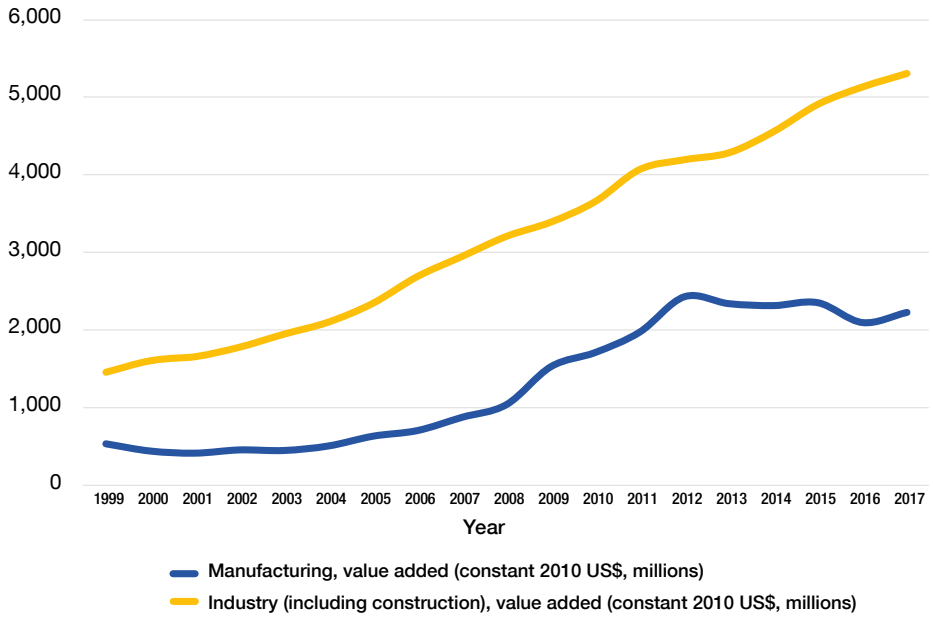
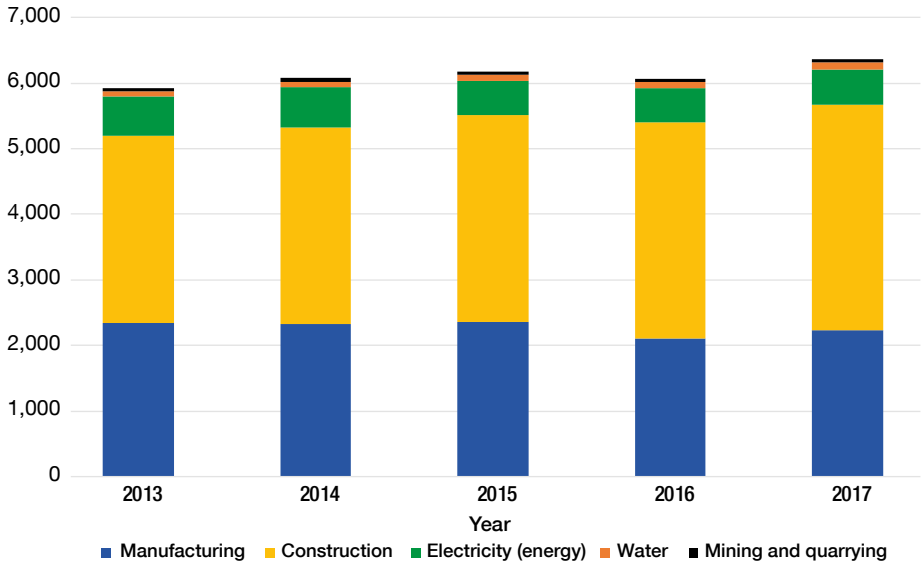


Figure 2.4: Industrial sectors in Uganda, 2013-2017 ($ millions)

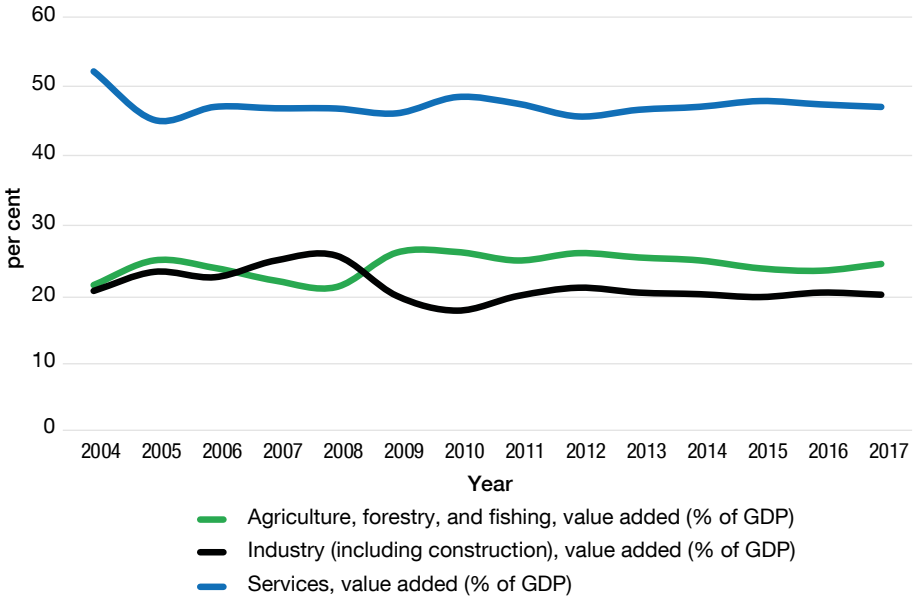


labour productivity would require an acceleration of employment in high-productivity firms and industries.

A sizeable subsistence agriculture sector and informal economy present serious challenges for energizing structural transformation in Uganda.

The slowdown in Uganda may be, in part, due to the large agriculture sector which employs 70 per cent of the workforce and contributes to about 25 per cent of the GDP (see figure 2.7), mostly in subsistence agriculture, i.e., as an informal activity and sector. The informal sector, by its very nature, faces significant challenges in improving technological uptake and increasing productivity. Commercial agriculture, services, the ICT sector and industry, offer a certain potential for transformative development. Here, the key challenge is spurring the development of high value-added activities and increasing the capacity of firms and industries in the private sector to be job creators and employers.

Figure 2.5: Economic sectors as % of GDP, 2004-2017

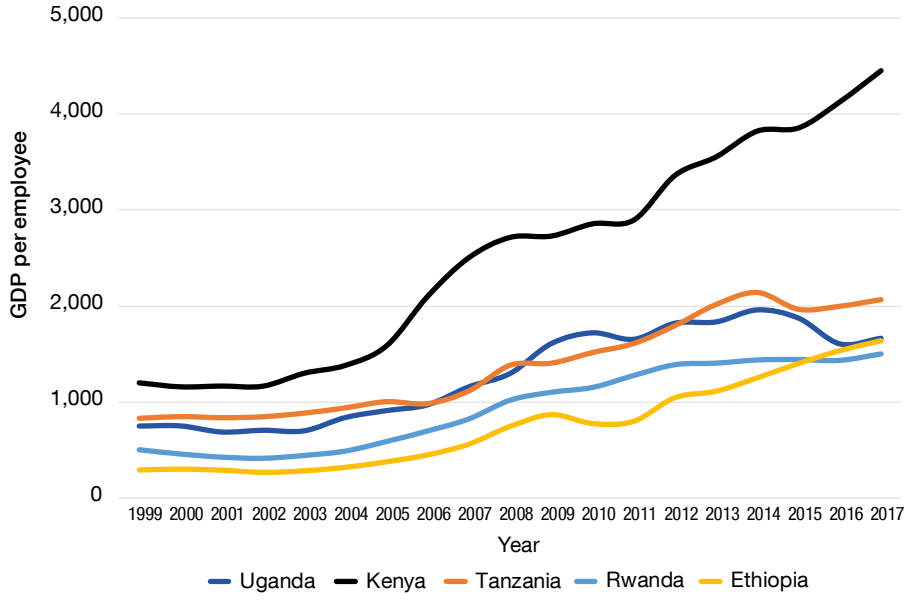


Source: databank.worldbank.org

Trade diversification processes have stalled and reversed, indicating a risk of deindustrializing and shrinking the already small industrial manufacturing sector.

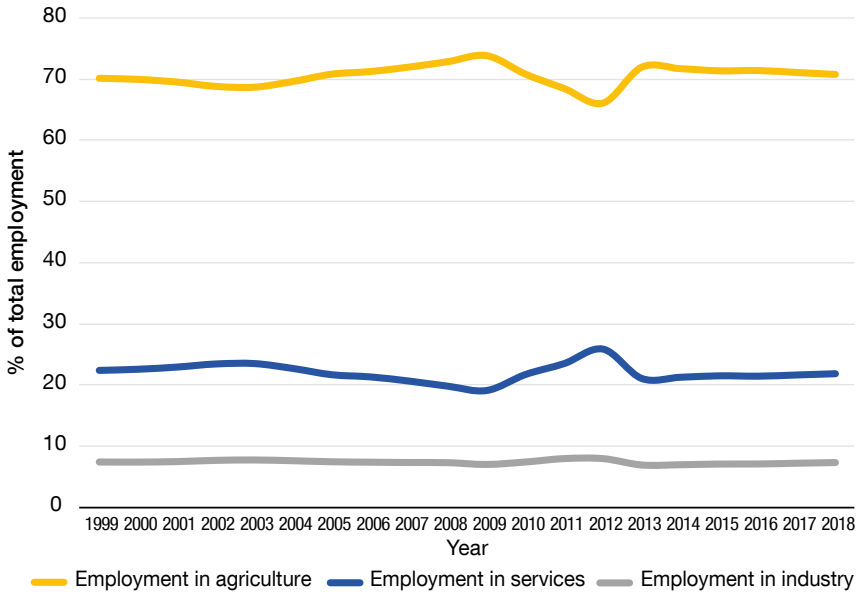
Further evidence underscoring Uganda's need to energize its structural transformation process is its export trade diversification (see figure 2.8). Following a strong export diversification movement from 1995 to 2007, exports have remained similarly diverse in the last ten years. As with productivity assessments, Kenya outperforms Uganda and its neighbours in export diversification as well. While there are complex factors and processes that precipitate such a condition, certainly a more facile trade environment would be a key determinant. This would include facilities and infrastructure (ICTs, ports, roads, rail transport, pipelines, etc.) as well as a supportive regulatory environment.

Figure 2.6: GDP per employee: Uganda and comparators, 1999-2017



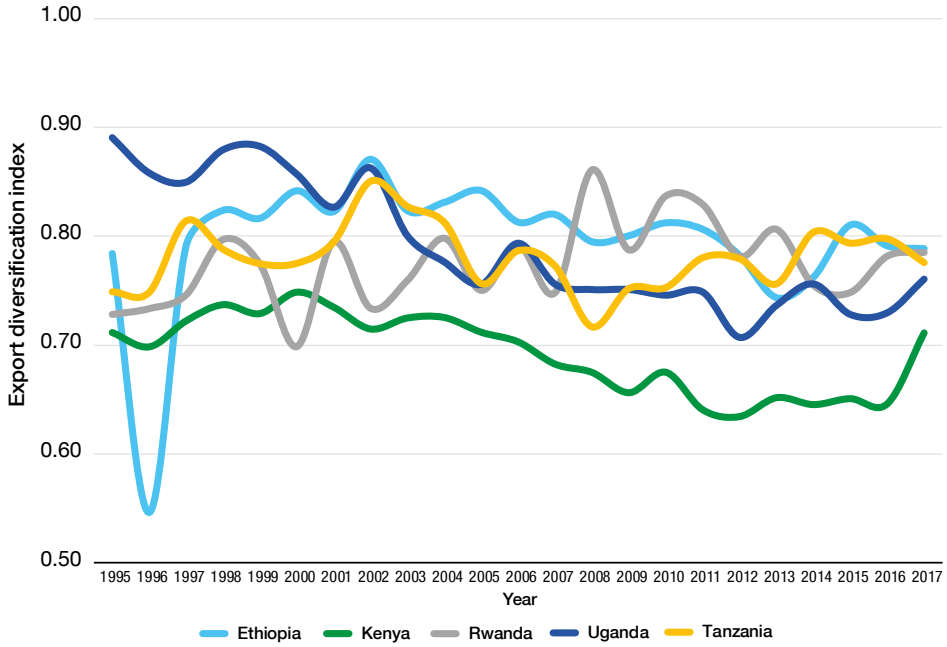
Source: databank.worldbank.org

Figure 2.7: Employment in agriculture, services and industry, 1999-2018



Source: databank.worldbank.org (based on International Labour Organization estimates)

Figure 2.8: Export trade diversification: Uganda and comparators, 1995-2017



Source: UNCTAD, unctadstat.unctad.org

Structural change in Uganda faces three significant challenges.

The first is the need to enable technology-led development in agriculture and agri-industry.

The growth in agricultural output, which approximately quadrupled between 2004 and 2014, from $1.7 billion to $6.8 billion, has been the result of extensive growth through increases of cultivated farmland and labour, while yields have generally been largely stagnant (Brownbridge and Bwire, 2016). This is due to the fact that Ugandan agriculture is dominated by smallholder farms that have low absorptive capacity for technology, limited financial resources and produce mainly for the country's own consumption. There are, however, cases of successful technological uptake in commercial agriculture. While these highlight possibilities, they are not enough to change the global situation.

The second challenge for structural transformation is to increase investment in private sector firms and industries.

Current estimates put investment at between $3.5 billion and $6 billion for recent years (UNCST, 2013 and 2016). This may be an overestimation as the surveys assume an equivalence between the sample group and the whole economy. Further explaining poor transformative outcomes is the notion that a large part of domestic and foreign investment has gone into sectors that neither produce jobs nor contribute to advances in productivity in a meaningful way, such as real-estate development or oil exploration. While there is no single explanation for insufficient private investment, the usual combination of market and institutional failures merge to suggest to firms a heightened state of risk and uncertainty. The overall characteristics of the business environment in Uganda are discussed in section 4.3.

The third challenge is to manage Uganda's population growth towards positive development outcomes.

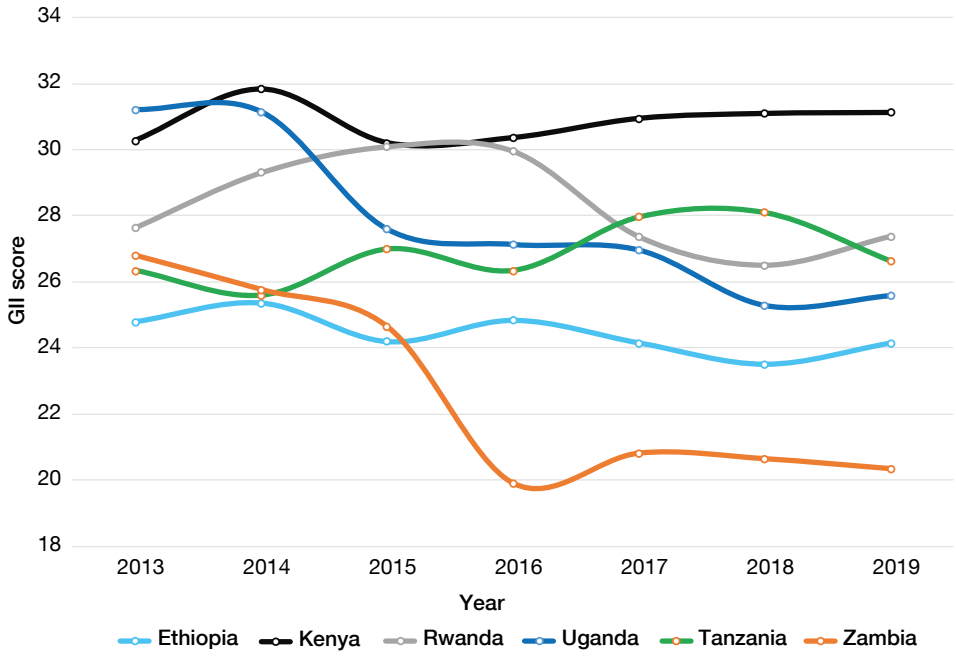
For now, Uganda's population growth has a negative impact on savings rates which limit available resources per capita for human capital development, as well as physical capital accumulation. Accelerated development and structural transformation are usually matched with slowing population growth. While a youthful and growing population is a powerful economic resource, it requires investment to achieve its potential. Without this investment, it becomes an obstacle in the way of accelerating transformative processes.

2.3 Innovation performance and comparators

The decline in the Global Innovation Index and ranking of Uganda indicate stalled transformational processes. Strong STI policy action is needed to energize the economy.[5]

Following growth in innovation scores and its ranking in the Global Innovation Index[6] (GII) up to 2014, there has been a decline in measured GII performance. This can almost certainly be attributed to the loss of momentum of transformational processes and productivity growth, as described in section 2.2. It is therefore encouraging that key STI policy initiatives have been taken in recent years, such as the design of a National Science, Technology and Innovation Plan in 2012 and the establishment of an STI sector ministry in 2016 (see section 3.1 for more details). The GII is presented in figures 2.9 and 2.10 and includes comparators. Uganda outperforms countries with similar GDP per capita. Nevertheless, a low and declining GII score will indicate any number of inefficiencies in the national innovation system. There may well be general governance issues that affect all policy domains. One important question is whether *policy formulation* and the development of institutional capacity for *policy implementation* in the STI sector are addressed concurrently. At its current development stage, Uganda's innovation performance is closely linked to the wider mix of socioeconomic policies. Investing in the activation of policy learning processes may be considered.

Figure 2.9: Global Innovation Index, 2013-2019: Uganda and comparators



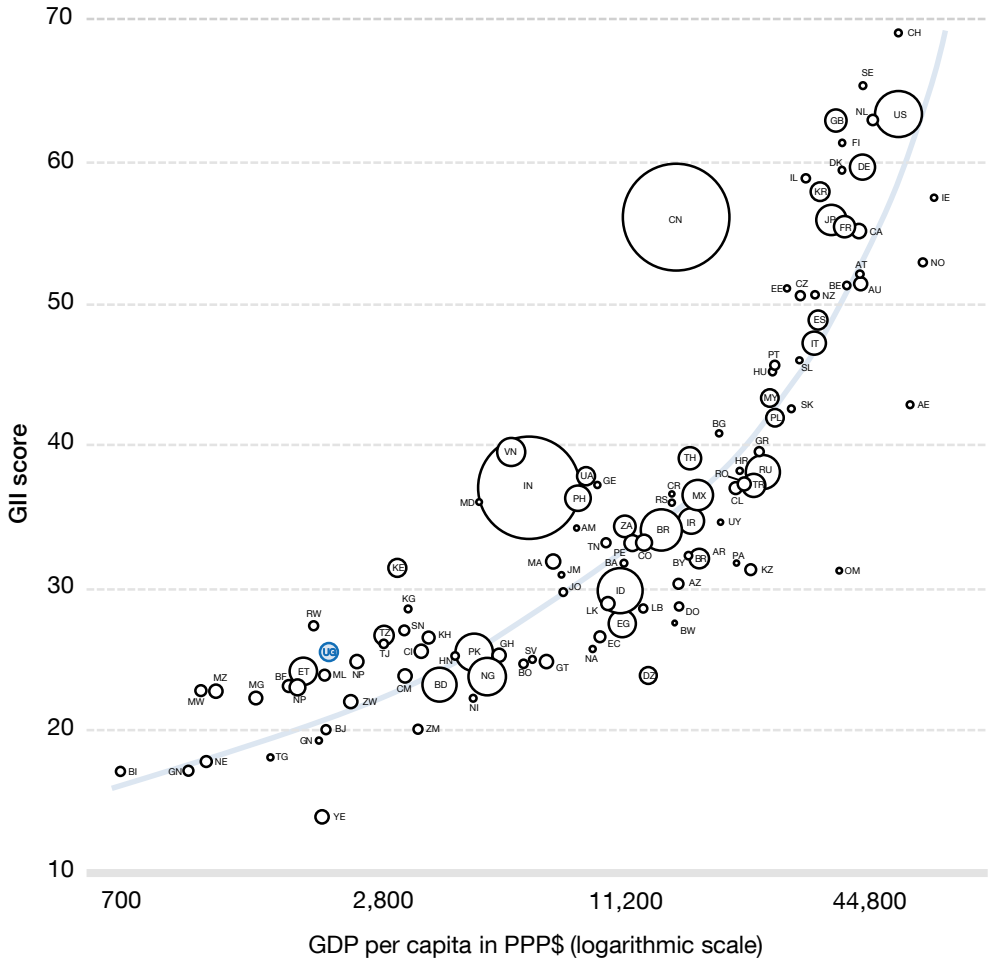
Source: GII; www.globalinnovationindex.org/analysis-indicator [7]

At a more detailed level, inefficiencies in the NSI are enhanced by, for example, a low level of interaction between universities and potentially innovative firms, or a lack of funding mechanisms for research and innovation. An important related issue is the existence of well-supported business incubation and acceleration facilities, and innovation clusters, that go beyond science technology research carried out, for example, at Makerere University and UIRI (GII, 2014). After initial success, or at least survival, many firms graduating from startup status and leaving incubators and accelerators, may find the cost and ease of doing business in Uganda are unacceptably high compared with that of other countries in the region.

2.4 Key sustainability challenges

Rapid STI-led industrial growth and global technological change is affecting all peoples and nations, including Uganda. It is straining our natural environment and increasing societal inequalities. At the same time, STI presents opportunities for humankind to evolve towards

Figure 2.10: Global Innovation Index vs. GDP per capita: 2019 ranking



Source: Cornell University, the INSEAD Business School and the World Intellectual Property Organization (WIPO) (2019)

greener and more inclusive societies. There are high expectations of STI in terms of impact on a vast array of human and societal challenges, from improved health and gender equality, to energizing entrepreneurship and engaging in frontier endeavours, such as artificial intelligence (AI) and space exploration. At the same time, sceptics remind us that technological progress is neither free nor risk-free. Gender, youth, and environmental challenges, and other issues that manifest as human and social rights inequalities, will to some extent find either solutions or further aggravation depending on how policymakers manage the national and international STI policy domain.

The policy framework for addressing the SDGs and Agenda 2030 are well established in the Ugandan policy domain. There is a high level of coherence and vertical alignment. The role of STI is uneven across policies however, indicating that they have been developed with insufficient coordination.

Global sustainability challenges are currently defined in Agenda 2030 and the SDGs. Agenda 2030 refers to *Resolution 70/1.* It was adopted by the General Assembly on 25 September 2015 entitled, *Transforming our world: the 2030 Agenda for Sustainable Development*. Agenda 2030 is a plan of action for people, planet and prosperity. It seeks to strengthen, "universal peace in larger freedom," and recognizes that, "eradicating poverty … is the greatest global challenge and an indispensable requirement for sustainable development." The 17 SDGs are presented in annex 2.

In Uganda, Agenda 2030 is implemented under Vision 2040 and, using its Comprehensive National Development Planning Framework (CNDPF), is the country's highest-level economic development policy tool. Under the guidance of Vision 2040 and

Box 2.2: Uganda's National Development Plan II and commitment to the SDGs

The NDP II recognizes sustainable development as an important challenge for land use and urban development (SDG 11 Sustainable Cities and Communities, paras 159 and 343 of the NDP II) and in response to climate change (SDG 13 Climate Action, paras 222 and 355). In its discussion of STI and industrialization, the NDP II highlights SDG 8 – Decent Work and Economic Growth – (paras 317 and 340) with special emphasis on creating youth employment opportunities. It notes, meanwhile, that SDG 7 – Affordable and Clean Energy – asserts: "… that that growth and development are inextricably linked to the use of electricity as a form of energy. Government is committed to improving electricity generation and supply to support industrialization" (paras 324 and 325).

SDG 9 – Industry, Innovation, and Infrastructure – guides the development of reliable and resilient infrastructure for regional trade (para 328). SDG 4 – Quality Education – highlights education as the main policy tool in achieving gender equality (para 341) and complementing the specific objectives of SDG 5 – Gender Equality (para 358). SDG 10 – Reducing Inequality, though explicitly noted in para 336, its treatment is implied throughout the entire NDP II. Given Uganda's level of development and ongoing battle with poverty, emphasis is given to SDG 1 – No Poverty (para 347), SDG 2 – Zero Hunger (para 350), and SDG 3 – Good Health and Wellbeing (para 352). Finally, the NDP II is keenly aware that Agenda 2030 relies on SDG 17 – Partnerships for the Goals – and SDG 16 – Peace, Justice, and Strong Institutions – as a means to strengthen overall implementation and governance (para 334).

CNDPF, Uganda is currently executing its Second National Development Plan (NDP II) for the period 2015/16-2019/20, which makes comprehensive references to Agenda 2030 and the SDGs as key pivots in its policy outlooks. Uganda was one of the first countries to develop a national development plan in line with the SDGs. The Government estimates that 76 per cent of the SDGs' targets are reflected in the plan and adapted to the national context. The NDP II highlights sustainable development as one of six key development strategies. It prioritizes agriculture, tourism, minerals, oil and gas, infrastructure, and human capital as development areas. An overview of how the NDP II references the SDGs is presented in box 2.2.

More specifically, the NDP II advises STI stakeholders to improve the national STI legal and regulatory framework in order to guide, "… the judicious use and application of traditional, conventional and emerging technologies for sustainable development" (page 199). The NDP II includes, in its annex 3, the listed SDGs as the most critical of the development obligations and commitments. This is in line with the Constitution of the Republic of Uganda, Uganda Vision 2040, the East African Regional Integration Protocols, Africa Agenda 2063, and as integrated into the NDP II's actions and activities.

Following on Vision 2040 and the NDP II, Ugandan policymakers have laid out key sustainable development challenges and directions for action in the following: the Coordination Framework for the SDGs (2015), the Roadmap for Creating an Enabling Environment for Delivering on SDGs in Uganda (2018), established by the Prime Minister and associated stakeholder institutions, and the Uganda Green Growth Development Strategy (GGDS, 2016) 2017/18–2030/31, spearheaded by the National Planning Authority.

The Coordination Framework for the SDGs, and the Roadmap for Creating an Enabling Environment for Delivering on SDGs in Uganda, have laid out the framework for developing concrete action that would lead Uganda onto an inclusive, lower-carbon and environmentally sustainable development path. The Roadmap aims to create an enabling environment to, "… empower all relevant actors to contribute to the realization of the [Sustainable Development] Goals." It recognizes the need to engage development partners and non-state stakeholders, and notes the importance of data, and monitoring and evaluation, in the policy process.

The GGDS proposes that, "… Uganda will need to reconsider its growth model to deliver inclusive economic and social outcomes while protecting

natural capital, addressing climate change, creating jobs and accelerating economic growth." It defines green growth as an, "… inclusive low emissions economic growth process that emphasizes effective and efficient use of … natural, human, and physical capital while ensuring that natural assets continue to provide for present and future generations." The GGDS suggests that green growth can add an additional 10 per cent of GDP growth during the period under consideration, as well as create four million additional jobs, and reduce greenhouse emissions growth by 28 per cent.

The GGDS's focus areas are coherent with the NDP II and recognize that inclusive economic development and sustainable environmental concerns go hand-in-hand. It recognizes the importance of a number of key policy conditions, including increasing the role of public procurement, the use of a value-chain approach in developing sectors and industries so that they encourage sustainable consumption and production, and the need for behavioural change. The GGDS notes that green growth necessarily means structural change and upgrading national human capital. Its key challenges stem from its limited treatment and awareness of the important role of non-government stakeholders, such as private sector firms and industries, academia and educational institutions, and civil society.

Neither the Roadmap nor the GGDS takes up science, technology or innovation as key components of implementation. Therein lies the institutional challenge for MOSTI: to deepen its cooperation with established institutions in the SDG process, and to promote the importance of STI in terms of defining the necessary functionalities of an innovation system that will enable sustainable development through the actions of practical and innovative firms, entrepreneurs, sectors and industries.

2.4 Technology needs assessments and STI for sustainable development

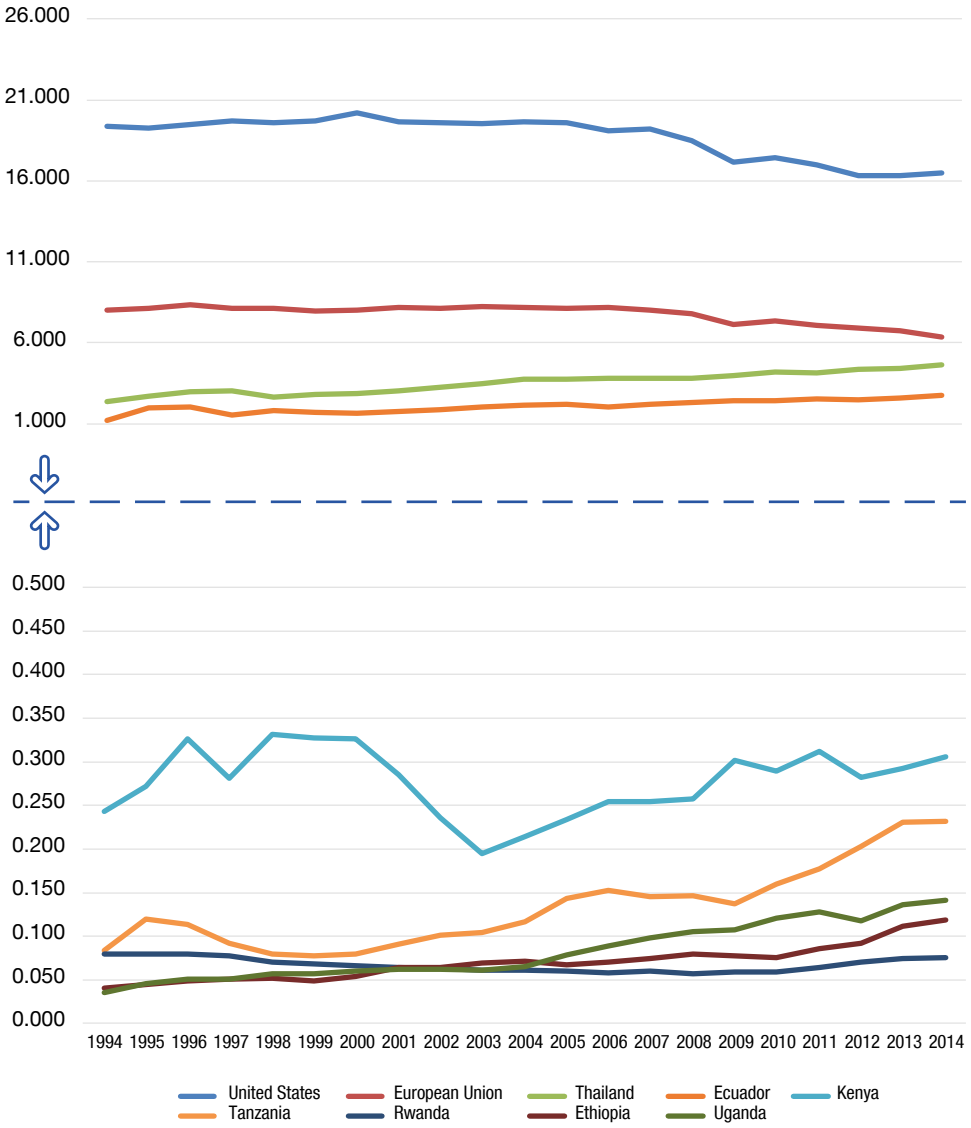
The key challenges lie with developing technology needs assessments (TNA), with a focus on the inclusive development components of the SDGs, and on slowing and reversing the deterioration of its environment.

If there is no commercial interest in addressing certain components of Agenda 2030, innovative firms and entrepreneurs may not come forward and play their role in identifying needs and developing solutions as products or services.[8] The role of the innovative firm or entrepreneur may be to an important extent replaced by a *technology needs assessment (TNA)* process. Such a process attempts, in a structured way, to identify important but commercially unviable needs and propose technologies, innovate solutions and assemble interested stakeholders into a coalition for action. Technology needs assessments are a set of country-driven and participatory activities leading to the identification of sustainable development challenges, and selection and implementation of technologies needed to spur sustainable and inclusive development. The methodology has been developed by the United Nations Environment Programme (UNEP) and has been implemented for climate change TNA in 75 countries.[9] Extending the methodology to cover other SDGs may be a worthwhile effort and a point of collaboration between national institutions and international organizations.

The key concern for Uganda is to prioritize sectors and technologies that will have the largest impact on moving towards the SDGs and meeting its Nationally Determined Contributions, as defined by the United Nations Framework Convention on Climate Change (UNFCCC). In the latter case, Uganda undertook a commitment to reduce greenhouse gas emissions by 22 per cent by 2030, by implementing mitigation and adaptation measures and technologies. Once priorities have been determined, technology action plans can be developed and funding can be sought, including from the Green Climate Fund (GCF) facility. From a policy perspective however, this is not an easy task, as the NDP II has taken up consideration of all but four SDGs.

Like other innovation endeavors, success will come only with a sufficient flow of bankable proposals for innovations that address the SDGs. In addition, in the Ugandan development context, technological innovation will more likely emerge through the identification and adaptation of existing technologies, i.e., technologies that are market-ready and deployable. This leads to the inevitable conclusion that progress will need to be largely entrepreneurship-based and innovation will be developed and deployed by firms, with government agencies in a supportive role. Therefore, it is key to involve private sector stakeholders from the start. However, and as noted in section 3.5 on financing STI in Uganda, the private sector has been seen by policymakers as having only modest abilities to actually address technological challenges related to sustainable and inclusive development.

Figure 2.11: Carbon footprints – Uganda and select regional and global comparators (CO_2 per capita in metric tons per year)



Source: data.worldbank.org

From a narrower climate change and TNA perspective, efforts at developing adaptation technologies are a key concern, especially in addressing the fragility of rural and agricultural communities. Mitigation was also important, although considering Uganda's modest carbon footprint of between 0.175 and 0.2 metric tons per capita of CO_2 emissions, its impact is negligible on a global scale. Assuming current levels of growth, by 2030 Uganda would have a carbon footprint of between 0.25 and 0.43 metric tons per capita of CO_2 emissions, still less than one tenth of that forecast for European Union (EU) countries.[10] Figure 2.11 describes the vast differences in global carbon footprints.

Nonetheless, there are sustainability challenges that are closely related to public health and SDG 3. For example, the entire Ugandan population is exposed to excessively high levels of PN2.5 and PN10 – a World Health Organization (WHO) measure of particulate matter pollution. In fact, Kampala is the most polluted African capital and it ranked poorly among global capitals for air quality. This is largely the result of the mass use of wood charcoal as fuel, often in urban areas and throughout all poor and rural parts of the country.[11] Technological solutions are known and available and centred around providing cleaner burning stoves and cleaner fuels, with bottled gas frequently mentioned as an improvement over charcoal fuel.

Expectations of development windfalls from the petrochemical sector, and commensurate policy attention, should not diminish policy efforts on developing alternative and renewable energy production and distribution.

Access to energy for citizens and firms is a key development concern. In order to satisfy the long-term development aspirations, per-capita installed generating capacity will need to be dramatically increased (see figure 4.2), and new generation capacity will need to be matched with grid extension. Hopes of the potential windfall of a growing and profitable petrochemical sector may act as a disincentive to invest in new projects based on renewables (hydro and solar). At the same time, the petrochemical sector has proved hard to materialize. There is uncertainty about how much of its output will be dedicated to domestic power generation and fuel supply on commencement of operations. Even when the petrochemical sector begins commercial operations, unless there are specific policy measures targeting the improvement of electricity access and fuel (gas) distribution in rural areas, the petrochemical sector may remain 'fenced off', with only minor impact on the social and economic development of Uganda.

Policies for adaptation to climate change are pertinent for rural communities due to their inherent economic fragility.

Adaptation measures aimed at agriculture, forestry, and water management should receive top priority, given the size of the rural population and the importance of agriculture for the economy in terms of value added and employment. Since the mid-1980s, there has been an overall decrease in average rainfall in Uganda of about 12 per cent (Ssentongo et al., 2018). While this trend was not expected to change dramatically in the foreseeable future, there has been a documented increase in the variability of rainfall distribution nation-wide, with some regions experiencing drought and increases in pestilence, while others faced threats from mudslides and related perils.

The technology needs of the transport and logistic sector require a holistic approach due to the large number of stakeholders and the complexity of the challenges.

Transport and logistics are another development challenge that require a holistic approach, informed by a plethora of sustainability concerns. Trade issues aside, the lack of effective, affordable and environmentally considerate transport solutions for Kampala has been generating substantive economic losses through time lost in traffic and a reduction of mobility. Public transport is privately owned. Suggestions of public involvement are deemed unrealistic, given the size of investment needed, potential engagement with existing private interests operating in the transport market, and the overall challenge of governing complex logistic systems, including handling daily operations. The most common modes of transport in Kampala are private taxi mini-buses (46 per cent), motorcycle taxis (32 per cent), and private cars (19 per cent).[12] Low income levels, the high cost of transportation and limited reach of mini-buses reduces mobility and access to jobs. Given that the transport system is as much a technological problem as a social and economic one, a sociotechnical systems approach could be a useful framework for developing and implementing policy, with a view to SDG 11.

2.5 Frontier technologies and relevance for national development

Whether and how frontier technologies are used to promote an inclusive and sustainable development agenda is fundamentally a policy decision. Given an understanding of their potential, support for their roll-out in innovative products and services that address critical social needs is a policy-must for Uganda. Here as well, innovation in the form of social entrepreneurship and impact investment, with policy playing a supportive and enabling role, may necessarily lead to sustainable action.

The key frontier technologies are AI, the Internet of Things (IoT), big data, blockchain, 5G, 3D printing, robotics, drone, and gene editing (see box 2.3). UNCTAD's *Technology and Innovation Report 2018 Harnessing Frontier Technologies for Sustainable Development* discussed how frontier technologies are converging through the increasing use of digital platforms to produce new combinatory technologies, accelerating the pace of change across multiple sectors. This report noted that while frontier technologies can accelerate the achievement of many of the SDGs, fast technological change can also outpace the ability of societies – and policymakers – to adapt and exacerbate existing economic, social and technological divides, and widen inequality.

Issues specific to particular technologies will appear, and policy bodies will need to provide

guidance to legislators. For example, AI can help curb illicit financial activity, including corruption and tax avoidance, by analyzing and reporting suspicious monetary transactions. But it may also support the development of biases against poor communities, vulnerable groups and individuals, and encroach on individual rights and privacy. Genetic engineering generates deep ethical questions in terms of its impact on all living creatures, human life included. At the same time, diverse and changing national legislations in export markets will require the alignment of national regulation and technological upgrading in exporting sectors and industries in developing countries. Failing this, export opportunities will be squandered. With regard to robotics, they are unlikely to replace workers in low-wage jobs in developing countries, or in trades and sectors that do not produce for export.

Box 2.3: Frontier technologies: Definitions

AI is defined as the capability of a machine to engage in cognitive activities typically performed by human brains, such as perceiving, reasoning, learning, interacting with the environment, problem solving and even exercising creativity.[13] AI is built upon vast sets of data, together with iterative processing and advanced algorithms, with which the software learns to perform cognitive activities.[14] Although AI is sometimes perceived as a future technology, it is in fact widely used today in the form of e-commerce, virtual assistants, photo identity recognition, or detecting credit card fraud.[15]

The IoT – or, Internet of Things – refers to the masses of Internet-enabled physical devices that are collecting and sharing data.[16] A complete IoT system is composed of four distinct parts: sensors/devices, connectivity, data processing, and a user interface.

Big data is a term used for datasets, the size or type of which goes beyond the ability of traditional databases to capture, manage and process. Big data has at least one of the following features: high volume, high velocity or high variety. Big data enables better and faster decisions by tapping into data that has traditionally been inaccessible or unusable.[17]

A **blockchain** refers to a time-stamped series of immutable records of data distributed on a cluster of computers not owned by any single entity. The information contained in the network is accessible by everyone on the network, but at the same time everyone is responsible for their own actions.

5G networks are the next generation of mobile Internet connectivity, offering faster download speeds of around 1-10 Gbps (4G is around 100 Mbps)[18] and more reliable connections on smartphones and other devices than ever before.[19] The low latency (the time it takes data to travel from one point to another) of 5G technology can contribute to fields such as IoT and tele-healthcare where a near-instant response time is required.[20]

3D printing (additive manufacturing) produces three-dimensional objects from a digital file. 3D printing is done with additive processes, creating objects by adding successive layers of material. Due to this additive feature, 3D printing can create more complex objects with fewer materials required than traditional subtractive manufacturing.[21]

Robots are programmable machines usually able to carry out actions, and interact with the environment via sensors and actuators either autonomously, or semi-autonomously.[22]

Drones are unmanned aerial vehicles or unmanned aircraft systems are that can be remotely controlled or fly autonomously using software supplied with data from drone sensors and Global Positioning Systems (GPS). Drones have often been used for military purposes, but increasing civilian use includes the following: search and rescue, surveillance, traffic monitoring, weather monitoring, firefighting, photography, videography, agriculture and delivery services.[23]

Gene editing (also known as genome editing) is a genetic engineering tool to insert, delete or modify genomes in organisms.[24] Gene editing is becoming increasingly affordable, and a promising tool with wider scale application over established methods, such as 'transcription activator-like effector nuclease' (TALEN), and emergent new technologies, such as 'clustered regularly interspaced short palindromic repeats' (CRISPR) and Prime Editing.[25]

Source: UNCTAD, 2020

Ugandan policymakers may need to be mindful of the changes in export markets for Ugandan products. The development of artificial intelligence and robotics, and other frontier technologies, in the markets of a developed export destination mean that Uganda will be decreasingly able to compete on lower labour costs. With insufficient development of industry and value-added services, Uganda risks being marginalized in the global economy and indefinitely entrapped at the lowest end of global value chains as an exporter of primary commodities.

In the context of the SDGs, the diffusion of frontier technologies will be critical to achieving many targets. Given Uganda's broad policy commitment to covering almost all the SDGs, it may be difficult to develop policy priorities regarding frontier technologies. STI road-mapping and forecasting will enable Uganda to anticipate and plan for developments in frontier technologies, instead of reacting to them when they appear, or when it is already too late.

With the acceleration of transformational and development processes, organic growth in the adoption of frontier technologies will likely come from the merging of digital and mainstream technologies. One such possibility will be innovations in medical technologies, in particular those relating to the use of ICTs to improve access to and the quality of health care. Positive effects can be expected on the delivery of basic health services to rural and remote communities, the provision of health-care education, and development of early warning systems for epidemics.

Agriculture, as discussed in chapter 5, can use frontier technologies to move Uganda towards developing sustainable food systems and producing food with adequate nutritional value while, at the same time, working towards SDGs 13, 14 and 15. Precision agriculture using satellite and drone mapping can be utilized to better manage the development and use of irrigation, fertilizer, and pesticide systems, while working towards increasingly sustainable outcomes.

There are indicative examples that frontier technologies can be highly relevant for Uganda's development needs.

The AI & Data Science research group at Makerere University specializes in the application of artificial intelligence and data science, including machine learning, computer vision and predictive analytics, to development problems in Uganda. Examples of recent AI-powered research include the mobile monitoring of crop disease (cassava), language processing techniques for low-resourced African languages, or automated diagnostics for malaria with digital microscopy.[26] Innovator Ketty Adoch is developing a geographical information system which will detect, quantify and monitor land cover change in and around Lake Albert and Murchison Falls National Park.[27] Both of these examples are especially focused on the scientific research end of the innovation processes and have been awarded international grants. On the more commercial side, Fenix International's ReadyPay off-grid solar electricity generators are IoT devices that incorporate smart controllers that are Global System for Mobile Communications (GSM) enabled and connected using MTN's mobile network. Their function is to monitor quality of service and enable features and services that offline devices cannot. A 3D printing initiative is described in box 2.4.

Big data is becoming perhaps the most relevant technology for SDGs. In 2015, the data innovation lab Pulse Lab Kampala started activities as an interagency initiative of the United Nations in Uganda and as a part of the United Nations' Global Pulse Labs network. Research has been devoted to mobile-based crop disease monitoring, mobile phone data analysis to strengthen vulnerability mapping, and satellite data analysis for environmental changes, as well as machine learning for managing the refugee crises. One key problem for the World Food Programme (WFP) and the United Nations High Commissioner for Refugees (UNHCR) was improving efficiency in aid distribution to refugees by using mobile money and digital payments instead of distributing food and material aid. To devise a solution, a data centric approach was taken examining what livelihood interventions were necessary to create a market system for aid that would seed and spur economic growth on top of satisfying basic human needs. As data plays an increasingly important role in adapting to climate change, some development agencies are seeking ways to use the data they gather to make their projects sustainable. One example is the Netherlands-based Technical Centre for Agricultural and Rural Co-operation. It provides finance for farmers, as well as location-specific advice for farmers to adjust crop schedules and techniques to prepare for oncoming weather. The sources of funding are subscriptions by farmers, and the sales of field-level data collected on crops, historical yields, labour deployed and GPS data from small hold farmers. However, initial indications of the salability of such data were moderate due to poor linkages and the scale of agro-industrial production.

Box 2.4: 3D printing in Uganda

A collaboration between the University of Toronto, Autodesk Research, the non-governmental organization (NGO) CBM Canada, social enterprise and non-profit Nia Technologies, and the Comprehensive Rehabilitation Services hospital in Uganda (CoRSU), are employing 3D-printing techniques to produce cheap, fast, and easily customizable prosthetics. The central idea is to provide prosthetics for children in order to improve their mobility and their participation in community life, thus reducing the risk of their social marginalization. Limbs are first scanned and processed using off-the-shelf commercial hardware and free software. The resulting model is printed on a 3D printer, which prints the socket (the point of contact with the body) in polylactic acid. This method can make a typical socket for under $10. This method avoids time-consuming production of negative molds using plaster, and the data on the fit is preserved electronically.

Ideally, the process would be fully transferrable to environments where the need arises. Competence would be developed locally, and scans would not be sent to developed country institutes for developing 3D models, thus reducing technological dependencies. As the number of people requiring amputations increases, the importance of establishing systems for providing affordable and locally available care becomes more important. WHO estimates that only 10 per cent of the global population has access to assistive technologies – a general term that includes prostheses – while these estimates are certainly lower in developing and least developed countries (LDCs). It also advises on the scarcity of prosthetic technicians in developing countries.[28] Training for prosthetic experts are rare in Sub-Saharan Africa. The lack of experts not only affects the ability to properly fit amputees but also to repair and maintain the prostheses. (Marino et al., 2015)

In September 2019, the Uganda Free Zones Authority issued a license for the establishment of a free zone to focus on blockchain and emerging technologies to Blockchain Technologies Ltd., and its parent company CryptoSavannah.[29] Uganda is the first country in Africa to issue this type of license. The free zone will contribute to establishing Uganda as the continental leader in blockchain and other Fourth Industrial Revolution (4IR) technologies. The Government hopes to combat the sale and distribution of counterfeit pharmaceuticals in Uganda and in the EAC. The contracted MediConnect blockchain-based platform enables the recording of prescription medication, thus identifying counterfeit drugs and preventing their distribution in the pharmaceutical supply chain. According to the Ugandan National Drug Authority, 10 per cent of prescribed medications have counterfeits on the market.[30] In other sectors, the South African coffee trader Carico Café Connoisseur, which trades quality Ugandan coffees like Bugisu Blue, has started tracking and tracing exports using blockchain technology.[31] A cryptocurrency exchange, Binance Uganda, has been active since June 2018[32] and has, to-date, 40,000 registered users.[33] With its large young and unbanked population, Uganda is seen as having potential for the deployment of cryptocurrencies. However, the Ministry of Finance has advised parliament that it is working on introducing regulations to govern cryptocurrencies, as there have been reports on the emergence of pyramid schemes branding themselves as crypto projects, with the usual consequences for naïve speculators.[34]

The use of drones in Uganda is as much a regulatory issue as a technological one. Currently, operation is allowed, but regulation is still under consideration as a draft, and is under consultation with stakeholders, including the Civil Aviation Safety and Security Oversight Agency. The Civil Aviation Authority has earmarked no-fly zones for drones.[35] Uganda is likely to see initial use of drones in development challenges. Environmental assessments aimed at evaluating conservation activity and ecosystem impact is an obvious direction. Social challenges, such as security in refugee camps and settlements near the South Sudan border, an area of about 250 km^2 and hosting about 270,000 refugees, require monitoring and reporting on potential points of conflict with the host community. Agriculture is another area. Drones can be used to perform soil and field analysis, and planting analysis, to define crop spraying needs, and conduct irrigation and crop health assessments. Finally, drone usage for photography and videography for news, events, leisure and hospitality (tourism) have commercial potential.[36]

2.6 Conclusions

There is an urgent need to energize transformational processes in Uganda. While there are a number of policy tools available, STI policy will require greater attention and efforts in implementation to address some of the challenges of the current economic slowdown. These challenges include a lack of productivity growth, export diversification and a change in sectoral balance of the economy away from low productivity agriculture towards higher productivity activities in industry and services.

Sustainability challenges need to be well defined, and in the context of Uganda's development aspirations, established through an objective process of technology needs assessments that engages all relevant stakeholders, and which fully considers the potential of all mainstream and frontier technologies.

Mastering technology transfer processes is key to both catalyzing transformational processes and working towards sustainability and inclusiveness, so that it has real impact. However, policymakers must move away from considering it as solely a technological exercise. Its success will depend on the ability of key institutions to reframe technology transfer as an economic *and* technological process of experimentation, which succeeds by embodying itself in products and services on the market or delivered by public services.

With this in mind, policymakers may consider the following:

- **A policy statement of the highest level is required to unify the perception of the importance of STI across all policy domains.** The acceptance of the role of STI is uneven across policies addressing economic development and, more specifically, the SDGs and Agenda 2030. This indicates that sectoral policies have been developed with insufficient coordination.
- **The development of a coordination process to energize a National System of Innovation that will work for firms and entrepreneurs, as well as activists and institutions working to meet the challenges of inclusiveness and sustainability.** NSI coordination will require investment in outreach and collaboration activities in all sectors, and improved inter-institutional communication at formal and informal levels. It will also require the joint development and implementation of activities and projects, such as capacity-building for STI policy or envisaged TNA exercises, in particular when these require interdisciplinary expertise.
- **TNA exercises should address inclusiveness and sustainability challenges of importance for Uganda.** Uganda's contribution to global greenhouse gas emissions and resulting climate change processes is negligible and is unlikely to be of significance before 2040. Nevertheless, policies for adaptation to climate change are very pertinent for rural communities due to their inherent fragility, as their fundamental economic activity is agriculture. High expectations of the positive transformative power of the future petrochemical sector are a disincentive for investing in alternative, renewable and clean energy sources, and this must be reflected in TNA as a distorting factor.
- **Frontier technologies and their use in promoting an inclusive and sustainable development agenda is fundamentally a policy decision. Policy should not prejudge their usefulness based on perceptions of frontier technologies being appropriate mainly for developed economies.** Frontier technologies can be relevant for Uganda depending on the ingenuity of their application and the social and entrepreneurial processes and challenges they set out to master and deliver upon. Policy should provide unambiguous support for social innovation and entrepreneurship and impact investment initiatives.

3. Policies and institutional capacity

3.1 Policies and institutions

The 2009 National STI Policy is consistent with the National Development Plan I (NDP I).

The 2009 National STI Policy was aligned with NDP I 2010/11–2014/15, with the intention to serve even longer until revisions were necessary. It assessed key elements of the STI environment and links STI policy key development goals, including poverty eradication. It noted the general lack of resources for all inputs into the STI process – finance, human capital, IP and institutional capacity – and asserted that such deficits were incompatible with Uganda's

development aspirations. The Policy established a set of guiding principles for the design and implementation (governance) of STI policy tools. It explicitly mentions the participation of the private sector, primarily as an investor. It anticipates elements of the future Agenda 2030 and the SDGs by highlighting safety, health, gender and equality concerns. It made 16 policy statements, grouped under four objectives, and with a unique goal: "… to strengthen national capability to generate, transfer, and apply scientific knowledge, skills and technologies that ensure sustainable utilization of natural resources for the realization of Uganda's development objectives." It provided an overview of institutional and financial requirements for implementation and concluded with a commitment to implement continuous monitoring and evaluation. Annex 3 presents the objectives and policy goals of the 2009 National STI Policy.

The 2009 National STI Policy was timely in its concern as it anticipated the challenges ahead.

The 2009 National STI Policy was timely in its anticipation of a slowdown in transformational and development processes and productivity growth, a concern that was juxtaposed against accelerating global technological development. The Policy understood the challenge posed to Uganda to make good its development vision to its people. However, the implementation of the 2009 STI Policy encountered a variety of obstacles, some of which stemmed from the processes of restructuring governance. For example, the ownership of the 2009 STI Policy rested with the UNCST, but the UNCST was moved from the Ministry of Finance, Planning and Economic Development, to the Ministry of Education, Science, Technology and Sports, before it was finally awarded to the newly formed Ministry of Science, Technology and Innovation. Other challenges related to a lack of financial commitment, and a lack of staff in various partnering ministries and agencies who could collaborate with the UNCST on implementation. The formulation of the STI Policy had its own issues, of which the modest reference to monitoring and evaluation is the most obvious. Lacking in performance indicators, evaluation criteria and time horizons for the its policy statements, the Policy was not well-equipped for implementation. As no data had been designated for collection (monitoring), a factual evaluation of the policy was not feasible. This had serious consequences for STI governance, as it reduced opportunities for policy learning and made developing an improved and significantly more implementable STI Policy for the NDP III 2019/2020–2023/2024 cycle unnecessarily difficult.

The National Science, Technology and Innovation Plan (NSTP) 2012/2013–2017/2018 introduced important advances in implementation frameworks for monitoring and evaluation.

In 2012, Uganda developed its National Science, Technology and Innovation Plan (NSTP) 2012/2013–2017/2018, which aimed to introduce and implement the framework for monitoring and evaluation. However, the framework itself was not implemented. The Plan's purpose was to facilitate the achievement of Uganda's development aspirations through STI. The key objectives were lifting out disenfranchised citizens from absolute poverty through the provision for basic human needs, a transformation of the economy from an agrarian to an industrial and knowledge-based economy, and enhancing Uganda's participation in global trade and development processes. It was also to serve in the implementation of the 2009 STI Policy through the development of an *Implementation and Results Framework*. Its 16 policy objectives and policy statements are largely identical to the 16 policy statements in the National STI Policy of 2009. The Framework specifies policy actions and expected results, as well as the institutions responsible, for each policy objective. However, it does not specify any indicators for monitoring, but concedes that an enhancement of capabilities for producing science and technology indicators is required. There is no mention of innovation indicators. Evaluations were intended to be disseminated as *Science and Technology Status Reports* (again, without mention of innovation), but none could be identified by the UNCTAD team.

In 2016, the Ministry of Science, Technology and Innovation was established.

To support efforts to achieve national development aspirations through STI-led growth, President Museveni established the Ministry of Science, Technology and Innovation in 2016. Its objective is to, "provide better coordination of STI efforts in the country, build effective linkages with all actors, and provide clear policy direction and supervision of STI initiatives" (MOSTI, 2017). In addition, the 23 Presidential Strategic Guidelines and Directives to the new Government guide policy interventions through which Science, Technology, Engineering and Innovation (STEI) could contribute to achieving the desired growth in the medium-term.

The creation of MOSTI is a key development as it creates policy space that is supported by the Government's budget dedicated to defined mandates. The lack of significant budgetary commitment to STI policy and corresponding institutional infrastructure has made evaluation of past policy initiatives difficult. The changes of institutional domicile of the UNCST during recent years has also not helped, neither with assessing needs in the STI sector and committing resources, nor with implementing monitoring and evaluation activities.

The creation of MOSTI aims at enhancing coherence and coordination in the STI sector and developing an NSI. The sector includes UNCST and UIRI as affiliated statutory institutions. The new structure of the sector also targets enhanced inter-sectoral linkages with other agencies, universities and institutions involved in STI and engineering activities. The Ministry has a mandate to provide policy guidance and coordination on matters of scientific research, development and the entire national innovation systems in the country. Its role is functional to enhance the effective implementation of the NDP II Interventions in STI to achieve the objectives of a) fostering the integration of STI into the national development process, b) increasing transfer and adaptation of technologies, c) enhancing R&D in Uganda, and d) improving the STI legal and regulatory framework.

The Ministerial Policy Statement (MPS) for the Science, Technology and Innovation Sector highlights the role of STI in achieving the objectives of Uganda Vision 2040.

The institutional system has been recently under reform and is in the process of finding new ways of functioning and new inter-organizational relationships within the newly established set-up. The first ever Ministerial Policy Statement (MPS) for the STI sector (MPS, 2017) acknowledges the essential role of STI in achieving the National Vision 2040 and the objectives set forth by NDP II. It recognizes that STI is indeed the engine of sustainable economic growth, development and transformation.[37] The MPS outlines several activities and functions for the STI sector and takes stock of its past achievements. However, there are problematic areas within this policy statement that need closer attention.

The Science, Technology and Innovation Sector Development Plan 2019/2020-2024/2025 identifies a number of challenges among which are a weak STI sector coordination and the need to invest in STI infrastructure.

The Science, Technology and Innovation Sector Development Plan 2019/2020-2024/2025 (in draft at the time of writing) lays out seven objectives and supports each with several thematic areas and associated actions. It also proposes four cross-cutting issues. These are presented in annex 4. The goal of the sector over the period of the Sector Development Plan is: "To strengthen the National Science Technology and Innovation system for Uganda." It proposes as the main pillars of the innovation system: a) access to business incubation, including access to scientific equipment and qualified technical supervision; b) functional science and technology parks for innovative technological firms; c) skilled human capital; and d) a legal-regulatory environment that fosters innovation. The Plan identifies a number of challenges among which are a weak sector coordination and institutional coherency, a need to invest in outreach to build popular appreciation and support for STI, an increase of investment in STI infrastructure, and an increase in financial resources available for the public sector STI institutions which currently stand at USh 184 billion or 0.56 per cent of the national budget for the 2018/2019 budgetary year.

Yet, policy still faces challenges in clearly defining the STI policy domain, with insufficient attention paid to the innovation component of policy and to the role of firms and entrepreneurs.

There is inconsistent engagement in policy with concepts of STI, and a hesitation in developing the innovation component as the primary element of policy work. Firms, and their central role in innovation, need to be redefined as the locus of STI policy. Throughout the document, sectors and industries as users and developers of knowledge and capabilities that can transform inventions into innovation, and thereby into economic and social value, are infrequently mentioned, as if they were not expected to play a central role in the process. This perspective has found its way into most government agencies that could be considered STI stakeholders. The consensus opinion is that as the private sector is weak, in particular industry and manufacturing, its role in STI policy can only be a minor one. The private sector is mostly seen as an investor for government conceived projects.

STI is a cross cutting issue that involves multiple stakeholders across sectors: complementarities should be encouraged in all possible ways. Other institutions extensively engage in research in the country, notably those related to agriculture and natural resources (see chapter 5 in this report), but they are not part of this sector and they are not mentioned in the MPS 2017. As the result of a long-established institutional setup, it is understandable that the shape of MOSTI is only now altering. However, research and innovation go beyond the boundaries of sectors and ministries, and their coordination and search for complementarities should be encouraged in every way possible.

The STI sector budget is dominated by personnel-related expenditures (i.e., salaries), which is understandable during the phase of creation of new institutions and their staffing. Nevertheless, the need for funding to enable the sector to implement sophisticated policies for innovation and research promotion cannot be underplayed. The nature, objectives, and rules of operations of the Innovation Fund are only sketched out in the document and remain largely undefined.

Funding of STI activities, and policy design and implementation, should be located in separate agencies according to recent best practice.

Discussions on the upcoming National Innovation Fund (NIF) indicate that the design of related policies and guidelines and in the implementation activities for funding of STI may rest in the same institution. This seems to be at odds with what is currently considered best practice: the separation of the functions of policy design from those of policy implementation using so-called *project implementation units* (PIUs). PIUs may be in-house but are often external and engaged on contract. If such a practice were to be followed, MOSTI would have as a primary role policy setting or serving as a locus for developing the highest-level national policy, including the design of specific policy instruments. The activity of managing public innovation funding would then go to nominated PIUs who have specific innovation fund management competencies (UNCTAD, 2019) and which may be held accountable to a prescribed level of performance.

Furthermore, rather than clarifying the division of roles, the provision of a policy function in each directorate of MOSTI may run the risk of causing confusion. This includes the issue that the role of the UNCST within the renewed STI governance framework is yet to be clearly defined. Thus far, the UNCST has been acting as a useful think-tank, policy designer and advisor, and manager of funding allocations. With the creation of MOSTI however, some of these functions will inevitably need to change.

Awareness of STI for sustainable and inclusive development is present and increasing.

The creation of MOSTI and the 2017 MPS for the STI sector highlights the interest and the importance for socio-economic and sustainable development that the Government of Uganda is giving to the issue of STI. The UNCTAD Team could detect an increasing and gradually spreading awareness of the relevance of STI for the economic and social development of the country.

3.2 STI indicators, monitoring and evaluation

3.2.1 Evidenced-based policymaking for STI

STI policy requires the production of key STI data on a regular basis.

Uganda's Vision 2040 and the global 2030 Agenda for Sustainable Development present ambitious aspirations and will require a major contribution from STI. The availability of relevant, reliable and accurate information on STI is vital to inform decision-making in the implementation of both strategic programmes.[38]

Data is increasingly easy to collect with the advances in ICTs, and Ugandan policymakers should take maximum advantage of this.

ICTs have facilitated access to and collection of a growing amount of data points as well as the design and use of analytical tools. There has also been a growing interest in public policy and private sector circles in such indicators. Nations that aim at knowledge economies with organized science and technology to achieve a wide variety of social, environmental and economic objectives, and in which firm and industry competitiveness is increasingly based on innovation, are all intense STI data users. In contrast, developing and least developed countries exhibit basic problems in the definition of indicators, the capacity to collect data, and indeed the political will to commit resources to the task. Fundamentally, data is often unavailable because it is not collected, or even if collected, may not be sufficient or reliable. For some indicators, data may not be collected in a systematic way, which will make it difficult to track

progress over time. Policymakers should be aware of how statistical operations, such as the use of mean or average scores, can mislead and disguise what is truly happening. Nonetheless, much can be done with existing STI data collection frameworks and efforts. Whether partial or experimental, they can still be very valuable to countries wanting to monitor their progress.

STI indicators will need to be measurable and coherent with future policy objectives. A distinction should be made however, between indicators that measure the progress of implementing the adopted STI policy based on the policy's proposed targets, contrasted with macro indicators that measure R&D, innovation, and higher education, amongst others, at the national level.

The NSTP 2012/2013–2017/2018 developed a Results Framework that aimed at translating the National STI policy of 2009 into measurable actions within a five-year period. This effort was a step in the right direction as its intent was to establish a monitoring and evaluation system that could inform on the performance of the Plan. This exercise would have been greatly beneficial if the proposed Results Framework had specified measurable indicators for the 16 proposed policy outcomes. As this plan is no longer current due to institutional changes, Uganda can develop a set of policy objectives and accompanying measurable indicators that would assess the country's STI performance covering the whole of its national system.

3.2.2 Rationale for monitoring and evaluation

A highly functional national policy monitoring and evaluation (M&E) system is crucial for providing information and feedback for policy learning.

Good policy design relies on data and critical assessment from established monitoring and evaluation systems and processes. Future policies need to reflect outcomes of informed decision-making processes. The role of M&E is to generate information about the efficiency, appropriateness, and effectiveness of public policy interventions. This information can be used to assess and enlighten processes of learning around policy practices and policy performance. Evaluation results may prompt policy learning: a re-positioning of policies and programmes, and adjusting the allocation or re-allocation of available human, financial and other resources. Their ultimate aim is to inform the development of a new national STI strategy.

The policy cycle for the National STI Policy 2009 has not been subject to a continuous M&E process. However, future policy cycles would be subject to, "A guide to policy development and management in Uganda" (2013) and "National Policy on Public Sector Monitoring and Evaluation" (2011).

In Uganda, greater attention to monitoring and evaluation will improve evidence-based policy development, resource allocation, and programme implementation. The ambition of the Government to systematically incorporate M&E into policymaking is manifested in the development of normative documents to guide this process. These documents include, A Guide to Policy Development and Management in Uganda (2013) and the National Policy on Public Sector Monitoring and Evaluation (2011), as well as the Results Framework in the National Science, Technology and Innovation Plan 2012/2013–2017/2018. These elements were absent in the previous STI policy cycle.

3.2.3 Production of evidence for policymaking

M&E requires high quality data. The Innovations Surveys of 2014 and 2016 are a step in the right direction.

Effective production of evidence requires the systematic collection of high-quality data and analysis of that data with rigorous research methods to create evidence for decision-making. Uganda's policy clearly states the need to strengthen the STI statistical system (Science, Technology and Innovation Sector Strategy Plan for Statistics 2013/2014–2017/2018) to produce high-quality data. As a result, R&D and Innovation Surveys were produced in 2014 and 2016. However, no new data has been produced since, despite the plans to produce data every two years. Though the Results Framework in the National Science, Technology and Innovation Plan 2012/2013–2017/2018 is commendable, it requires further definition of indicators and mechanisms for measurement, tracking and reporting. This presents an opportunity to further coordinate the objectives of the STI national plan with the capacities of the STI statistical system.

Interaction between policymakers and statisticians is key to developing high-quality data.

A strong STI statistical system, in addition to well-trained statisticians, needs policymakers that

understand the implications of the systemic nature of innovation. Statistics are often treated as though their meanings are transparent, even though they always rest on, sometimes implicit, conceptual foundations that need to be further understood to improve the selection about what evidence to collect. Good public management practices require unambiguous performance indicators focused on outputs and impacts. Too often, they rely on the measurement of isolated policy instruments supported by linear model rationales, such as Gross Domestic Expenditure on R&D, total R&D personnel, and others. Although it is possible to make crude correlations at the macroeconomic level between these indicators and the system's performance, such calculations need to be complemented with more detailed information about the links between policy and the observed impacts, the efficacy of particular policy mixes and individual instruments, and the specific actions needed to improve the overall system performance.

Evaluation is a learning process, not a system of punishment.

It is important to remember that the evaluation component is reactive. If it punishes those who try something different, or are perceived to do so, it can act as a disincentive to innovation. In contrast, the value of evaluation is in its ability to identify what can be learned both from 'successes' and 'failures' and the implications for future directions. Strong evaluation systems will be charged with a high level of independence, will work in a continuous and systemic manner, and will broadly contribute to quality assurance in policy processes.

3.2.4 Advocacy and communication of evaluation results

Strong advocacy for M&E is required because it is sometimes difficult to relate STI policy actions to innovation outcomes.

Creating strong advocacy for M&E presents a significant challenge for Ugandan STI policymakers given that advocacy for overall STI policy and activities is a struggle, let alone the M&E component of policy design and implementation. For the unacquainted, the utility and relevance of M&E STI policies can be difficult to grasp. Concessions are usually based on requests from international development partners and donor agencies or directives from policy mandates. This attitude is usually the reaction to several characteristics of STI. First, STI activities can have impacts that may be difficult to measure. Secondly, evaluation results are often needed early for policy decisions, sometimes long before the possible or desired socio-economic effects become apparent. Finally, many effects cannot be attributed unambiguously to one distinct project or programme. Efforts to communicate evaluation results will ensure the use of its findings and therefore build the collective credibility of the evaluations, policymakers and policies. Demand for M&E can be stimulated with the development of standards for the quality of evaluations, guidelines for how to conduct different elements of the evaluation, evaluation competencies, quality assessment systems, and communication competencies.

3.2.5 Funding for M&E

The Science, Technology and Innovation Sector Strategy Plan for Statistics 2013/2014–2017/2018 includes a funding plan for M&E activities embedded in policy processes.

This plan covers all aspects relating to the collection and dissemination of STI statistical data, including data production and development, human resources development, quality assurance, usability and dissemination, and coordination and management. M&E efforts need to be further integrated in the lifecycle of policies, as well as in the policy implementation mechanisms. Therefore, it is paramount to reserve appropriate financial and human resources to integrate M&E in all policy processes, as they are not a goal onto themselves.

3.3 Technology transfer capabilities

Technology transfer processes require greater policy support in Uganda if it is to realize its development aspirations and commitments to Agenda 2030.

Technology transfer processes in Uganda have significant challenges and are at a level that is not commensurate with its development aspirations, nor its commitment to the SDGs, as expressed in the NDP II. There are several factors that contribute to this situation. The first is a small manufacturing sector and an agricultural sector that produces largely for subsistence, rather than for market. The second is that, from a policy point of view, technology transfer is seen as a unique concern and considered as a techno-financial issue outside or, at best, on par with, the core of a broader

STI policy context. There are isolated projects in diverse sectors, but their impact on national technology transfer processes and nation-wide sustainable development has been negligible. Finally, technology transfer is often seen as an issue of international technology relationships and flows, whereby foreign technology is identified, imported, and adapted to local circumstances. This perception is essentially correct in the Ugandan development context. However, it falls short of recognizing that, when any technology's embodiment in a product or service is offered to consumers, its success depends on whether it then succeeds or fails in the national or local marketplace. This biased emphasis on the international dimension of technology transfer sways policy focus away from developing technology transfer support structures, and absorptive capacities for knowledge and technology in firms and industries.

The required policy framework for technology transfer overlaps with that required to develop a functional innovation ecosystem, a major function of which is to enable technology transfer. Thus, ensuring strong industry-academia cooperation, energizing an entrepreneurial culture and availing financial support to innovative firms and industries, and investing in developing the needed human and professional competencies, contribute to the development of technological absorptive capacity among firms which is the basic requirement for successful transfer of technology (UNCTAD, 2009).

Enabling technology transfer in order to address the SDGs is a known concern. Some activity has started, namely with the initiation of projects on so-called technology needs assessment for sustainability. UNEP and the Technical University of Denmark are at the start of an assessment process with the UNCST, while other development partners, such as the United Nations' Technology Bank for LDCs and UNCTAD, are working to complement UNEP's activities. While these initiatives are commendable, care needs to be taken that they do not limit themselves merely to the technological end of the challenge. Implementation and the sustainability of the proposed solutions will be the key challenge and may benefit from considering entrepreneurial approaches, social innovation models, and linking up with impact investors.

Institutions mandated to engage in technology transfer processes in Uganda are focused on the scientific and technological aspects. So far however, transferred technologies embedded in products and services have not managed to achieve notable commercial results in the national market.

There are several institutions nominally addressing technology transfer processes in Uganda.

Makerere University has a technology transfer locus in its Directorate of Research and Graduate Training. However, the UNCTAD mission found that a significant effort would be needed to operationalize the Directorate.

The mandate of the UNCST is to support the incorporation of science and technology for national development, advise the Government on STI policy matters, and coordinate R&D activities. It aims also to strengthen Uganda's innovation system, including technology transfer processes.

UIRI engages in collaborative technology transfer projects with foreign research organizations from industrialized developing countries, such as Malaysia and China. The UIRI aims to promote technology transfer that achieves the transfer of both technology and organizational know-how among collaborating institutions. The fundamental aim is the technological upgrading of the recipient's capacities and capabilities. Projects so far have been diverse, and span a multitude of sectors, from agriculture and craft manufacturing to electronics. The Institute hosts several pilot plants, a technology development centre and business incubation programme, which explore transfer and adaptation processes and challenges.

The rate of graduation from The Institute's incubation programmes remains extremely low. The main stated reason is that tenants do not have access to the necessary finance that will enable them to commercialize and leave the incubator (World Bank, 2014). This outcome can be recast however, as the result of a support process that is incomplete at the commercialization end and that does not provide an accompanying innovative business model that would serve to attract investors. Finally, there is no obvious link between selected projects and incubator tenants and the SDGs. Given the level of commitment to the SDGs in the NDP II, the opportunity for initiative, at least in the technology domain, lies squarely with the UIRI and collaborating institutions.

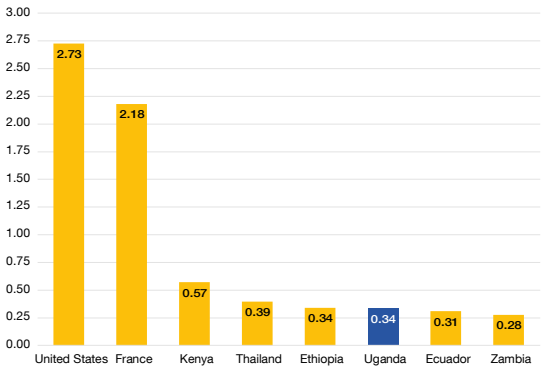
3.4 Investment in R&D

Uganda will need to increase demand for R&D activities. At current levels they do not have any meaningful impact.

The gross domestic expenditure on research and development (GERD) is one of the most common and oft-quoted R&D indicators, revealing how much a country spends on research and experimental development as a percentage of GDP. In developed countries, data on R&D activities are usually an important input for policymaking. R&D is part of a class of intangible inputs that also include software production, higher education and capacity building. Intangible inputs are as important a source for long-term economic growth as physical investments are in machinery. Figures 3.1 through 3.4 present key R&D indicators in Uganda. In addition, a minimum critical mass of researchers needs to be allocated to research and innovation activities. Current levels of R&D activity in Uganda do not allow for a reliable evaluation of their economic impact.

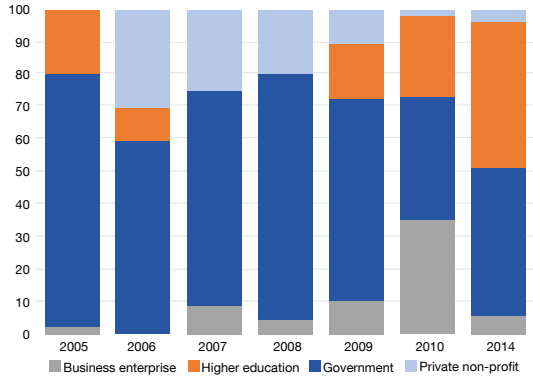
While Uganda's GERD as a percentage of GDP stood at 0.47 per cent in 2010, it had dropped to 0.17 in 2014. Compared with other developing countries, as well as regionally, this is not a significant difference. In Uganda, innovation drivers are weak, and demand for research that can translate into economic impact through entrepreneurship or social innovation is modest. Therefore, STI policy must realign its focus on policy objectives that create demand for technological upgrading which will, in turn, increase demand for R&D.

Figure 3.1: Average GERD as a % of GDP, 2006-2017



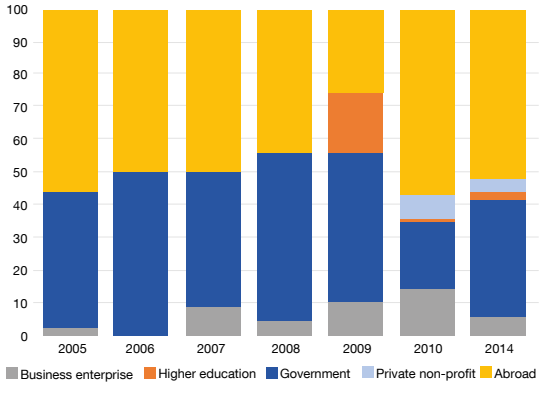
Source: World Bank

Figure 3.2: R&D expenditure by sector of performance



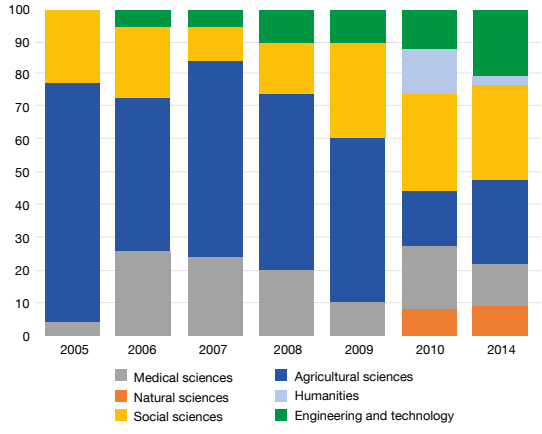
Source: UNCTS (2013 and 2016)

Figure 3.3: R&D expenditure by source of funds



Source: UNCTS (2013 and 2016)

Figure 3.4: R&D expenditure by field of science



Source: UNCTS (2013 and 2016)

Increasing R&D activities should be demand driven. However, R&D spending in firms and industries is low and fickle.

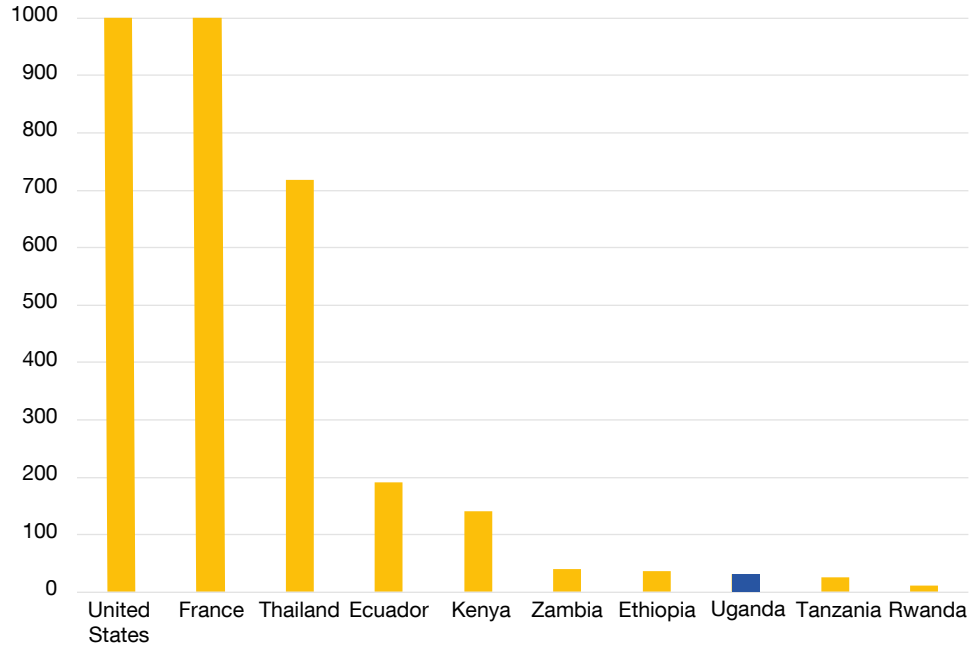
Governmental-sector expenditure in R&D accounted for 38.6 per cent of the total R&D expenditure in 2014 (UNCST, 2016). Government is the second biggest funder of R&D behind the international community. The growth of R&D that occurred in higher education between 2009/2010 and 2014 may be indicative of a trend. Despite this relative increase, however, the sector has little impact in terms of overall funding and R&D performance. Businesses seem to have made a relative improvement between 2005 and 2010 before dropping back in 2014. Generally, businesses make a limited contribution as a funding source of R&D.

Historically, agricultural sciences have dominated R&D expenditure. However, in 2010 it registered a big drop, which was counterbalanced by an increase in expenditure on social sciences, but also on engineering and technology, natural sciences and medical science, before picking up again in 2014. This flux is notable in part because agriculture is one of the priority fields of the NDP II. Expenditure on natural sciences only began to be registered in 2010, which makes establishing data continuity and assessing trends and appropriate policy action difficult.

The low relative number of R&D personnel in Uganda reflects a low demand for R&D services, as well as a perception that working in research is not a desirable profession.

In Uganda, R&D personnel number between 30 and 40 per million inhabitants, and of these only about 30 per cent are women. This number is similar in neighbouring countries but less than, for example, Ecuador or Thailand, who have at the same time similar GERD as a percentage of GDP (see figure 3.1). There are suggestions that the number of research personnel has been dropping from 37 per million in 2010 to 26 per million in 2014. A similarly dramatic change is reported in the number of researchers in the private sector, which has dropped from 50 per cent in 2010 to less than 5 per cent in 2014.[39] Policymakers will need to identify whether there are methodological issues with the statistics or if it is an indication of job offers and careers in research becoming undesirable, particularly in private firms and industries.

Figure 3.5: Total R&D personnel per million inhabitants, average 2006-2017



Source: World Bank

3.5 Financing STI

Limited access to financing can curtail innovations. The hampering effects on innovation caused by limited access to credit and capital for innovative Ugandan firms cannot be underestimated.

However, a key policy shift is needed in letting go of the understanding that financing R&D necessarily means funding innovation. While it is a necessary component of an innovation ecosystem, emphasis on R&D spending clouds the focus on the most acute issue facing Ugandan STI policymakers: firms and industries need funding to improve their capabilities to innovative in order to be more competitive and commercially successful, nationally and globally.

3.5.1 Banks and credit

Bank finance conditions for innovation and entrepreneurship are particularly challenging in Uganda.

Limited access to financing affects any business activity and decision (Ayyagari, 2012). It guides firms to minimize uncertain and risky activities and, by consequence, curtails innovation. There are 25 commercial banks and ten investment banks operating in Uganda (see table 3.1 for an overview of the financial sector). Average commercial lending rates are about 20 per cent (BoU, 2019). According to the World Economic Forum (WEF), Uganda's financial system is roughly in line with the Sub-Saharan African region (SSA). Its main weakness is a lack of instruments targeting innovation (WEF, 2018). Access to credit was not identified as a major problem following the Doing Business Report (World Bank, 2018), with only 19.6 per cent of firms identifying access to finance as a major constraint, compared with 39.2 per cent for SSA (World Bank, 2018). According to the World Bank Enterprise Survey, firms' use of bank credit remains low in Uganda. Only 3.1 per cent of investments were financed by banks (9.7 per cent in SSA and 14.8 per cent in the world), with the bulk of financing coming from internal sources (80.3 per cent vs. 74.2 per cent for SSA). Only 10 per cent of firms have a bank loan or line of credit, a proportion which is less than half the average for low income countries, at 22 per cent, and lower than in 2006 in Uganda, at 17 per cent.[40]

One area of strength for the country would be microfinance, with gross loans amounting to 1.7 per cent of GDP, which is 20th in a global ranking (Cornell University et al., 2018).

While microfinance is playing a positive role in Uganda, evidence from the last Global Innovation Index (GII 2018) paints a bleaker picture for the rest of the financial sector. Domestic credit to the private sector remains a considerable comparative weakness, and still represents a very small share of GDP (14.5 per cent). Another recent report reaches similar conclusions, stating that, "…While there have been big gains in financial inclusion, particularly formal financial inclusion, 22% of the population is still excluded, requiring both policy and private sector intervention." (FINSCOPE, 2018, p.33).

3.5.2 Development funding

Programmes promoting development funding of productive activities are active in Uganda. However, they do not focus on innovation.

In Uganda, active programmes promoting development funding of productive activities are often financed through international development cooperation. One of the largest is the Youth Livelihoods Programme (YLP) managed by the Ministry of Gender Labour and Social Development (MGLSD, 2013) and aimed at financing small projects developed by young potential entrepreneurs in rural areas.

The YLP was evaluated in 2016 (3ie, 2016). The main thrust of the programme was to invest in young people who have no prior business experience. Although the programme was effective, indicating potential and solid rationale for replication, it had had little influence on innovation, at least in part because it was disconnected from other STI stakeholders.[41] Nevertheless, some innovations are emerging from projects (cassava for cakes and cooking oil from palms), with many examples of frugal innovation (MGLSD, 2018). In addition, the requirement to pay back capital appears to have generated a high degree of financial responsibility among participating youths (see box 3.1). It incentivized them to invest in productive ventures capable of generating revenues, thereby improving their welfare, as well as enabling them to pay back the borrowed capital. With the exception of an emerging collaboration with the UIRI incubator and with the vocational education initiatives of the Ministry of Education, however, the programme also suffers from its relative disconnection from other programmes that focus on innovation promotion and technical support, like innovation labs and incubators.

Table 3.1: Uganda financial sector overview

Microfinance institutions	Commercial banks	Investment Banks	UgandaVenture capital firms
Mercantile Credit Bank Ltd*	Commercfial Banks	African Alliance Investment Bank	Mara Fund (start-ups)
Pride Microfinance Uganda	ABC Bank		Angel Initiatives (social enterprises)
BRAC Uganda	Absa Bank Uganda Ltd		Yunus Social Business (social enterprises)
FINCA Uganda	Afriland First Bank Uganda Ltd		GroFin (small growing businesses)
PostBank Uganda Ltd**	Bank of Africa Uganda Ltd		East African Premiere Investments (for-profit venture)
Uganda Finance Trust	**Bank of Baroda Uganda Ltd**	**Baroda Capital Markets Uganda Ltd**	
Top Finance Bank Uganda Ltd	Bank of India Uganda Ltd	Crested Capital Ltd	
	Cairo International Bank	Dyer & Blair Investment Bank	**Private equity firms**
Centenary Bank	**Centenary Bank**		Pearl Capital Partners
	Citibank Uganda		The Damascus Group
	DFCU Bank		Burbidge Capital Fusion Capital
	Diamond Trust Bank		
	Ecobank Uganda		
Equity Uganda	**Equity Bank Uganda Ltd**	**Equity Stock Brokers Uganda Ltd**	
	Exim Bank (Uganda)	UAP Old Mutual Financial Services Ltd	**Development banks**
	Finance Trust Bank		East African Development Bank
	Guaranty Trust Bank		Uganda Development Bank
	Housing Finance Bank		
	KCB Bank Uganda Ltd		**Impact investment fund**
	NCBA Bank Uganda		MANGOFund
Opportunity	**Opportunity Bank Uganda Ltd**		
	Orient Bank		
	Stanbic Bank Uganda Ltd	**CfC Stanbic Financial Services Uganda Ltd**	
UGAFODE Microfinance Ltd	Standard Chartered Uganda	Baraka Capital Uganda Ltd	
EFC Uganda Ltd	Tropical Bank	Rock Financial Services Ltd	Online loans for small business
Yako Microfinance Ltd	United Bank for Africa	SBG Securities Ltd	Kiva.org

* Wholly owned subsidiary of General Machinery motor vehicle dealer
** Wholly owned by the Ugandan government
Source: mangofund.org, ugfacts.net, Bank of Uganda, Captal Markets Authority and Uganda Securities Exchange

The Uganda Development Bank Limited (UDB) may need to scale up its innovation-focused financing as it positions itself to become an important venture capital investor in Uganda. Financial institutions that are entering the field of innovation financing should be actively involved in the development and implementation of STI policy.

Organizations like UDB and the National Social Security Fund (NSSF) have made first steps towards a greater involvement in innovation processes. The Bank, its partners and stakeholders, should review its mandates and continue to develop a baseline commitment to funding innovative firms and industries as part of its lending portfolio. There is a wide consensus that development banks could be an important source of innovation funding (Mazzucato and Penna, 2015). Development banks may act as lead funders of mission-oriented innovation, not only fixing market failures, but also shaping and creating markets. In this sense, the UDB could be another possible source of innovation financing. The Bank is a wholly government-owned Development Finance Institution with a mandate to finance enterprises in key growth sectors of the economy. UDB is partnering with the Government of Uganda in delivering its 2040 Vision and the NDP and focuses on the key growth sectors of the economy. Its role is very different from the role of the Uganda Development Corporation, the latter representing the actual investment arm of the Government. UDB loans approved during 2015-17 amount to a cumulative value of approximately $94 million (USh353 billion) (Uganda Development Bank, 2017), and disbursements for the same period reached $56 million (USh209 billion) for a total of 113 transactions.

The UDB is positioning itself to become the key Ugandan venture capital investor, though its impact is still limited. Recently, however, the Bank has faced challenges in funding, with the amount of capital raised lower than the loans disbursed and approved. Interestingly, from the point of view of its possible contribution to innovation in the country, the UDB is moving towards venture capital funds and has started an accelerator programme to scale up business ideas. One example, though still small, is a new challenge fund for smart agriculture, whereby the Bank provides seed capital through a grant, helps to incubate the idea, and may invest some equity later. Their main involvement in technology and innovation however, consists of financing the acquisition of machinery and equipment. In short, even if Uganda is a relatively small economy and the Bank's activities look encouraging, the financial size and scope of the

Box 3.1: Financing young entrepreneurs in rural areas – Youth Livelihoods Programme (YLP)

The YLP is a five-year development programme that began in 2013, targeting poor and unemployed youth aged between 18 and 30 in the 112 districts of Uganda. The Programme's development objective is to empower youth to harness their socio-economic potential and increase self-employment opportunities and income levels ('3ie' – the International Initiative for Impact Evaluation, 2016). The YLP provides support in the form of revolving startup credit-for-skills development projects and income generating activities initiated by youth groups. The programme is managed by the Ministry of Gender Labour and Social Development but implemented through district and local authorities. Expressions of interest are first presented by local communities to local authorities. The Ministry defines indicative planning figures for budget allocations by district, depending on population, relative poverty, and land.

The fund is recovering at a 66 per cent repayment rate as of July 2018. The interest rate is [zero][free] for the first year, and 5 per cent from the second year to cover inflation. Funding mainly goes to livelihoods projects (70 per cent), with the largest shares in agriculture and trade, to skills development and apprenticeship (20 per cent), and to institutional support (10 per cent). The programme had financed a total of 16,169 youth projects by August 2018 across the 112 districts of Uganda, for a total of USh123 billion ($33.5 million approximately). An estimated 197,728 youths benefited from the programme directly or indirectly. The demand for credit was overwhelming, and the programme could only respond to about a third of applications. Notably, 46 per cent of the beneficiaries were women.

Source: 3ie, 2016, and UNCTAD field visits.

UDB appears far from the levels required to finance the necessary substantial investments for STI-led development.

The NSSF is embarking on a new $300,000 fund to finance nascent enterprises during their incubation stage. These same firms may eventually become recipients of equity investments from the NSSF. While these are still small amounts, due to the risky nature of innovation investments, the Fund should carefully consider the impact of investing in innovation. Without doubt, its financial capacity will need to stay engaged primarily in ensuring the fulfilment of national social security mandates. Spurring growth through STI-led development should be everybody's business however, and the NSSF may need to assume an increasingly prominent and catalytic role, in particular by generating experience and capabilities in venture capital activities that can be absorbed by the investor community.

3.5.3 National Innovation Fund

To respond to the needs of financing innovation, MOSTI has also been developing a proposal to create a National Innovation Fund (NIF).

When the NIF started operating it was without a comprehensive legal framework. This represented a bottleneck in the administration of the fund and the oversight of funded projects. As a result, the 10th Parliament of the Republic of Uganda recommended that the Government expedite the process of developing a legal framework to enable the NIF to operate effectively (MOSTI, 2018, p.7). The main goal of the Fund is to promote R&D, technology incubation, and technology commercialization activities. Its legal basis and the proposed framework are described in box 3.2.

An innovation fund is an essential instrument in any STI policy or strategy, and best practices should apply to the NIF of Uganda.

Broad best practices can positively advise on the characteristics that an innovation fund should have, and on the factors determining its success. An innovation fund is an essential instrument for any country's innovation strategy. For example, a recent innovation policy review of Trinidad and Tobago noted that "… the most striking shortcoming is the absence of efficient public funding mechanisms to support business R&D and innovation, the central pillar of any advanced innovation ecosystem" (Guinet, 2014). Recent research establishes several key main characteristics of a successful innovation fund (Navarro, 2014). These are discussed in annex 5.

With specific reference to the proposed framework for Uganda's Innovation Fund, the Government of Uganda should carefully assess the available international evidence and evaluate possible alternatives. Policy reflections along the following lines are recommended:

- **The difference between invention and innovation needs to be absolutely clear** in the foundational document of an innovation fund. A clear innovation mindset should prevail and guide the functioning of the fund. For example, among the eligibility conditions for the award, the Curriculum Vitae (CV) and the list of publications of the researcher are frequently mentioned (MOSTI, 2018, p.29). While a researcher's CV may be relevant for a research fund aiming at financing scientific or applied research, it is of minor relevance for innovation where entrepreneurial drive and competencies in firm incubation and product commercialization are more critical.
- **The Fund will need to clearly decide if it will fund academic researchers or innovative firms, or a combination of both.** Given poor or non-existent links between academia and industry there is a large likelihood that the fund will finance academic research and call it "innovation". To avoid this pitfall, there should be distinct facilities in the NSI targeting different goals, but with a priority for funding firm-level innovation with proposals tabled by partnering industry-academic collaborators.
- **Selection criteria should target specific development objectives or SDGs.** The document mentions that, "…each proposal is evaluated on the basis of the set-out selection criteria." It should be explicitly stated that selection criteria will target specific strategic development objectives, including some or all of the SDGs. Policy coherence and directionality will need to inform mission-oriented research and innovation actions and their funding, oriented to address and solve specific challenges that Ugandan society faces, such as food security, nutrition, import substitution, climate change, gender inclusion or others. These objectives could be modified or reprioritized over time, as they become relevant in the process of development.

Box 3.2: The Proposed Uganda Innovation Fund – Governance and legal framework

The proposed framework explains that "The Innovation Fund is a set of Government funding instruments aimed at encouraging creativity and supporting innovations in Uganda. The main goal of the Innovation Fund is to promote R&D, Technology Incubation and Technology Commercialization activities. The direct objective of the Innovation Fund is to promote the implementation of innovative projects with the aim of facilitating the realization of new or improved products, processes or services designed to raise the economic efficiency, improve the innovative potential and technological level of enterprises, increase private investment and enhance the dynamics of innovation processes in Uganda" (page 8). The Fund's specific objectives are to: a) support technology development, transfer and diffusion activities in areas of strategic importance to Uganda; b) enhance STI capacity through strategic partnerships within and among institutions, sectors and disciplines for effective and sustainable technology commercialization; and c) support the development of key STI infrastructure and requisite human capital for its efficient utilization (MOSTI, 2018, p.8).

The Innovation Fund Awards Committee will be composed of the following members: an economist, an industrialist, a technologist, an entrepreneur, a lawyer, a finance and investment analyst, and an academician, all appointed by the Minister of Science, Technology and Innovation. They should hold office for a term of three (renewable) years, on a personal level rather than as representatives of institutions. The Committee will be supported by "Funding Proposal Assessors" selected on a case by case basis. They will do the following: evaluate and score project proposals for technological soundness and project impact, the strength of the intellectual property and the market, and the commercial attractiveness of the innovation; assess projects based on both the strength of the written proposal as well as the inventor's vision and passion for the project; and recommend the eligible proposals for consideration by the Committee. The work of the Committee will be supported by a Secretariat in the Department of Policy and Planning of MOSTI.

Proposed is that the awards will go to individuals or companies, and that there will be distinct funding windows for R&D, incubation and commercialization.[42] In addition, there is a provision of funding for national STI competitions targeting primary, secondary and higher education institutions in Uganda in carrying out new initiatives and innovative approaches in STEM, with emphasis on programmes that enhance teaching and learning.

The proposal also includes a role for the Innovation Fund to provide support to awardees in non-monetary ways. These would include coaching and mentorship in technical and business areas, strategy consultation, financial management, revenue strategy and fundraising, governance and human capital support, as well as legal advice in areas such as negotiation and the writing of contracts. There would also be access to networks and platforms for researchers and innovators to catalyse collaboration.

The Awards Committee in liaison with the Top Policy Management will also identify programme priorities and timelines in coordination with the Secretariat. It is not clear whether the award will be a grant or a loan. There is no mention of the possibility of a matching grant, with different percentages of matching contributions depending on the nature of the activity, or of the degree of innovativeness of the proposal. For example, international practice reveals that the greater the contribution to public good resulting from the activity, the higher the percentage of matching grants are likely to be. Whereas the matching grants will be lower if the benefits from innovation could potentially be fully appropriated by the innovator.

Source: UNCTAD field visits.

- **The attitude towards IP needs to be clear and representative of a consensus among STI and development stakeholders.** The document foresees that, "…The equipment procured under the Innovation Fund shall be public assets … and that … such equipment is not for the sole use of the Awardee and must be made available to other researchers/research institutions as and when the need arises" (p. 36). This is unsupportive of IP as a policy tool. It can create an impediment to private enterprises applying to the Fund. This provision, while perhaps justifiable for research projects, would not fit the needs of profit-oriented innovation projects that aim at commercialization into domestic and international markets.
- **Monitoring and evaluation are key implementation functions.** The document seems to underplay the role of solid, independent, after-the-fact, impact evaluations. They are different from forecasts and feasibilities, and ongoing monitoring and evaluation, and they require different capabilities and organization. They are essential in assessing whether the policy brought about the expected results, and whether public money was well spent, and what policy corrections need to be made in the successive cycle.
- **Innovation should be the top priority.** A risk of encompassing too many objectives surfaces from the proposal. Among the activities the fund aims at promoting are research, its commercialization, technology development, capacity building and institutional development. Such a large number and variety of objectives may be hard to achieve with the same instrument. Innovation should be considered a priority objective, provided that an innovation mindset is acquired and gains prominence in Uganda's STI stakeholder and government agencies, and especially in MOSTI and in the other organizations considered the core of the national innovation system.
- **In executing agencies and offices capacity building is a key issue.** The technical, financial, and administrative capacities required to manage an innovation fund cannot be underestimated. The capabilities required are not normally found in government bodies and they are also often hard to find on the market. MOSTI should foresee a budget and make a concerted effort to build such capabilities in a timely and effective fashion.

3.5.4 Presidential initiatives

Several interesting research projects are in development with grant funding under the Presidential Initiative programme. Their commercial success or development impact however, is difficult to assess.

Since 2010, financing for certain research initiatives in Uganda has been rewarded through the *Presidential Initiative for Science and Technology*.[43] This mechanism is very different from the examples of innovation funding presented above, as it operates only through grants and not credit. Moreover, the focus is on research rather than innovation. This Presidential Initiative was started with the purpose of enhancing the development of science and research in the country. The Initiative works through various bodies, including the UIRI, the UNCST, Makerere University Institute of Science and Technology/Food Science, and various research stations across the country.[44] The Presidential Initiative has so far financed the activities of Kiira Motors Corporation, which has a plan to produce electric cars in the country. It has also financed ten projects in the faculty of Technology of Makerere University through a Presidential Innovations Fund, and the Presidential Initiative on Banana Industrial Development known as 'PIBID'.

The PIBID and other Presidential Initiative programmes have made interesting research inroads, though meaningful commercial outcomes have yet to materialize. PIBID was generated in Makerere University with the objective of better exploiting the potential of banana production in Uganda, the largest in the world in per capita terms. It researched ways to develop technology for producing starch from green bananas which could substitute flour and fibres for food and pharmaceutical excipients. The initiative employs 16 scientists, and has a campus in the Western region, with a pilot farm, research units and labs. The key challenge for PIBID is to improve its linkages with other research initiatives in the country and with public bodies, firms and industries that can contribute to commercialization. Currently, PIBID is largely focused on research, with the development of possible applications, with market potential currently a secondary priority. For example, the initiative lacks any International Organization for Standardization (ISO)[45] or health and sanitary certifications, and this would be a serious obstacle in the way of generating products and solutions for the export market, or for domestic use in the food processing industry.

Innovation and commercialization of the research outcomes of Presidential Initiative programmes will require access to scientific data and data for feasibility analysis.

In order to evolve better linkages with other STI stakeholders, transparent access to financial, scientific and technical details, as well as operational directives of the Presidential Initiatives on Science and Technology, is needed. Insofar as MOSTI takes the lead in coordinating the Ugandan NSI, as announced and confirmed by the first budget assignments, the following policy elements should be considered:

- Policy initiatives should fall within the scope of planning, financing, monitoring and evaluation performed by MOSTI, and enjoy the maximum communication and transparency.
- A good international practice in research financing is the method of peer reviews and competitive financing, rewarding the best projects on the basis of blind independent peers' assessments. Evidence of this process could not be found in the present assignments.
- Research and innovation are two related but distinct activities, governed by a different logic and different rules, and requiring different human and technical skills. The design and management of funding mechanisms should take into account these differences and plan distinct and separate activities and resources accordingly.

3.6 Conclusions and recommendations

While much progress has been made on STI policy design and formulation, substantial challenges remain, among them in implementation, M&E, and collaborative policy action with other stakeholders. The following deserve highlighting:

- **A new innovation-focused mindset will need to be instilled in newly created institutions, and in those already in place.** The UNCTAD mission noticed that a research and science-driven approach has been prevailing for many years in the UNCST and has travelled to MOSTI during the recent phase of institutional development. Often, it is assumed that the researcher is also the innovator, and that research will necessarily produce innovation. However, Uganda has a growing understanding of research as an essential but separate dimension of innovation. Innovation – the act of bringing knowledge and inventions to market or to the public – is a risky activity with uncertain outcomes. Innovation is mostly carried out by firms and industries. It requires a different mindset from that found in scientific and research institutions.[46] The element of value-creation is central, be it market or social value, and should be reflected in the STI institutions' mandates and in their practices.
- **Mainstreaming STI policy will require both high-level and broad public dialogue.** The awareness that Ugandan society has about how STI can contribute to growth, welfare, employment, reduction of vulnerability, and improved welfare of livelihoods is nascent and needs enhancing. This is essential for a variety of reasons and should enjoy high priority in the shaping of the current strategy. Greater and a more comprehensive awareness of the role of STI in society and for the economy of Uganda would help MOSTI and the STI Sector to: a) gain higher priority in Cabinet decisions and budget allocations; b) acquire relevance and reputation among other ministries also engaged in activities and policies related to STI (e.g., Agriculture, Energy, Finance); and c) develop a consensus among the social and economic actors in Uganda on how a well-functioning and modern NSI can contribute to socio-economic development. The success of these tasks will be invariably linked to the support MOSTI receives from the Presidency and its Cabinet.
- **MOSTI will need to evaluate its internal organization in the near term, having acquired feedback on its initial years of operation.** MOSTI needs to improve its internal organization to strengthen its role as coordinator (orchestrator) of the national system of innovation. Different organizational solutions should be studied and assessed for this purpose with the involvement, where needed, of the international and donor community with the relevant expertise. These might include: a) using the Innovation Fund as a tool for enhanced coordination among all the actors engaged in investments in STI; and

b) establishing a role for MOSTI in evaluating and supporting other entities' investments in STI. These approaches could involve ex-ante planning and alignment of the STI-related funding vehicles in collaboration with other sectors, as well as ex-post appraisals of public spending on STI policy activities, using established and transparent monitoring and evaluation processes and tools.

- **MOSTI will need to be better connected with other political, economic and societal actors in Uganda.** As MOSTI correctly observes, the STI mandate is a cross-cutting one. Designing policy plans and strategies requires participation and inputs from all STI stakeholders and this has been largely the case in Uganda. However, the energy to move forward in a collaborative implementation will require a significant increase. MOSTI is well positioned to perform this role as catalyzer. It should act to raise STI policy concerns in the national development dialogue, communicate with other public and private entities, provide analytical contributions and insights into the use of policy tools, and activate virtuous policy learning cycles based on robust M&E.

- **The role of the Uganda National Council for Science and Technology in providing data on STI for evidence-based policy design and implementation will need to be strengthened.** After many years of activity, the UNCST has acquired a reputation of professionalism and efficiency. The new strategy could build on these achievements and define the roles of the UNCST. These roles would include taking charge of collecting (and creating if necessary) information on the innovation system, offering long-term strategic vision, and adding a technology foresight capacity. Within its roles it could improve the evaluation functions of innovation-related programmes and projects (so far largely neglected due to a limited understanding of their role and usefulness), helping to build a new function to carry out solid impact evaluations. The results would inform the design of new policies and programmes, or the reform of existing ones.

- **Policy must evaluate technology transfer, for sustainability or otherwise, based on the materialization of the transfer into product, processes, or services delivered by firms, industries or public bodies, to the market, or by providing a service to citizens**. To date, institutions mandated to engage in technology transfer processes in Uganda are focused on the scientific and technological aspects. M&E processes attached to implementation plans for STI policy will need to revise assessment methods and concede that existing technology transfer entities are, in fact, applied research and technology development institutions. Alternatively, these institutions can be upgraded through links with funding entities, and by enlarging their scope to address soft technology through improving linkages and collaborations.

- **Investment in R&D should be increased.** Care should be taken that this increase is demand driven and supports projects and activities that favour innovative firms and industries, as well as sectors and institutions tackling social and environmental challenges.

- **Financing STI, such that results in the form of products and services delivered on the market or through public service.** Financing STI will require a strong multi-stakeholder approach, analogous to the required financing mix. Financing STI can be easily misunderstood as financing public institutions that design and implement STI policy, including managing funding mechanisms.

4. Framework conditions for the national system of innovation

The level and quality of interactions among STI stakeholders and their capacities to create, absorb and produce knowledge and technology will deliver either a functional, or a fragmented, national system of innovation (NSI). Favourable framework conditions are the key to success for the NSI and STI policy in general.

The development of an NSI is only possible when framework conditions are favourable. Differences in countries' innovation performance depend on the behaviour and aptitude of relevant individual actors. These include firms,

universities, research and technology centres, public agencies, financial institutions, quality, metrology and certification agencies, and other innovation stakeholders. However, innovation performance also depends crucially on the interactions among these actors within a given policy framework.

Beyond the macroeconomic context, the most important framework conditions include physical and financial infrastructures supporting innovation. The nature of the business environment and competitiveness of firms and industries is another key condition. Human capital and its formation through the education and vocational system is also significant, as is the firm-level training, as well as the institutions and organizations relating to standards and IP, among others.

4.1 Key infrastructures supporting STI

4.1.1 Information and communication technologies infrastructure

ICTs are a primary platform for innovation: their availability and access, and use of broadband infrastructures, are key indicators. Chapter 6 of this report is devoted to ICTs, but it is useful to note several insights.

ICT infrastructure is a key development enabler. Improving services and lowering prices will require more infrastructure development.

Despite continuous growth, both mobile and Internet penetration appears lower in Uganda than in the rest of the African continent. According to the UCC (2018), there are 21.6 million mobile subscriptions, of which about ten million have Internet access. There 18.5 million Internet users which amounts to a 47 per cent penetration rate. More indicators are presented in table 4.1.

For entrepreneurs, firms and industries, the high prices of data in Uganda are a disincentive to innovate.

The costs of using broadband is high in Uganda compared with other countries in the region. While mobile data prices have dropped (see tables 4.2 and 4.3), costs are still higher than many other countries in East Africa. The example of Rwanda shows that progress is possible even in a low-income LDC context. Policymakers need to be clear on whether they wish to treat the mobile telephony and Internet services sector strictly as a commercial industry, which contributes to the national development and the public good mainly through paying taxes, or are wider issues at stake? ICTs are often under acute policy scrutiny because they are an enabler of other sectors and industries as much as they are a commercial venture. The current situation in Uganda is detrimental to its development aspirations. STI stakeholders, public agencies, regulators and telecom operators may need to jointly audit the conditions that have precipitated this situation.

Table 4.1: Key ICT indicators in Uganda[47]

Indicator \ Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Fixed broadband subscriptions	14 000	35 514	38 400	41 500	55 198	80 724	92 115	9 683	11 779
Fixed broadband subscriptions (per 100 people)	0.043	0.106	0.111	0.116	0.150	0.211	0.232	0.024	0.028
Fixed telephone subscriptions	327 114	464 849	314 956	272 844	324 442	328 811	368 243	262 286	186 902
Fixed telephone subscriptions (per 100 people)	1.01	1.39	0.91	0.76	0.88	0.86	0.93	0.64	0.44
Individuals using the Internet (% of population)	12.50	13.01	14.10	15.50	16.90	17.83	21.88	23.71	24.20
Mobile cellular subscriptions	12 828 264	16 696 992	16 356 387	18 068 648	20 365 941	20 220 273	22 838 486	24 948 878	24 472 033
Mobile cellular subscriptions (per 100 people)	39.56	49.88	47.33	50.62	55.18	52.90	57.60	60.60	57.27
Secure Internet servers	9	22	58	66	81	114	156	840	864
Secure Internet servers (per 1 million people)	0.28	0.66	1.68	1.85	2.19	2.98	3.93	20.41	20.22
ICT goods exports (% of total goods exports)	5.65	6.35	6.55	2.32	0.67	1.42	1.02	0.36	0.54
ICT goods imports (% total goods imports)	7.42	7.82	6.63	5.39	4.26	5.24	4.21	4.07	4.04
ICT service exports (% of service exports, BoP)	4.36	4.19	3.50	4.86	2.61	3.17	2.09	2.39	2.12
ICT service exports (BoP, current US$)	56 876 904	74 570 471	74 295 051	102 120 949	56 876 299	65 358 634	39 940 587	39 113 038	30 645 182

Source: The International Telecommunication Union (ITU), UNCTAD, the International Monetary Firm (IMF) and Netcraft

Table 4.2: Price of 1GB pre-paid mobile telephone and data package

Operator	Package designation	Technology	Price in USh	Price in $
Uganda Telecom	Premium Pack (1 Mbps) Fixed Data Bundle	wimax	37 000	9.99
MTN	MTN InternetShare	4G/LTE	35 000	9.45
Africell	Data Bundle	4G/LTE	34 500	9.32
Smile	Smile Lite Bundle	4GLTE	32 000	8.64
airtel	Monthly 1.5GB	4G	10 000	2.70

Source: Kompare.ug

Table 4.3: Affordability of 1GB prepaid mobile telephony and data (price as % of income per capita)

	2015	2016	2017
Uganda	27.71	15.33	16.20
Zambia	14.94	12.25	12.25
Ethiopia	19.63	13.53	9.65
Ecuador	6.58	4.12	6.11
Tanzania	8.74	6.25	5.83
Kenya	9.72	4.33	4.01
Rwanda	20.16	8.42	3.87
Thailand	2.27	1.19	1.31

Source: Alliance for Affordable Internet

Frequent policy changes, especially regarding the price and tax burden of utilities, create uncertainty which is detrimental to innovation.

A tax on mobile transactions and social media was levied in July 2018. The mobile money tax was then reduced within three weeks, from 1 per cent on both deposits and withdrawals to 0.5 per cent only on withdrawals. This inconsistency in policy creates uncertainties that damage innovation. Endeavours in innovation and their outcomes are, by their nature, highly unreliable. Any additional doubt about the business framework and fiscal conditions exacerbates the uncertain nature of innovation. The recent tax on social media access is an additional source of concern. Many entrepreneurs use social media to communicate on business activities, manage relations with clients and conduct market discovery. Not only do the taxes exacerbate uncertainty – which is a universal characteristic of poor policy design – the implemented taxes particularly hit the poor and un-bankable, i.e., those who are not able to use mainstream banking services to financially manage their livelihoods.

4.1.2 Energy

Uganda has ample hydro and renewable energy potential but suffers from energy poverty and high electricity prices.

Access to modern forms of energy and particularly electricity is a critical development challenge. This is particularly important for STI-led development where innovative firms and entrepreneurs explore new products and technologies, which are, without exception, all contingent on dependable and affordable energy. As well, improvements in public infrastructures, health and education needed for human development, rely on inexpensive and universal access to energy.

Energy consumption in Uganda amounts to about Btu 2.5 million per capita annually and is low, even by regional comparison (see figure 4.1).[48] As most of the population lives in rural areas, the most used energy source in Uganda is biomass. Biomass provides more than 90 per cent of nationally consumed energy, with the rest split between electrical generation (mostly hydro) and imported fuel used for transport.

Uganda is set to double its electrical generating capacity by 2025.

Uganda currently has 1,246 MW of installed capacity, of which approximately 945 MW is hydro, 152 MW is thermal, and 50 MW is solar generating. If projects under construction and under proposal go as planned, Uganda may see its generating

capacity more than double before 2025. Electricity supply has been limited mainly to urban and semi-urban areas. Between 2005 and 2018 access to electricity increased from 9 per cent to 22 per cent of the population, and the total number of subscriptions grew from 292,000 to more than 1.1 million over the same period.[49] Installed electrical energy production capacity per capita is about 0.032 kW (see figure 4.2).

Electricity production and distribution is largely seen as a business sector and consequently as a source of tax revenue, and to a lesser extent as an enabler of development.

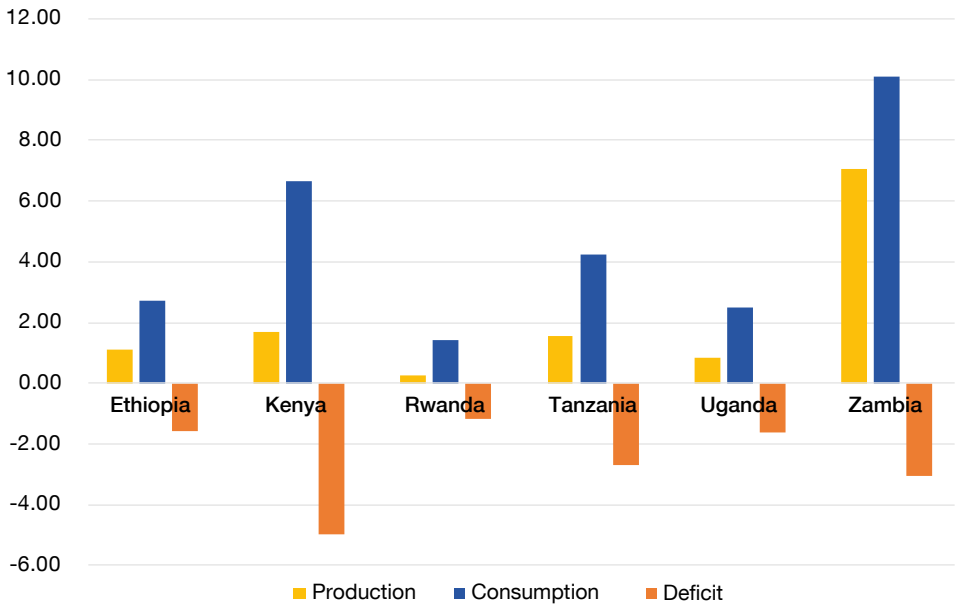
A change in implied policy occurred with the Electricity Act of 1999, which aimed to liberalize and unbundle the electrical industry in order to create a more efficient and competitive sector, open to private sector investment. However, results have not met expectations. Box 4.1 describes the framework for energy policy in Uganda. Power generation capacity is far below what is needed to materialize development aspirations, and equally the electrification rate is very low: 5 per cent of the population has access to the grid, but this figure drops to two per cent in rural areas. The key issue is that a lack of demand-side energy policy (subsidies, tax credits, etc.) that would enable poor and rural populations to access and pay for electricity, reduces the incentives to the sector to build generation capacity and the grids to service them. On the supply side, companies with small capacities may not be able to produce at a cost that allows for affordable tariffs.

Sustainability issues have a vastly different context in Uganda compared to developed economies.

Sustainability issues in Uganda, in terms of energy production and consumption, need to be contextualized against actual development concerns that are vastly different compared to mid- or high-income countries. In addition, several perceptions increase energy development challenges for Uganda. One is that sustainable development and increasing energy use and intensity are conflicting developments and should be a concern for Uganda. Even with optimistic growth forecasts, Uganda's carbon footprint should not be a major concern as it is currently only at about 0.15 metric tons per capita, in other words between 50 and 150 times less than in developed economies.[50]

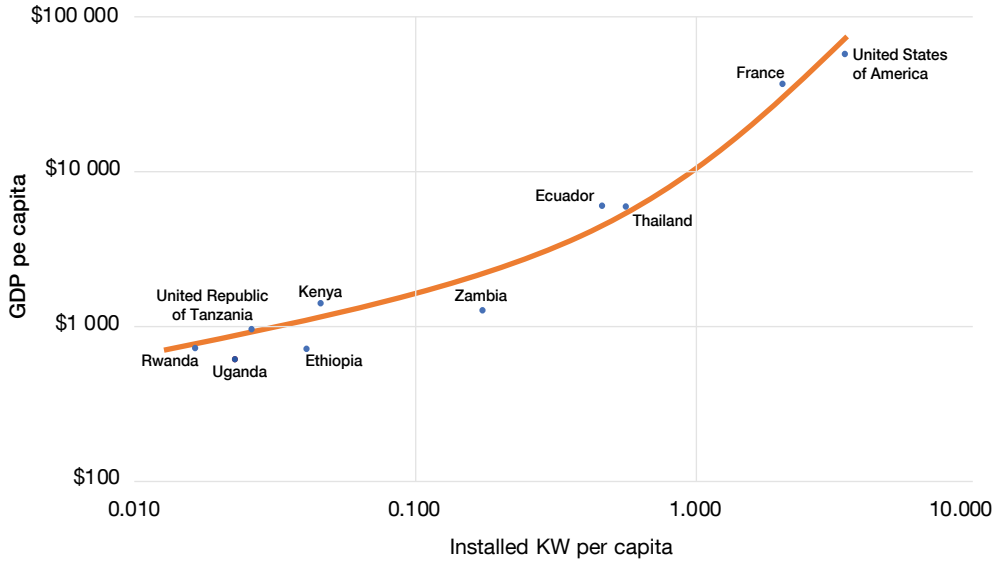
In terms of the effects on health and deforestation, the use of charcoal (biomass), which represents 90 per cent of total energy consumption in Uganda (see chapter 2 for a discussion and comparison of CO_2 emissions), undoubtedly poses a problem of sustainability. Another potential sustainability

Figure 4.1: Energy production, consumption and deficit, 2016 (Btu millions per capita)



Source: US Energy Information Administration

Figure 4.2: Installed generation capacity (kW) and GDP per capita ($)



Source: World Bank

issue is the effect of small hydroelectric generators on river health and biodiversity. There is also an assumption that electricity distribution should be a commercial venture when, in reality, it is a monopoly with a captive market. Finally, there is a perception that energy generation can be, in some part, based on smaller private firms under contract feeding into the grid. However, small producers neither have the economy of scale to produce at prices appropriate for Ugandan consumers, nor any negotiating strength vis-à-vis the monopsony buyer – Uganda Electricity Transmission Company (UETCL).

While the potential for renewable energy production and consumption is high, general awareness of available technologies is low.

Renewable energy sources, beyond hydro, have a large potential in Uganda. Estimates of potential

Box 4.1: Energy Policy in Uganda

Energy policy in Uganda is under the purview of the Ministry of Energy and Mineral Development. The Ministry is responsible for policy and for designing legislation in the energy sector.

The Electricity Act of 1999 liberalized the electrical industry by reforming the antiquated Uganda Electricity Board into three entities charged with electricity generation, transmission (covered by the UETCL) and distribution (UMEME Limited). It established the Electricity Regulatory Authority, a Rural Electrification Fund and an Electricity Dispute Tribunal to address consumer issues.

The objectives of Uganda's Energy Policy of 2002 are as follows: (1) to develop positive linkages between the energy sector, poverty alleviation and economic growth, (2) to integrate the objective of environmental sustainability into all energy initiatives, (3) to conduct demand-side management and improve energy efficiency, (4) to develop an energy resource base and disseminate key information, (5) to promote private participation and the development of competitive markets in energy technology and services, and (6) to develop, where necessary, appropriate regulatory frameworks and capacity.

The goals of the Renewable Energy Policy for Uganda of 2007 are as follows: (1) to promote renewable energy investments, (2) to support financing of renewable energy, (3) to promote R&D, technology transfer and innovation in renewable energy, (4) to improve use of biomass, (5) to promote use of biofuels, and (6) to promote the conversion of municipal and industrial waste to energy.

The Atomic Energy Act of 2008 provides a regulatory framework and guidelines for peaceful application of atomic energy, including for energy production. It establishes a national Atomic Energy Council and develops guidelines for individual, social and environmental safety, including the treatment of radioactive waste.

Table 4.4: Electrical generation capacity (as of 2019, MW)

	Number of power stations	Operating	Under construction	Proposed
Total hydro operating	21	945.30		
Total hydro under construction	8		696.80	
Total hydro proposed	8			730.96
Total thermal oil	3	131.50		
Total thermal bagasse	5	119.60		
Total thermal proposed	2			112.00
Total solar	4	50.00		
Total solar proposed	2			100.00
Total geothermal proposed	2			250.00
Total	55	1 246.40	696.80	1 192.96

Source: List of power stations in Uganda, Wikipedia.com

are 450 MW for geothermal, 1,650 MW of biomass cogeneration, and an average of 5.1 kWh/m^2 of solar energy. Including a potential total 2,000 MW of hydro, the overall renewable energy power generation potential is estimated to be above 5,000 MW.[51] However, public awareness about the efficacy and potency of renewable-energy technologies is low. There is important potential that comes from agricultural residue (cane, coffee and rice). Kakira Sugar Works has an installed capacity of 52 MW, the Sugar Corporation of Uganda Limited has an installed capacity of 14 MW, and Kinyara Sugar Limited has an installed generation capacity of 40 MW. The Electricity Regulatory Authority authorizes the sale of electricity to UETCL as a proportion of generating capacity. Table 4.4 summarizes the state of electrical generation capacities in Uganda.

Uganda is endowed with ample solar radiation of 4–5 kWh per m^2 per day. It has four solar power plants operating now with a total installed capacity of 50 MW. More than 40 geothermal sites have been studied to assess their temperature, chemistry, natural heat transfer and fluid characteristics to identify specific project areas and prioritize those for more detailed investigation. Investigations done so far have revealed three major potential areas for detailed exploration: Katwe-Kikorongo, Buranga and Kibiro (Fashina et al., 2018). Renewable solar technologies are in use for the development of off-grid solutions. Firms such as BBOXX, Virunga, MKOPA, and Fenix International are developing deployable innovative technologies that provide off-grid electricity to households in rural Uganda for the first time. The link between ICTs, mobile telephony, mobile money, and off-grid solar may

Box 4.2: Fenix International – Off-grid power meets mobile technologies

Fenix International is a Kampala-based next-generation energy and financial services company with a mission to transform their customers' quality of life through disruptive innovation in energy and financial services. By replacing fossil fuel-powered lanterns, solar home systems allow off-grid customers to illuminate their homes with light-emitting diode (LED) lights, as well as charge phones and run radios, and other home appliances. Fenix's off-grid power solutions are GSM-enabled. This allows Fenix to assess product usage and potential technical issues remotely, and provide timely service, improving the customer experience. Its flagship product, ReadyPay Power, is an expandable, lease-to-own home solar system financed through instalments from just $0.15 per day using MTN Mobile Money in Uganda. Real-time transaction data is used to create a next-generation credit score to finance power upgrades and other life-changing loans. To date, Fenix has installed over 500,000 ReadyPay Power systems in Uganda, Zambia, Côte d'Ivoire, Benin, and Nigeria. Fenix is expanding its product portfolio and geographic coverage to other African countries to bring power and a wider world of financing to over two million customers by 2020.

not be immediately obvious but it has enabled Fenix International to grow its business and accelerate deployment. Box 4.2 provides some details of their technical and business model.

The price of electricity in Uganda does not support its development aspirations. Despite the vast potential for electricity production from hydro, geothermal, solar and biogas/biofuel sources, electricity in Uganda is expensive compared with its East African neighbours (see table 4.5). Developing competitive sectors and industries is highly dependent on a consistent electricity supply at reasonable tariffs. Failure to improve access and reduce tariffs will have consequential negative effects on productivity, employment and wages. Domestic consumers pay USh752 per kWh, while commercial users pay USh666 per kWh. Medium industrial consumers pay USh595 per kWh, and large industries pay USh364 per kWh. A reduced "lifeline" (poverty) tariff is available for the first 15 kWh consumed.

Table 4.5: Price of 1 kWh in $

	Business tarrif	Household tariff
Uganda	0.18	0.20
Rwanda	0.24	0.20
Kenya	0.19	0.15
World average	0.12	0.14
Tanzania	0.10	0.10
Ethiopia	0.04	0.06
Zambia	0.04	0.04

Source: www.globalpetrolprices.com[52]

Oil industry

While Uganda has had confirmed oil reserves since 2006, it has yet to produce or ship any oil. If properly managed, the oil sector could provide revenue for investment in Uganda's socio-economic development.

Annual petroleum consumption in Uganda is currently about 12 million barrels.[53] Imports amount to more than $2 billion per year and represent about 8 per cent of total national imports or about 20 per cent of total export earnings.[54] Uganda does not produce any hydrocarbons, but there are expectations that this will happen in the near future due to the discovery of commercially exploitable oil reserves in 2006. Consumption of petroleum products has grown annually by 2 per cent on average during the last ten years. Figure 4.3 describes trends in petroleum consumption in Uganda and its country comparators.

Due to multiple and complex reasons, domestic oil reserves are not currently exploited. Uganda has an estimated reserve capacity of over 6.5 billion barrels of oil and 500 billion cubic feet of gas.[55] There are differences in interests among the many public and private entities involved concerning the development of refining capacity and about whether the primary customer would be the domestic or export market. The key issues for the oil sector are limited public finances, a modest ecosystem of proximate services and industries (bitumen, lubricant, fuels, plastics and other chemicals, and engineering services), a lack of strong consumer demand, and a large number of public agencies involved in a sector yet to commence production. Box 4.3 goes into some detail in describing developments in the oil sector.

4.1.3 Transport and logistics infrastructure

Uganda's transport and logistics infrastructure presents a challenge for the development of innovative and competitive firms and industries.

Transport and logistic infrastructures are highly relevant for innovation as they provide the physical conduits for the transfer of knowledge and technology, as well as services and goods, and facilitate the interaction with global markets of competitive and innovative Ugandan firms and industries. Vision 2040 explicitly states that, "Uganda must urgently attain an integrated transport infrastructure network to spur its own economic growth. This will entail development of a highly interconnected transport network and services optimising the use of rail, road, water and air transport modes." The National Transport Master Plan 2008-2023 presents the development of a framework and investment plan for the national transport and logistics system. It covers all modes of transport as well as transport in the Greater Kampala Metropolitan Area. Investment in transport infrastructure will aim to develop Uganda as a logistics hub within the EAC region and beyond, taking advantage of its central geographic location.

Box 4.3: Oil discoveries in Uganda: Are they going to change the economic trajectory of the country?

In 2006, Uganda confirmed discovery of crude oil resources of up to 6.5 billion barrels (BBL) in the Lake Albert Basin in the southwest, along its border with the Democratic Republic of Congo. Estimates suggest that about 1.4 BBL are recoverable, but only 40 per cent of the country has been explored so far. The institutions to manage such a discovery and its exploitation have been created, including Uganda's Petroleum Authority, the Directorate of Petroleum under the Ministry of Energy, and the Uganda National Oil Company, and several licenses have been granted of which nine production licenses and three exploration licenses are active. Negotiations with foreign oil and engineering companies are also underway, and additional investments by foreign companies of $20 billion are foreseen during the course of the next five years. As has been the case with other SSA countries, the Government has given local content (which in Uganda is defined as national content) a key role. The Government defines national content as the share of labour, services and goods for the petroleum sector provided from within the country and which constitutes an added value to Uganda.

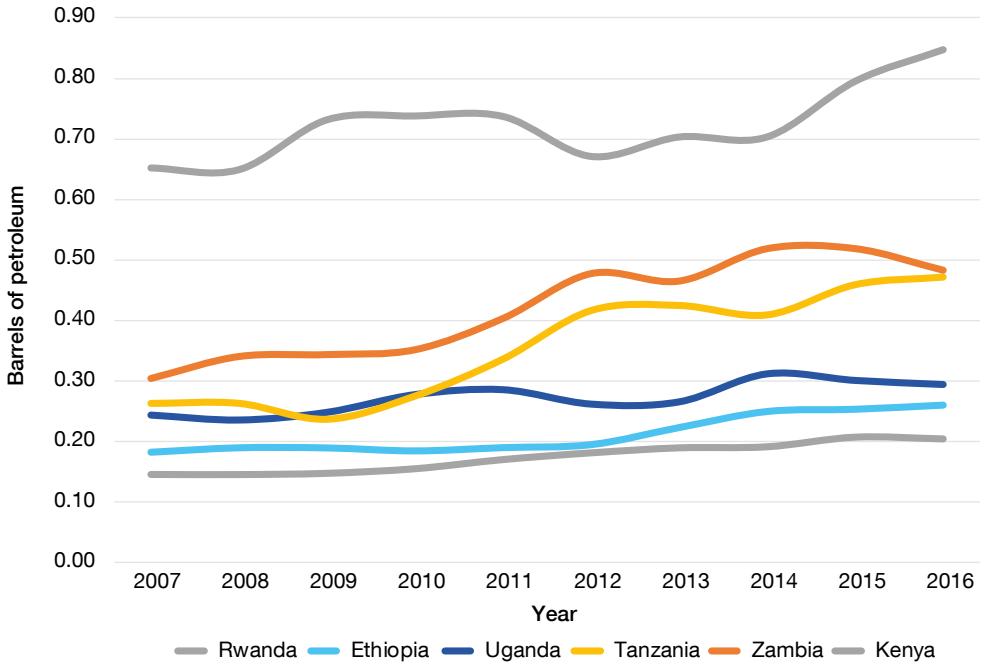
The oil discoveries have raised expectations of radical change to the economic trajectory of the country, eventually pushing it to a middle-income status. However, substantial uncertainties loom over the sector and its future impact. These uncertainties are multidimensional. They relate to the actual volume of reserves, the strategy to explore and then exploit the reserves, the costs to transport and market them, the private sector partners' involvement and their perceptions of feasibility, and the Capital Gain Tax and other taxes to be imposed by the Uganda Revenue Authority.

One crucial unfinished part of the development is the pipeline that will transport and commercialize the oil through Tanzania which, at 1,445 km, will be the longest electrically heated pipeline in the world. The dispute over the pipeline is related to the amount of oil that could be transported. In the opinion of foreign investors, it should be large enough to ensure economies of scale to cover the high construction and running costs. Another current issue is the Government's plan to build a refinery and therefore retain enough oil for local processing and consumption. This may not be a priority by the pipeline investors. Strategic considerations of Uganda's energy security however, are motivating the Government to develop local refining capacity.

In order to take full advantage of a developing petrochemical sector, Ugandan enterprises will need to take advantage of national content provisions. Recent studies suggest that Ugandan firms' capabilities to participate in the petroleum supply chain will require support in technological upgrading. When oil production starts and reaches expected levels, Uganda's next big challenge will be managing the huge revenues it is expected to make over the assumed 20 years of production. There have been discussions over the creation of a petroleum fund, inspired by the experience of Norway, that would fund infrastructure and other development projects. This would be a welcome and arguably necessary development.

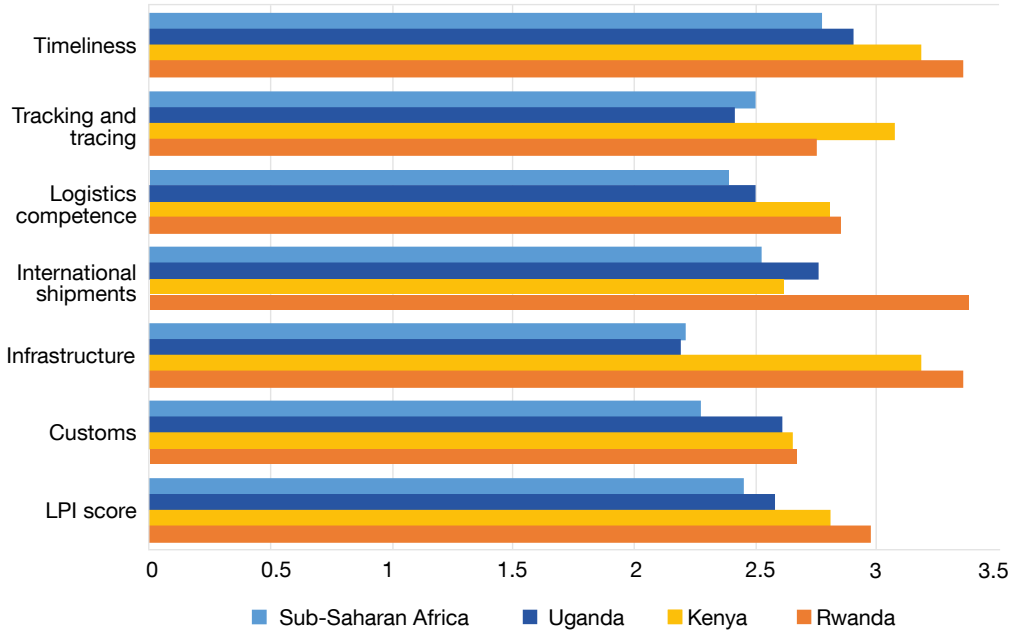
Source: UNCTAD field visits; Neuman et al. (2019); www.independent.co.ug/bad-oil-deal/ and www.ft.com/content/e057c978-1555-11e7-b0c1-37e417ee6c76.

Figure 4.3: Annual consumption of petroleum and other liquid fuels per capita[56]



Source: US Energy Information Administration, www.eia.gov

Figure 4.4: Logistics Performance Index – Uganda vs. Comparators, 2018



Source: World Bank, Logistics Performance Index 2018

The fragmented nature of the transport sector means policies, including those for sustainable development, are difficult to implement.

Most Ugandan transport companies are owner-operated, with individuals, firms and industries engaging them on a one-off or short-term basis. Infrastructure to neighbouring Kenya and Tanzania, in particular road and rail connections, is inadequate, and skills and competencies in the transport and logistics sector are equally lacking (World Bank, 2017). According to the World Bank's Logistics Performance Index, Uganda is better than average in the SSA region in many areas of logistics, but worse than its immediate competitors, Kenya and Rwanda (see figure 4.4).

Transport infrastructure, while growing, is insufficient for meeting development targets in Vision 2040 and in particular for growth in tourism, trade, industry and agriculture.

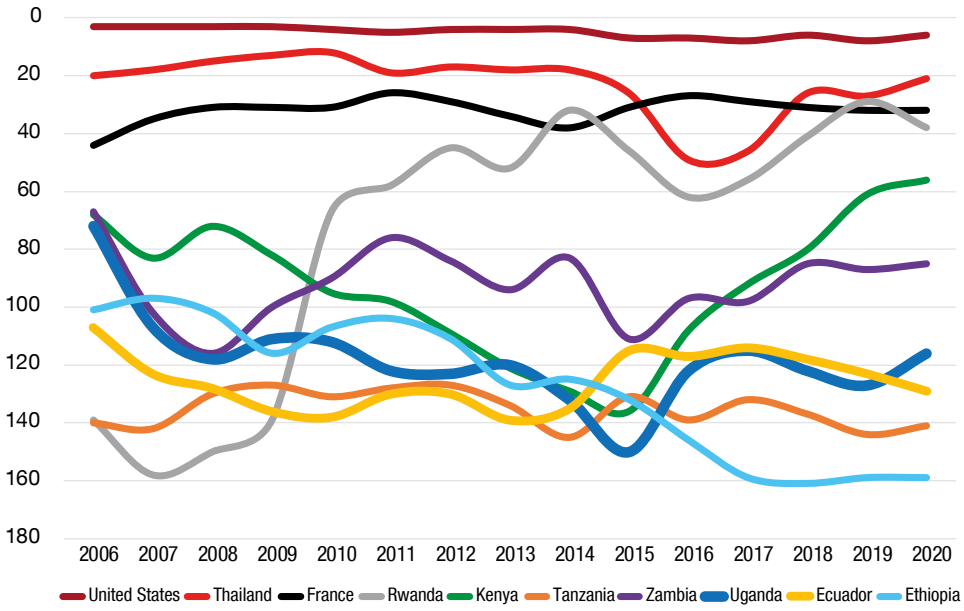
Ninety-five per cent of cargo freight in Uganda is moved by road. Uganda's total paved road network was reported to be 4551 km, with 97 per cent of the network rated as 'fair' to 'good' in 2017/18. The main trade road connecting Uganda and Kenya is a two-lane single carriageway with rudimentary truck stop facilities on entry and exit. The Kampala-Entebbe Expressway was officially opened in June 2018. The railway network is 1,266km long and consists only of narrow-gauge rail of which 325 km is operational. Commercial aircraft movements have been steadily increasing, with about a quarter of a total of 1.5 million passengers (arrivals and departures) flying to Kenya. Air cargo handled about 55,000 tons (imports and exports), and almost 30,000 aircraft movements were registered (MoWT, 2018).

4.2 Firm competitiveness and entrepreneurship

The state of the current business environment in Uganda, while matching regional averages, may not serve to achieve its development aspirations.

Enhancing the business environment is a highly important objective for energizing the national innovation system and improving its effectiveness. According to international benchmark indicators, the framework for international competitiveness in Uganda, measured by the WEF's Global Competitiveness Index (GCI), is at about the regional average, though rather low worldwide (117th in the ranking out of 140 countries) (WEF, 2018). Two of the competitiveness "pillars" identified by the WEF appear relevant to our purposes and refer to the innovation subsystem: they are "*Business Dynamism*" and "*Innovation Capability*".

Figure 4.5: Rankings on Doing Business for Uganda and comparators, 2006-2020



Source: World Bank Doing Business (2005-2019)

Business dynamism "concerns two elements that are intricately linked: the quality of a country's overall business networks and the quality of individual firms' operations and strategies".[57] These factors are especially important for countries at an advanced stage of development. Among the indicators are the cost and time to start a business, insolvency recovery rates and regulatory framework, the growth of innovative companies and the companies embracing disruptive ideas, and the state of cluster development. *Innovation capability* includes considerations for an environment that is conducive to innovative activity and supported by both the public and private sectors. The indicators considered, based on actual measurements or on executive opinion surveys, contain the following: investment in R&D, the presence of high-quality scientific research institutions and scientific publications, collaboration in research and technology between universities and industry, and patent and trademark applications, among others. Uganda is relatively better placed in these two pillars than in other fundamental pillars of competitiveness, like health, skills, and infrastructures. These are substantially weaker in comparative terms.

Another alternative approach to assess the effectiveness of the political and institutional environment for business are the *Doing Business* reports produced annually by the World Bank (World Bank, 2018). These reports measure the factors that are likely to affect the "ease of doing business", ranging from regulations, to infrastructures and credit.[58] Of course, these indicators do not specifically focus on innovation, or on science and technology, but they are likely to offer some insights regarding the factors fostering or hindering business development, and indirectly also the enterprises' innovative behaviour, decisions and strategy.

In this regard, Uganda appears to be in a worse place than other countries in the broader region, such as Rwanda, Kenya, and Zambia (figure 4.5). The areas in which Uganda is performing relatively better are in securing credit, enforcing contracts and paying taxes. Meanwhile, the regulatory framework to start a business, registering property, trading across borders and acquiring electricity, all appear to be problematic areas (figures 4.6 and 4.7). These survey results were often upheld during UNCTAD team field interviews.

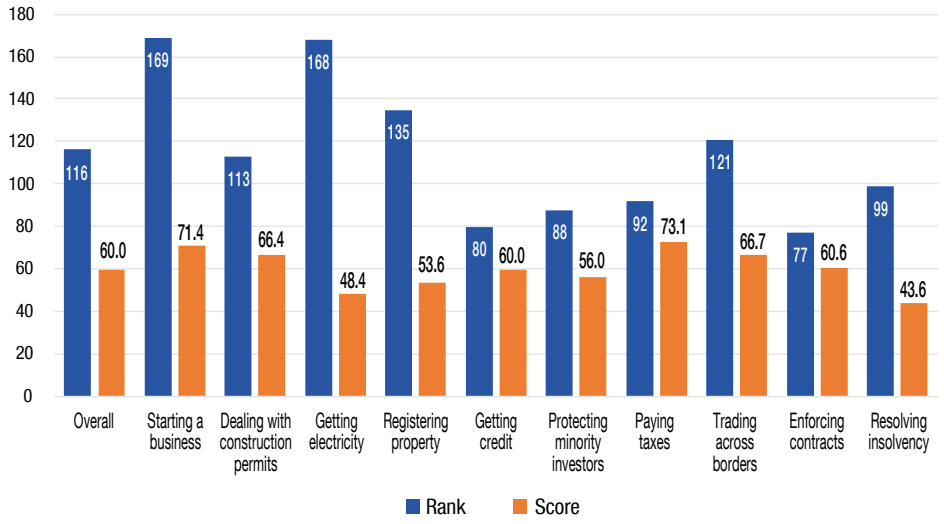
Uganda has a healthy attitude toward entrepreneurship and entrepreneurial risk and therefore is fertile ground for innovation.

Interestingly, the dimensions in which Uganda appears to excel are its attitudes towards entrepreneurial risk, growth of innovative companies, diversity of its workforce, multi-stakeholder collaboration, R&D expenditures and scientific publications. The Global Entrepreneurship Monitor (GEM) of the London Business School positively describes the Uganda entrepreneur. Perceptions of opportunities and own capabilities are high, fear of failure is low and almost 60 per cent of the population between 18 and 65 years of age intends to start a business sometime in the next three years. The social status of entrepreneurs is respected, and it is seen as a positive career choice. However, it is reported that less than 6 per cent of would-be entrepreneurs expect their future venture to innovate or create jobs in any significant manner.[59] The Global Competitiveness Index of the WEF gives additional insight regarding issues identified by the GEM. As the focus of the GEM and Global Competitiveness Index investigations is on advanced countries however, some caution should be applied in interpreting the results according to their definitions of innovation and competitiveness.

While entrepreneurship is pervasive in Uganda, much of it is out of necessity rather than opportunity.

The existence of good attitudes towards entrepreneurship and of good advisory services for entrepreneurs, such as Enterprise Uganda and the UNCTAD Empretec programme, creates an additional factor enhancing the working of the innovation system in a country. Although the assessment of Uganda's entrepreneurial system offered by the GEM is positive overall, it also raises substantial doubts. The last available data from 2014 suggests that the country may have, "… an abundance of willing entrepreneurs held back by limited skills and a lack of support from the Government."[60] However, these entrepreneurs are often more likely to be acting out of "necessity" rather than "opportunity", compelled to take initiative as a reaction to a lack of employment opportunities. This poses substantially different policy challenges. Their self-perceived opportunities, as well as skills and capabilities for entrepreneurship, are higher than regional and even global averages. They show low levels of fear of failure and see good opportunities to start a business within the next three years. These indices have been improving over the years, with a steady increase of female participation in entrepreneurship.

Figure 4.6: Rankings on Doing Business by topic for Uganda

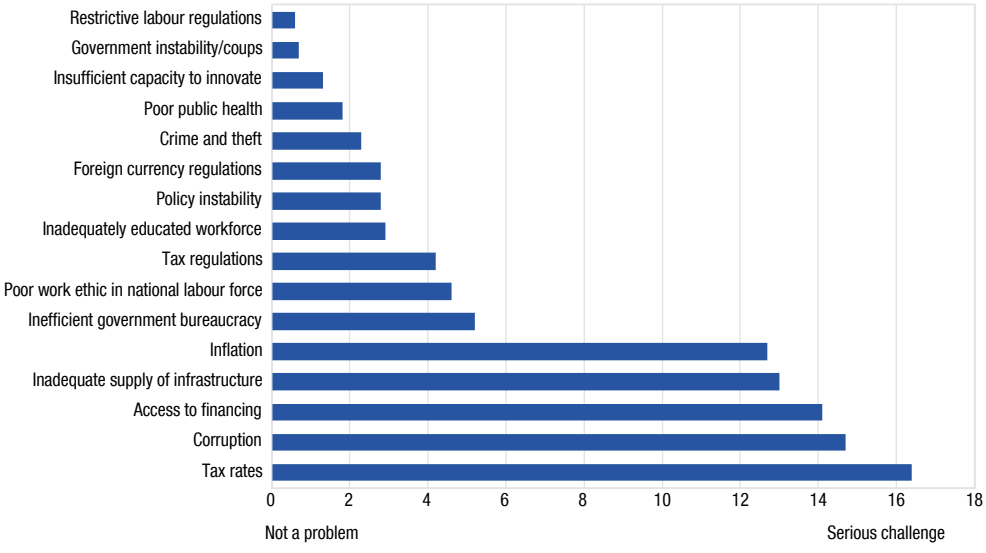


Source: World Bank Doing Business (2019)

Ugandan entrepreneurs will diversify across several micro-ventures rather than growing a business, as a fundamental risk-management strategy.

Positive indications of the prevailing attitudes towards entrepreneurship often fail to translate into actual dynamic enterprises due to several obstacles. The impediments most frequently mentioned in the surveys are unsupportive government policies (mainly heavy bureaucracy and taxes), and a lack of financing. Moreover, major challenges appear to include a resistance to grow and employ larger numbers of people, as well as the high business discontinuation rates. Some people discontinue when their businesses are ripe for sale. Thirty per cent of those who discontinued a business were currently starting another one, while 82 per cent expected to start in the next three years, and 58 per cent already owned another business (GEM, 2014). Thus, Ugandan entrepreneurs tend to own multiple small and micro businesses rather than growing one venture. Moreover, the innovativeness of the entrepreneurship initiatives in the country appears to be substantially lower than the regional average or countries with similar levels of income.[61]

Figure 4.7: Most problematic factors for doing business



Source: WEF Executive Opinion Survey [62]

Table 4.6: Types of innovation in firms

Type of innovation	Total (%)	Industry (%)	Services (%)
Enterprises with innovation activity	**77.0**	**85.7**	**73.8**
Product only innovators	11.2	7.2	12.8
Process only innovators	12.7	13.7	12.4
Product and process innovators	48.2	59.2	44.1
Enterprises with 'ongoing only' activities	2.4	2.4	2.4
Enterprises with 'abandoned only' activities	1.9	2.7	1.6
Enterprises with ongoing and abandoned	0.5	0.5	0.5
Enterprises without innovation activity	23.0	14.3	26.2

Source: UNCST (2016)

Many Ugandan firms innovate by purchasing technology or research and development. Their capability to conduct R&D in-house is low and may reflect overall national challenges in technological upgrading and acquisition. Firm-level investment in innovation will need to be increased several times to insure impact.[63]

In 2016, the National Council for Science and Technology conducted an Innovation Survey for 2011-2014 (UNCST, 2016) based on the Oslo Manual. The target population consisted of firms in the mining, manufacturing and services sectors. It excluded businesses in the sectors of health and education, the public sector, agriculture, fishing and forestry, and trade. The survey collected data from 589 firms employing ten or more persons from a total population of 6,475 business enterprises in the industry and services sectors.[64]

These enterprises generated 85.7 per cent of all turnover and employed 73.8 per cent of total labour in the sample. The survey results on the prevalence and types of innovation suggest that many Ugandan firms conducted some (usually low) level of innovation (see table 4.6). Indeed, 77 per cent of all enterprises employing ten or more persons in industry and services have conducted innovation activities in the reference period. During the period 2011-2014, industry is somewhat more innovative than services in terms of innovation activities, but not in terms of investment in innovation where the situation is reversed.

Firm investment in technology and innovation is too low for development aspirations.

Investment in technological innovation activities amounted to nearly $700 million in 2014 (see tables 4.7 and 4.8). Of this, the services sector enterprises invested $510 million, with industry investing $290. Over 64 per cent, or about $450 million, of investment in innovation was spent on the acquisition of machinery, equipment and software. Less than ten per cent of the total was invested in in-house R&D. The second largest investment line was in the purchase of external R&D. This is indicative of two critical problems that expose the low technological capabilities within Ugandan firms. First, they are technology users with minimal capacity to energize their own technological upgrading. Second, the actual figures are minimal as they represent about 0.22 per cent of GDP. For there to be meaningful impact, private investment in innovation will need to be increased in multiples.

Funding, innovation costs, economic risk and incumbent competition are the main perceived obstacles to innovation.

Most firms reported experiencing some kind of problem during the innovation process, including delays (32.6 per cent), abandonment of innovation projects at concept stages (22.6 per cent), and abandonment after the activity was started (21.3 per cent). Industry and services reported similar rates of abandonment and delays. The main perceived obstacles hampering innovation were a lack of internal capital, a lack of external funding, the high cost of the risk of innovation, excessive economic risks, and competition by established firms. Activities remain perceived mainly as cost obstacles. Figure 4.8 gives details on factors hampering innovation.

Table 4.7: Investment in innovation by sector and ownership, in $

	Ownership		Sector		All firms
	Ugandan	Foreign	Industry	Services	
In-house R&D	29,230,769	30,269,231	4,192,308	55,384,615	59,615,385
Purchase of external R&D	125,000,000	8,153,846	3,842,308	129,230,769	133,076,923
Acquisition of machinery, equipment and software	378,461,538	65,000,000	158,461,538	285,000,000	442,307,692
Acquisition of other external knowledge	7,653,846	6,884,615	888,462	13,653,846	14,538,462
All other innovation activities	10,038,462	28,730,769	8,384,615	30,346,154	38,846,154
Total innovation expenditure	550,000,000	138,461,538	175,384,615	511,538,462	688,461,538

Source: UNCST (2016)

Table 4.8: Investment in innovation by firm size – number of employees, in $

	Number of employees				All firms
	250+	50-249	20-49	1-19	
In-house R&D	1,653,846	3,130,769	18,692,308	36,000,000	59,615,385
Purchase of external R&D	1,530,769	3,807,692	118,846,154	8,961,538	133,076,923
Acquisition of machinery, equipment and software	51,538,462	338,461,538	20,769,231	33,038,462	442,307,692
Acquisition of other external knowledge	161,154	4,807,692	2,769,231	6,807,692	14,538,462
All other innovation activities	492,308	5,961,538	1,823,077	30,461,538	38,846,154
Total innovation expenditure	55,384,615	352,692,308	162,307,692	117,307,692	688,461,538

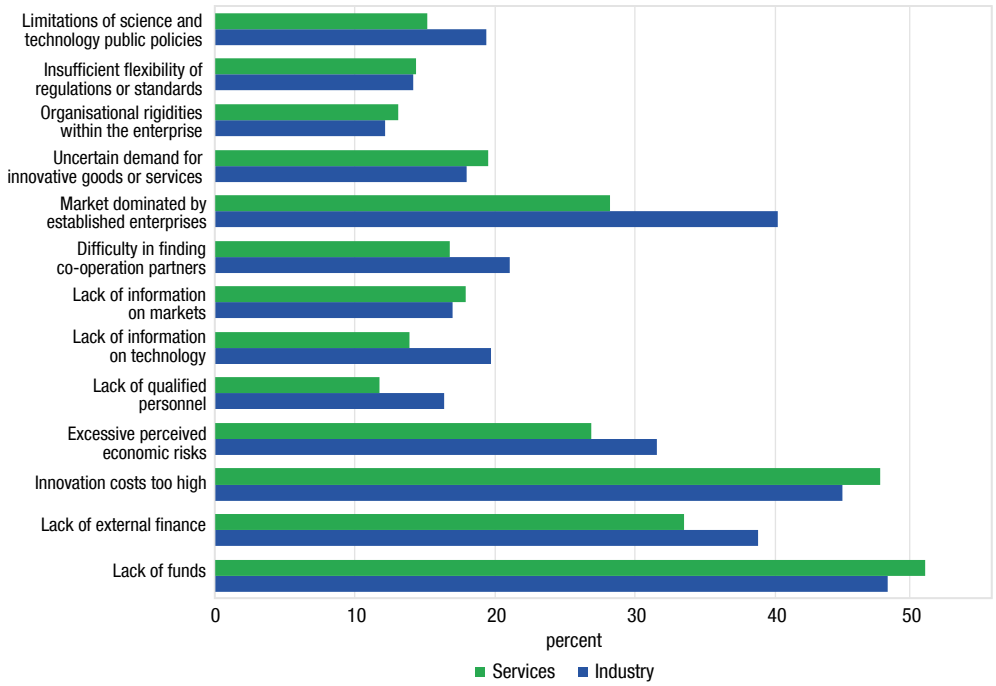
Source: UNCST (2016)

A key and underused policy tool for stimulating private sector investment in innovation is tax policy in the form of tax relief for investment in R&D or technology upgrading.

Additional conditions that may influence innovation in an economy are the specific provisions that may be granted by the Government – usually the Ministry of Finance or the Ministry of Trade – to stimulate investments in innovation. For firms operating in Ugandan Free Zones a 100 per cent deduction of expenditure on scientific research can be requested. Furthermore, all firms can deduct the cost of training or tertiary education, not exceeding five years, of an employee that is a Ugandan citizen or a permanent resident of Uganda (Stanbic, 2019).

Recognition of the importance of a supportive fiscal environment for the fostering of research, technology and innovation is crucial. In Uganda, most machinery and capital equipment are imported from abroad, and with them the technology embodied is transferred to domestic enterprises. In this regard, Uganda has a relatively favourable treatment of machinery imports,

Figure 4.8: Main factors hampering innovation in innovative firms



Source: UNCST (2016)

as tariff rates are lower for electrical and non-electrical machinery, transport equipment and other manufactures than for agricultural products (both for final bound and for most-favoured-nation duties). Moreover, large shares of these goods are imported duty-free (WTO, 2018).[65] In addition, the Uganda Investments Act of 1991 stipulates that 50 per cent of capital allowances for plants and machinery are deductible from a company's income on a one-time basis in Kampala, while 75 per cent of capital allowances are deductible in the rest of the country. Similar fiscal treatment should be extended to other inputs and resources that are needed to improve, sustain or strengthen STI activities in firms and industries, as well as in public research and related institutions.

4.3 Industrial parks, business parks, and incubators

4.3.1 Business parks and industrial parks

The policy instrument of creating and supporting industrial parks and business parks has been increasingly used in developing countries.

The names used to define the specific geographical areas with administrative, regulatory, and often fiscal regimes are different (and typically more liberal) from those of the domestic economy. The overall target of these initiatives is to promote investment, innovation and exports, investment attraction and employment generation. Thus, special economic zones, science parks, business parks and districts, are interchangeably used as generic terms to encompass a wide range of modern free zone types, such as export processing zones (EPZs), free trade zones (FTZs), special economic zones (SEZs), and others (Farole, 2011). In addition to frequently favourable fiscal concessions – e.g., low (zero) import tariffs, low (zero) corporate taxes, and export incentives – these areas sometimes include simplified ("one-stop-window") procedures to grant authorizations, licenses, access to services, and infrastructure provision.

STI parks require a diversity of tenants including firms, financiers and researchers.

In parks that have a strong STI orientation, the co-location not only of firms but also of research and training organizations, universities and technology service providers, is critical for success. The expectation is that geographical agglomerations in such industrial or science parks will enhance innovation through various avenues. These would include an easier match of innovation demand

and supply, public provision of research, easier collaboration and user-producer interactions in research and innovation. Diversity is key, and the enabling of informal interaction among entrepreneurs, financers and technologists is needed to precipitate positive innovation outcomes.

To maximize commercial and development impact STI parks need to be populated with tenants that would include industrial firms as well as research organizations, financiers and various companies providing, for example, design, marketing or logistics services.

The *Uganda Investment Authority* (UIA) has a mandate to establish 22 industrial parks and business parks to create jobs and add value to locally available raw materials. Some of them are currently operating, others remain in the planning stage.[66] The UIA can grant land for the industrial parks that, according to the plan, would include the creation of four regional Science and Technology Parks. The parks would work with MOSTI and with the National Planning Authority in the implementation of STI-led development polices. During field visits, the UNCTAD team understood that the approach currently followed is geared towards parks as a means of planning, and towards directing the allocation of land to various economic activities. This differs from what has guided the creation of parks in other countries. These had the explicit objective of enhancing "collective efficiency" (Schmitz, 1995) through the fostering of innovation by agglomerating diverse economic activities, as well as by developing clusters of research and technology organizations with pronounced commercial activities and objectives. A clear assessment of the objectives and implementation of the industrial parks in Uganda in light of good international practices may be useful.

4.3.2 Uganda Industrial Research Institute

The Uganda Industrial Research Institute (UIRI) has been at the forefront of the national effort to create and manage industrial parks.

The mandate of UIRI is to engage in activities that will lead to the rapid industrialization and productive transformation of Uganda, including applied research and the development and acquisition of appropriate technology. Its mission is to: a) improve the capacity and competence of indigenous entrepreneurs in undertaking viable industrial production processes and in producing high quality marketable products, and b) provide demand-driven scientific and industrial research and development and internationally competitive technical services (see box 4.4).

The UIRI is performing a valuable and relevant role in Uganda's innovation system.

UIRI's role in the Ugandan innovation system is especially noteworthy for its function of disseminating knowledge and helping existing and new firms to utilize knowledge and innovation for their commercial ventures. It is still small in relation to the size of the economy however, and its productive sector and could be strengthened and improved in multiple ways.

- The activities of UIRI should be expanded to improve its presence in the regions outside of Kampala.
- Its financing should be stabilized by the Government and make the institute less vulnerable and dependent on ad-hoc initiatives by donors and partners.
- UIRI activities should be consistently integrated into a coherent systemic vision, embedding human capital development, research and technology, and financing. Its integration into MOSTI offers an opportunity to follow such a systemic approach and position UIRI accordingly.
- Finally, supplier development programmes are notably absent from the range of services offered, whilst they could perform a useful role in helping to develop a local capacity to supply large (foreign) companies and traders operating in the country. Many international good practices exist, and these should be explored.

4.3.3 Incubators and accelerators

Incubation and acceleration activities have emerged in Uganda and have already produced success stories. Regardless of whether they are in the public or private sector, they deserve the full support and heightened attention of any policymakers and public agencies that are a part of the innovation system.

Incubation is the activity of providing highly flexible combinations of business development processes, infrastructures and people, designed to nurture and grow new and small businesses by supporting them through the early stages of development and

change. It is a public and/or private, entrepreneurial, economic and social development process designed to nurture businesses from idea generation to startup companies and, through a comprehensive business support programme, to help them establish and accelerate their growth and success (MOSTI, 2018).

A business accelerator is a programme that gives developing companies access to mentorship, investors and other support that helps them become stable, self-sufficient businesses. Companies that use business accelerators are typically startups that have moved beyond the earliest stages of establishment. In other words, they have entered their "adolescence" – they can stand on their own two feet – sometimes as a result of a successful process of incubation – but still need guidance and peer support to gain strength.[67] Therefore, in principle, a time sequence can be foreseen, in which incubation comes first, followed by acceleration. Of course, this is by no means obligatory, and firms may enjoy support from one or the other, or both, or simply develop autonomously.

Box 4.4: Industrial Research and Incubation for Innovation and Development in Uganda

The Uganda Industrial Research Institute (UIRI) was formally established by an Act of Parliament and H.E. the President to the Act on 30th July 2003. It is a progeny of the Nairobi-based East African Industrial Research Organization of the defunct East African Community (EAC). After the demise of the EAC in 1977, the three member-states continued with splintered Industrial Research Organizations, and hence the Kenya Industrial Research and Development Institute, Tanzania Industrial Research and Development Institute, and the UIRI were born. The Research Council of the EAC approved the setting up of a Food Technology and Industrial Ceramics Research Institute in Kampala (Lall and Pietrobelli, 2002, p.130).

In 1997, UIRI benefitted from a grant and an interest-free loan from the Government of the People's Republic of China to build a campus and some technologies for pilot plants. The formal handover of the modern facility to the Ugandan Government was concluded in the year 2000. For several years the Institute provided training and product development services in the food and ceramics sector, before expanding into other sectors and activities.

The UIRI's mandate is to engage in activities that will lead to the rapid industrialization and productive transformation of Uganda, including applied research and the development and acquisition of appropriate technology. The UIRI has been growing remarkably in the last few years, with 44 staff in 2005, to 250 staff in 2015, and a totally renovated technology facility installed with World Bank support. Its budget has also expanded from $170,000 in 2005 to $3.8 million in 2017. The UIRI is governed by a Board of Directors. It was under the Ministry of Trade and Industry (MOTI), but is currently under the new MOSTI. In fulfilment of its mandates, the UIRI performs the following functions, to:

- Identify and/or develop appropriate technologies and processes for the exploitation of the nation's natural resources.
- Upgrade and strengthen the existing indigenous technologies through basic and applied research.
- Set-up pilot plants to demonstrate the operation and benefits of new technologies, and otherwise perform the role of an incubator for new industrial enterprises.
- Design, develop and adapt machinery, tools, equipment and instruments suitable for small-scale enterprises, especially in rural areas.
- Maintain a comprehensive data bank on industrial research, technologies, materials and products.
- Facilitate the provision of technical advice and other assistance to existing enterprises in order to improve their competences and their operational efficiencies.
- Provide research findings to entrepreneurs to assist them in setting up new projects.
- Collaborate with other organizations, both nationally and internationally, to create synergies to improve knowledge, networking and capacity building for the benefit of the client base and for rapid industrialization through technology transfer.
- Serve as a production technology reference centre.

Box 4.4 (continued)

UIRI's incubation role is especially noteworthy, with its incubator space in Kampala and its work with a limited number of targeted clients. The UIRI has also expanded its processing facilities into rural areas, serving grassroots enterprises in less well-served regions of the country, and helping them to add value and contribute to the quality and marketability of commodity crops.

Some of the services they offer to their tenants are entrepreneurship training, business advisory services (including marketing, promotion and business development), mentoring, shared business support services, networking, as well as technology and technical know-how (World Bank, 2014). Most importantly, their incubators follow a principle of shared equipment and resources, whereby clients bring their material, are given supervision and advice, and are provided with machinery. In order to be accepted to the UIRI incubator programme, an enterprise must do the following: it must provide a comprehensive business plan illustrating the feasibility and viability of the company, the potential for commercialization, the timeframe of the collaboration, as well as enterprise ownership. It must also be willing to submit periodic financial and operational reports, and sign a Memorandum of Understanding in a virtual form, with clients located off-campus.

UIRI's business incubation activity is part of a technology development centre that helps develop capacity to carry out technology assessments. This centre also provides enterprises with services, such as improvement in product design, product development, product analysis, technology assessments and procurement. Currently UIRI is also developing a project for an Industrial Skills Training Centre with 200 trainees at any given time to serve the industrial sector, with Chinese funding from Hunan Province and co-financing offered by the Ministry of Finance.

Source: www.mtic.go.ug and UNCTAD field visits.

Recently, incubation has surged in Uganda with the emergence of a number of business incubators. Many of them, like the two noteworthy examples of Outbox and The Innovation Village, are promoting ICT-related ventures, and are analysed in chapter 6. However, some incubators are also emerging in more traditional sectors, like food and agribusiness. Among the many incubators operating in the country, the *Food Technology and Business Incubation Center* (FTBIC) is currently working at the University of Makerere's School of Food Technology, Nutrition and Bioengineering.[68] The objectives of the incubator include job creation through value addition to commercialize traditional products, based on research and training conducted at the university (see box 4.5).

Box 4.5: The Food Technology and Business Incubation Center at Makerere University

This incubator began in 2009 as a competition among students: 1000 candidates presented their business ideas, of which 100 were admitted and 30 graduated from the programme. Initial support was provided by the Rockefeller Foundation, which offered them training and enabled them to attend international incubator meetings, and by the Norwegian and Malaysian governments. However, the main source of funding comes from the Government of Uganda, through the Presidential Initiative for Value Addition, to equip the incubator with laboratories and processing lines.

Initial admission criteria were formalized, but later a new approach was adopted, admitting anyone with a prototype that showed the applicant's technical and business feasibility. Selected applicants are given an initial trial period of at least one month, and firms typically end up staying two to three years, during which the operation is on a cost-sharing basis. The project is not financially self-sustainable. The incubator can host 20 firms at a time, with each processing line used by more than one. The tenants (mostly fresh graduates) have access to processing facilities and are provided with technical support to boost their capacity in production, marketing and business management. This has led to the development of new food value addition enterprises, eleven of which are currently supported by the incubator. The focus is clearly on agro-industry, and on the commercialization and product improvement of traditional products of the country, such as pineapple, soya beans, katunkuma berries, amaranths, milk and meat.

Source: UNCTAD field visits.

The FTBIC focuses on smaller firms than those served by the UIRI, putting an emphasis on job creation, with innovation as an important but secondary consideration.

The FTBIC incubator performs an interesting role to improve commercialization of traditional products through technical and business advice, testing facilities and shared equipment. The focus of the newly created firms is mainly related to job creation and import substitution, and FTBIC typically serves smaller firms than the ones served by the UIRI incubator. New fast-growing firms are not likely to emerge from the incubator because, after they leave, they lack most of the additional conditions necessary for their success. This is partly due to the focus tending to be solely on the local market, but also because of a lack of credit, subsidized space and support to address more demanding (national or export) markets. The missing (fragmented) innovation and entrepreneurial system is a strong obstacle to overcome. The Government does not help new firms with support schemes or special tax provisions, though it does appear that a new awareness might be surfacing. This was made evident in the new loan from the African Development Bank to the Ministry of Education to support the incubation functions of Ugandan public universities.

A new dynamism in the activities of accelerators has also been observed in Uganda, but they suffer from the systemic fragmentation of the Ugandan innovation system.

Box 4.6: Innovation Village, Kampala

The Innovation Village stands in the deep gulley, where young businesses and ideas from Ugandan innovators previously used to fall and meet their imminent death. Setting out in mid-2015, our motivation came from watching multiple innovation competitions and award ceremonies that focus on the top three winners out of 100 submissions. In trying to answer, "… what happens to the other 97 ventures?" we built The Innovation Village to be a destination they can call home. Our programmes and initiatives capture new value from the digital economy: creating products, experiences, and businesses. We bring together a community where people can design, prototype, test, scale and launch imaginative and enterprising ideas together. Everything we do is built on four fundamental pillars – Place, Innovation as a Service, Ventures, Data and Technology Services to develop products and services for the ecosystem.

Over the years we have grown to become an ecosystem builder at the heart of an interconnected network of entrepreneurs, academia, private sector, government, investors, believers and doers deepening the application of technology in powering social economic prosperity. We have converged over 2,000 entrepreneurs, 40 per cent of these are young women, across six sector labs. What we offer in our labs is access to capital, capacity, networks, insights on sector trends, market opportunities and influencing policy. In 2019, The Innovation Village accepted two awards at the Top 100 Mid-sized Companies Award Gala. It was awarded as the leading Ugandan startup hub and The Most Innovative Company of 2019 and yet these awards are the journey and not the goal.

As we embark on the next decade, our core strategy is focused on market making for entrepreneurs to build a platform to ensure entrepreneurs are solving challenges at scale. Central to our growth has been the launch of initiatives including our custom incubation and acceleration model, launching a venture building model that ensures support at all the stages of growth, and an angel network and investment fund dubbed The 97 Fund. We are excited to do this at scale through launching three regional locations in the country to include new sites in Gulu, Jinja and Mbarara. Through this expansion, we dream of providing 300,000 opportunities for the young people of Uganda.

Source: CK Japheth, Founder, Innovation Village

Flaws in the Ugandan innovation system have particularly affected digital and ICT-related activities, such as the Challenge Driven Accelerator programme. This is a network of technical resources, as well as a network of potential investors, promoted by The Innovation Village (see box 4.6). New acceleration initiatives from the UDB and the NSSF have also been noted. As in the incubation activities described above however, accelerators appear to suffer from the incomplete and fragmented nature of Uganda's innovation system. They tend to operate in isolation and cannot easily leverage the relationships with other actors in the system, such as banks, research centres, large companies and foreign investors. The insufficient availability of technical skills, the fragmentation of many physical infrastructures, and the incomplete and embryonic national quality infrastructure, all contribute to the limits of the influence of the few emerging acceleration activities.

4.4 Human capital, education and vocational training

Improving human capital and access to education and vocational training are essential framework conditions for STI.

Firms, as well as research and government institutions, substantially benefit from access to an educated and skilled workforce with advanced technical skills and competencies. Skills and competencies range from research and development and applied engineering, to the soft skills and technical qualifications needed in commerce industry. Since skills and knowledge are generally considered to be for the 'public good', investments in education and skilling are typically supported by government and publicly financed. Firms and industries may hesitate before investing in employee skilling for fear that newly skilled employees may leave to work for another employer, taking their acquired competencies with them.

Uganda has youthful and growing population. This is both a challenge and an opportunity.

The opportunity found in Uganda's large and youthful population is in the productive and innovative energy that youth brings to all social and economic activities. The challenges for Uganda are threefold. The first is that high population growth consumes half of its yearly economic growth on a per capita basis. The second is that the knowledge and skills needed by Ugandan firms and industries are only partially matched by the outcomes of the educational, academic and vocational training systems. The third is that STEM studies are not seen as opportune directions for professional development and neither, therefore, for material gain.

The education sector in Uganda is itself constrained by many challenges, among which a lack of qualified education professionals and curricula that do not address the needs of students and pupils, nor of sectors and industries.

While the commitment to education is strong in policy documents, in practice Uganda is not finding sufficient resources to invest in its human capital development. Female enrolment in tertiary education is increasing and the relative gap between male and female enrolment still favours males, though that bias has decreased from 12 per cent in 2010 to 8.7 per cent in 2017. Basic figures describing the education sector in Uganda are presented in tables 4.9 and 4.10. All the indicators in table 4.6 are fairly constant during the observed period, except for a steady increase in female enrolment in tertiary education. Table 4.9 establishes that Uganda spends significantly less on education than many other countries in the east African region.

Other key challenges in education are a high level of teacher and student absenteeism, weak school-level management structures, inadequate availability of learning materials, and large class sizes. A major issue is also the availability of teachers in disadvantaged areas and a lack of accommodation for teachers in rural, hard-to-reach areas.[69] Public funding for higher education has also been declining over time. Pressure is put on existing old facilities in public universities, with a poor quality of service delivery as a result (UNESCO, 2017). Teaching methods are old-fashioned, and textbooks are often inadequate and not always used effectively.[70]

Table 4.9: Education in Uganda – key figures 2010-2017

Indicator \ Year	2010	2011	2012	2013	2014	2015	2016	2017
Government expenditure on education as % of GDP (%)	2.39	3.04	2.48	2.21	2.25	2.77	2.56	2.64
Government expenditure on education, $ (millions)	434	613	501	511	554	757	694	636
Enrolment in:								
Grade 1 of primary education, both sexes	1,943,552	1,839,714	1,877,801	1,883,803	1,932,489	1,843,058	1,888,847	1,965,606
Grade 1 of primary education, female	969,343	916,625	934,740	937,917	958,848	913,190	939,586	974,566
Grade 1 of primary education, female (%)	50	50	50	50	50	50	50	50
Primary completion rate, female (%)	55	52	54	54	57	56	53	52
Primary completion rate, male (%)	56	53	54	54	57	56	52	50
Enrolment in								
Grade 1 of lower secondary general education, both sexes	324,487	320,211	317,286	346,537	348,701	326,428	358,724	347,529
Grade 1 of lower secondary general education, female	156,605	153,537	152,366	167,524	168,067	159,604	175,529	170,595
Grade 1 of lower secondary general education, female (%)	*48*	*48*	*48*	*48*	*48*	*49*	*49*	*49*
Enrolment in								
Tertiary education, all programmes, both sexes (number)	120,646	140,087	124,561	141,436	165,396	160,288	167,195	174,103
Tertiary education, all programmes, female (number)	53,139	61,270	52,410	64,808	72,183	72,561	76,025	79,490
Tertiary education, all programmes, female (%)	*44*	*44*	*42*	*46*	*44*	*45*	*45*	*46*

Source: UNESCO and World Bank

Table 4.10: Selected international indicators for education[71]

	Ecuador	Ethiopia	France	Kenya	Rwanda	Tanzania	Thailand	Uganda	United States	Zambia
Secondary education (teachers per 1,000 population)	5.33	1.07	7.36	2.67	2.00	2.17	3.49	1.58	5.41	n/a
Pupil-teacher ratio (primary school)	23.32	57.34	18.36	41.36	62.46	49.17	16.55	47.38	14.40	49.85
Government expenditure on education (% of GDP)	4.78	5.02	5.52	5.73	4.09	3.81	3.99	2.54	4.95	1.36

Source: UNCTAD calculations based on UNESCO and World Bank data

The National Curriculum Development Centre is an autonomous body of the Ministry of Education and Sports in charge of developing curricula for primary, pre-primary, secondary and Business, Technical, Vocational, Education and Training (BTVET) schools. While there is broad discussion and questions about the relevance of the current curricula for Uganda's socio-economic reality and development aspirations, the Centre is confident that its subject-related curriculum development boards are operational and embrace all the necessary stakeholders. A revision of O-level secondary curriculum has been in the works since the mid-2010s with the aim of refocusing core themes and reducing the number of subjects from 43 to 20.[72] Stakeholders, including firms and industry representatives, are included in the consultations of the curriculum boards. There is no evidence however, that stakeholder concerns have affected curriculum development and stakeholder participation on the various boards are mainly seen as an expression of goodwill and a wish to maintain courteous inter-institutional relationships.

The limited ability of the BTVET institutions to produce skills and competencies relevant for Ugandan firms and industries is a bottleneck for STI-led development.

The BTVET system is characterized by an amorphous structure, with the coexistence of many different entities (UNESCO, 2017). The country's 33 vocational and technical institutes train students in technical skills needed in industry, but the extreme variance in quality and content of vocational training remain a challenge, as do the problems of coordination and management. Discussions with entrepreneurs during UNCTAD missions to Uganda indicated that while the private sector unambiguously advises that training is essential for business, the ability of the BTVET institutions to produce skills and competencies continues to be a bottleneck for Uganda. Curricula are often outdated, and skillsets far removed from the needs of modern manufacturing, and even further away from the needs of innovation. In many vocational training institutes, the courses on offer have changed very little, and areas such as digital technologies, automation, and artificial intelligence are not typically covered. Many manufacturing workers have never entered a factory before employment. This forces larger companies to vertically integrate and provide trainee programmes and shop-floor training to all their employees. As a result, they are internalizing the necessary costs of additional training and thereby reducing their competitiveness.

University and tertiary education are being challenged to produce adequate numbers of STEM graduates that have an innovation mindset and competency and confidence to easily step into professional life upon graduation.

Current levels of communication and coordination with representatives of sectors and industries is insufficient to meeting the supply and demand of the labour market. In tertiary education, total student enrolment is around 260,000 per school year, from an eligible population of about four million youths. While most public universities offer several degrees in science and engineering. Expenditure on research for the year 2017/18 was 6.2 per cent of the budget of public universities and only 2.51 per cent in private universities (Uganda National Council for Higher Education, 2019). Most universities do not propose areas of study that address sustainable development and socio-economic challenges. Disciplines that tackle problems in water, sanitation, energy, shelter, infrastructure, food industry etc., are not adequately addressed in engineering curricula in Ugandan universities (MOSTI, 2016). The bulk of engineering jobs will tend to be in civil engineering within the construction industry, which is the largest sub-sector in industry.

4.5 Standards

The effective definition of standards and functional certification mechanisms are an essential public service for an innovation-led economy.

Standards provide the language and means of communication for sharing the necessary knowledge on products, services, and their intrinsic characteristics, and to foster how markets and firms work within them. Moreover, services such as equipment calibration, and product testing and metrology, foster firms' efficient production and are essential determinants of innovation and learning at the firm-level. This is especially true for developing countries, where these institutions do not necessarily exist. Such institutions are not taken for granted as they might be in more industrialized countries, where sometimes these services are also provided by private organizations, industry associations and technical service centres (Lall and Pietrobelli, 2005).

Box 4.7: The role of standards in innovation – the Uganda National Bureau of Standards (UNBS)

The UNBS is a statutory body under the Ministry of Trade, Industry and Co-operatives established by the UNBS Act Cap.327 in 1983, and it became operational in 1989. It is governed by the National Standards Council. It is responsible for providing oversight and policy guidance to ensure effective service delivery. The Council is mandated to: a) formulate and promote the use of standards; b) enforce standards in protection of public health and safety, and to protect the environment against dangerous and sub-standard products; c) ensure fairness in trade and precision in industry through reliable measurement systems; and d) strengthen the economy of Uganda by assuring the quality of locally manufactured products to enhance the competitiveness of exports in regional and international markets.

The Bureau operates through three directorates, in charge respectively of the formulation and promotion of standards, the products and system certification, and metrology and laboratories. They act as a regulatory body, issue standards, as well as facilitate their compliance, certify, as well as ensure, imports and market inspection and surveillance. They employ about 200 staff, and work with 18 technical committees, often headed by professors and universities/research organizations. Although the laboratories and metrology facilities remain in the newly constructed headquarters in Kampala, they have offices in other regions and are pushing towards greater decentralization. Their standards are largely harmonized with EAC standards.

The UNBS charges fees for many of its services to firms and currently obtains about 50 per cent of their revenues from these services, representing a substantial improvement from the past, when over 90 per cent of resources came from the Government (Lall and Pietrobelli, 2002). Nevertheless, it is still a lower percentage than other similar organizations in the region. For example, the Kenyan Bureau of Standards is nearing 100 per cent of self-financing. The Bureau often collaborates with the private sector through associations such as Uganda Manufacturers' Association, Uganda Small Scale Industries Association, Uganda Women Entrepreneurs Association Limited (UWEAL), and others, and has strong linkages with universities and research organizations.

Source: www.unbs.gov.ug and UNCTAD field visits.

The performance of the Uganda National Bureau of Standards (UNBS) has been improving during the last four years across various indicators.

In Uganda, the Government entity in charge of formulating, promoting and enforcing the use of standards is the UNBS. It was created in 1989, with a mandate to formulate, promote, and enforce standards in the country. An overview of the UNBS is presented in box 4.7. According to the latest available annual report, the performance of the Bureau has been improving during the last four years, with substantial increases in the area of samples testing, equipment calibration and verification, and the inspection of market outlets and consignments (see table 4.11). This is good news for the country's innovation system, but its role and diffusion in the economy could certainly be increased and spread wider. An area for improvement would clearly be in enhancing firms' demand for standards and related services, which would require a deep change in culture and awareness. Its role could be greatly enhanced in the industrial parks that the Government of Uganda is planning, and in those already in existence, especially as far as export promotion is concerned.

The UNBS should consider seeking a higher involvement in innovation processes and activities.

Given the laboratory services, competencies and equipment that reside with the UNBS, it may consider seeking more involvement in innovation programmes that require its expertise, such as product development and testing, and prototyping. During UNCTAD field visits, senior management of the Bureau rightly acknowledged that among the organization's pressing challenges was the need to increase people's understanding of the role and mandate of a National Standards Bureau, and to expand collaboration on natural resources and agriculture (e.g., coffee and the Uganda Coffee Development Agency). The knowledge

Table 4.11: Uganda National Bureau of Standards performance indicators

Key performance indicator	2014/15	2015/16	2016/17	2017/18
Number of standards developed	466	451	355	254
Number of samples tested	9,526	9,883	12,439	14,472
Number of equipment calibrated	1,359	1,709	2,677	2,233
Number of certification permits issued	562	718	941	849
Number of market outlets inspected	1,153	1,093	1,128	2,278
Number of equipment verified	720,764	706,939	757,551	848,456
Number of consignments inspected	80,648	99,980	118,467	133,517

Source: Uganda National Bureau of Standards Annual Report 2017/18[73]

transfers and the learning made possible by a larger adoption of and compliance with standards are likely to represent important opportunities and inducements for firms to innovate. Moreover, the Government should consider that the Bureau is currently performing many functions that in other countries are carried out by different specialized organizations. For example, private laboratories could be certified by the Bureau rather than developing in-house laboratory and testing capacities. Standards design could be separated from certification. Uganda is perhaps not yet ready to have strong separate institutions, but this separation of functions could be pursued in the future, with the advantages of specialization and better focused activities.

4.6 Intellectual property

Well-designed intellectual property rights (IPRs) can encourage innovation and enable technology transfer. Ugandan policymakers need to be aware however, that the academic and policy debate is not unanimous about the level of effectiveness of IPRs.

There are examples, from past as well as recent industrialization processes, where weak IPRs have enabled reverse engineering and imitation, such as in Korea or China (Yu, 2001). Countries that have used weak IPRs to innovate and diversify their economies eventually embark on policies that strengthen IPRs as development gains are captured. Either way, IPRs may not be a prerequisite for development in its early phases when technological capacities are weak and economic output is low. As the economy and its sectors and industries grow, IPRs increasingly become an integral and essential part of a complex innovation system.

4.6.1 Legal framework

From the perspective of a legal framework for IPRs, Uganda is following the global trend in harmonizing IPRs legislation around several international conventions and treaties.

Uganda ascended to the Paris convention in 1965 and to the WIPO convention in 1973. In 2006 the country signed the Patent Cooperation Treaty. The first IP law in Uganda was the Copyright and Neighbouring Rights Act passed in 2006. The national Industrial Property Act was passed in 2014. Uganda is also a signatory state of the Harare Protocol on Patents, Designs and Utility Models, which was adopted in 1982 in Harare, Zimbabwe, and came into force in 1984. Since then the legal context for Uganda and IPRs has grown and is presented in box 4.8.

4.6.2 National Intellectual Property Policy

The recently drafted National Intellectual Property Policy provides the required policy clarity on the issue of IPRs and highlights several key challenges, among which are the enforcement of IPRs and the commercialization of intellectual property.

The National Intellectual Property Policy (2019) aims to support the objectives of Uganda Vision 2040, the NDP II and the United Nations' SDGs. It recognizes that Ugandans are involved in creative and innovative activities, but that the system of IPRs is not performing in their favour, nor in the interests of the country. Awareness of intellectual

Box 4.8: Uganda's Intellectual Property Laws and Treaties

Laws:

- The Industrial Property Act, 2014 (2014)
- The Geographical Indications Act, 2013 (2013)
- The Trademarks Act, 2010 (2010)
- The Trade Secrets Protection Act, 2009 (2009)
- The Copyright and Neighbouring Rights Act, 2006 (2006)

Implementing Rules and Regulations:

- The Industrial Property (Fees) Regulations, 2017
- The Industrial Property Regulations, 2017
- The Trademarks Regulations, 2012
- The Copyright and Neighbouring Rights Regulations, 2010
- The Judicature (Commercial Court Division) (Mediation) Rules, 2007
- The National Environment (Access to Genetic Resources and Benefit Sharing) Regulations, 2005
- Uganda Registration Services Bureau Act (Commencement) Instrument, 2004
- The Patents Regulations, 1993

Treaties:

- Beijing Treaty on Audiovisual Performances, signed on 8 October 2012
- Marrakesh VIP Treaty, in force since July 23, 2018
- Nairobi Treaty, in force since 21 October 1983
- Paris Convention, in force since 14 June 1965
- Patent Cooperation Treaty, in force since 9 February 1995
- Patent Law Treaty, signed on 2 June 2000
- World Intellectual Property Organization (WIPO) Convention, in force since 18 October 1973

Source: WIPO

property is low, among citizens and among policymakers (MoJCA, 2019), and its integration into national and sectoral policies will require efforts in successive policy cycles.

Among major challenges highlighted in the National Intellectual Property Policy are commercialization and enforcement (MoJCA, 2019). The problem of commercialization is seen as a result of misplaced incentives, whereby research in academia is published but not protected, and where resulting inventions lack funding to move out of labs and into prototyping, testing, production and marketing. This is, strictly speaking, not a problem of IPRs but rather of a fragmented and unsupported innovation system.

The problem of enforcement is that there are too many bodies (six) with insufficient capacities. This creates a situation where it is unclear how innovative entrepreneurs and technologists can move forward, and what mechanisms

are available in case a remedy is sought for violations to IPRs. Among these bodies are the Uganda Registration Services Bureau, the Collective Management Organization, the Uganda Communications Commission, the UNBS, the Customs and Excise Department of the Uganda Revenue Authority, and the Judiciary. The law and enforcement agencies are guided by eight enforcement regulations. This situation creates policy thickets, whereby a large number of policies, regulations and fragmented institutional responsibilities and capacities, create complexities that are debilitating for firms and industries, especially for innovative technology-led startups.

The Uganda Registration Services Bureau (URSB) is the national bureau for business and civil registrations. It is also in charge of the National Intellectual Property Office for administrative IP rights, with several branches outside the capital. According to the URSB, innovators are also not sufficiently aware of the Intellectual Property Office at URSB and public registration procedures, despite the sensitization campaigns undertaken in recent years (on the radio, TV, web, in newspapers, and outreach organizations). Drafting applications for IPRs requires expertise and these are lacking. Furthermore, it is significantly costly to apply for patents. The examination of applications is also a challenge, with very little resources and only a few staff engineers recruited as examiners. Filings for different types of IPRs are presented in table 4.12. Trademarks are the only notable IPRs in use in Uganda, while filing for patents is negligible.

4.6.3 Challenges in implementation

Implementing intellectual property policy requires the establishment of cooperative relationships, nationally and internationally, and the development of human and financial capacity, in particular for patent filing and maintenance. At the same time, policymakers should not lose sight of the value of the knowledge commons, open access and public licenses.

Legislation of IPRs is a fundamental but insufficient precondition needed in order to take advantage of IPRs as a development policy tool. What is also needed is a strong human and institutional capacity for an IPRs regime to work for the benefit of Uganda's development. Cooperation with international organizations such as WIPO, the WTO and UNCTAD can address some of these issues. A good example is the Programme on Technology and Innovation Support Centres, developed in cooperation with WIPO. By organizing visits to all relevant institutions in Uganda, and in particular to universities, eight centres have been promoted in the country.[74] Within these, significant capacity building efforts were deployed with women and youth associations, such as training on IP registration. While it is important to have a high level of competency in front-line IPRs institutions, other STI stakeholders, such as MOSTI, the National Commission for Science and Technology (NCST), or the Uganda National Council for Higher Education (NCHE), need to be able to conduct a competent policy dialogue on IP and discharge their related responsibilities.

Domestic commercialization of research through IPRs requires that research and academic institutions and firms develop their IPRs' policies and expertise. Universities with STEM programmes should have a *Technology Transfer and Intellectual Property Office* on campus that enables shared or joint IP registration and filing. The aim is to provide greater incentives for creativity and innovation to staff and employees, thereby encouraging the commercialization of research outputs. Registering, maintaining and enforcing IP can be a significant cost for an innovator, especially if one is seeking worldwide protection. For example, a comprehensive patent registration, including North America, Europe and select middle-income developing countries, can be as high as $150,000 per year per patent.[75] If an owned patent is found to be violated, enforcing patents through litigation abroad may also require large financial means, while assuming the risk of dealing with an uncertain legal outcome in foreign jurisdictions.

Policymakers need to have a clear idea about the full scope of IP policy, including the fact that R&D depends on an ever-expanding *global commons of scientific and technological knowledge*, which is free from IPRs. In this sense, publicly funded research should be openly accessible and distributed under public and open copyright licenses, while patents that are the results of publicly funded research should be open for licensing under statuary or compulsory licenses. In addition, there are vast amounts of exploitable knowledge and technologies already in existence with recently expired patents and in the public domain, or under open and public licenses.

4.6.4 *Traditional knowledge and genetic resources*

Preservation and commercialization of traditional knowledge and genetic resources using IPRs can be contradictory objectives. Therefore, absolute clarity is required in policymaking on these two important issues.

In Uganda, the use of IPRs to innovate by drawing on local and traditional knowledge and genetic resources was raised several times during the UNCTAD missions. There are three key conditions to achieving this. First, policy initiatives are needed to build a broad awareness about the value of traditional knowledge and genetic resources and the need for their IPRs-based protection. Secondly, inventories and databases will need to be established, and human capacity and financial support will need to be assigned. Finally, practical tools will need to be developed, such as guidelines, protocols and model contracts and agreements, and competent agencies will need to implement them.

Using IP to protect or exploit traditional knowledge, cultural expressions, and genetic resources, is squarely a matter of national innovation strategy. It should be clear however, that IP protection is not the same as preservation and safeguarding. The latter involves the identification, documentation, popularization and promotion of cultural heritage. IPRs aim to conserve the innovation and commercial potential of traditional knowledge and cultural expression by creating a tradeable right (e.g., a trademark, copyright or patent). This may contradict the aim to preserve and safeguard, which usually results in placing digital reproductions of traditional knowledge and cultural expression unprotected into the public domain. Works that enter the public domain, however, relinquish any existing or potential property rights. Therefore, the use of public licenses, such as Creative Commons, may be preferable. One on-going initiative to strengthen the protection of traditional knowledge is the development of a National Intellectual Property-Related Traditional Knowledge Action Plan. It is currently under discussion and drafting, led by the URSB. In July 2017, the URSB and WIPO organized a *Workshop on Intellectual Property and Traditional Knowledge for Economic Development: Empowering Local Communities of Uganda*, to improve awareness on the issue.

Genetic resources in themselves are not creations of the human mind and thus are not directly protected as IP in most countries. However, inventions based on genetic resources, whether they are related to traditional knowledge or not, may be protected as IP. At the same time, genetic resources are subject to access and benefit-sharing regulations arising from the Convention on Biological Diversity and related protocols and treaties.[76] The creation of a database on genetic resources can help patent examiners identify prior art and dismiss patent applications. These applications might include those that do not comply with the Convention on Biological Diversity's obligations on prior informed consent, mutually agreed terms, fair and equitable benefit-sharing, and disclosure of origin.

4.6.5 *Patents, trademarks and other IPRs*

In the context of Uganda's developing economy, while the number of patents filed is insignificant, the most common type of intellectual property (IP) will be trademarks.

The small number of patent applications and granted patents is mainly due to Uganda's overall development level and the typically accompanying financial constraints for patent filing, as well as a lack of awareness about the use of copyrights. Trademark data describes the extent of activity in two key aspects of innovation which are not usually covered by patent or utility indicators. These are marketing innovation and innovation in the services sector. Table 4.12 presents the number of IP applications filed in Uganda by origin of the applicant (residents and non-residents) between 2000 and 2018, including the number of applications filed by Ugandan citizens living abroad.

Patents will be rare, as the cost of patenting is great, in particular for international patenting. What is surprising is the lack of utility models. A utility model is an IPR where the terms and conditions for granting the right are less demanding than those for normal patents – and therefore should be less costly – including a shorter term of protection and less stringent eligibility requirements. There is no data on applications for geographical indication, even though Geographical Indications Act No.8 of 2013 provides a legal basis for this IP instrument.

Table 4.12: Intellectual property in Uganda 2000-2016[77]

	Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2013	2014	2015	2016	2017	2018
Total trademark applications	Resident	228	140	258	266	389	413	325	325	498	423	725	1,076	1,046	1,291	1,359	
	Non-Resident	668	441	580	572	641	645	779	778	931	760	1,354	1,590	1,769	1,753	115	
Total patent applications	Resident				5	12	3	11	6			10	5	9	16		6
	Non-Resident					1			1			4	3				
Total utility model applications	Resident																
	Non-Resident					3		2									
Total design applications	Resident																29
	Non-Resident																

Source: WIPO statistics database. Last updated in October 2019.

4.7 Conclusions and recommendations

Framework conditions for innovation present a plethora of challenges. A number of these are under the purview of the Government, but not necessarily under MOSTI. From this arises a challenge for MOSTI: how to motivate other ministries and agencies to work towards enabling STI-led growth by reconsidering their objectives.

- **STI policy should have as its top-level objective the operationalization of the Ugandan National System of Innovation.** Activities that energize collaboration, horizontal and vertical information flows, and the development of linkages and networks among all stakeholders should receive the highest level of priority. Some examples of activities would be using the Innovation Fund to incentivize collaboration, promote cluster initiatives, encourage mobility of staff and employees across public institutions and between public and private sectors, create spaces for informal interaction, as well as engage a formal stakeholder involvement in policy formulation and implementation. The level and quality of interactions among diverse stakeholders, and their capacities to create and absorb knowledge and technology, will deliver a functional or a fragmented NSI.

- **ICTs are a key development enabler if they are accessible and affordable. This clearly defines the immediate policy goals.** Government should develop active partnerships and collaborations with private sector telecoms and consumers to explore all possible means to improve the current state of the telecommunications market. Insufficient public investment in infrastructure results in poor service and high prices, as private telecoms build their own networks. High prices for data in Uganda are a disincentive to innovate for all entrepreneurs, firms and industries.

- **Energy is a foundational development resource. Awareness building on the potential for alternative, clean and renewable energies should by spearheaded by MOSTI, the Ministry of Energy and partnering ministries and agencies.** Uganda has ample hydro and renewable energy potential and should not suffer from energy poverty and high electricity prices. The consideration of electricity production and distribution as a critical enabler of STI-led development should be given higher prominence in energy policy and sector management.

- **Transport and logistics will require investments in infrastructure, such as the Malaba border with Kenya and in metropolitan Kampala.** The transport and logistics sector presents a challenge for the development of innovative firms and industries. The fragmented nature of the transport sector means policies, including those for sustainable development, are difficult to implement. This is particularly acute as Vision 2040 development targets highlight the growth potentials of tourism, trade, industry and agriculture – all sectors heavily dependent on an efficient and effective transport and logistics system.

- **An active and substantial National Innovation Fund (NIF), managed according to global best practices, is urgently required. The Fund will need to focus on firm innovation and incentivize collaboration among innovation actors.** The hampering effects of limited access to finance on innovation in Ugandan firms cannot be overstated. First steps have been made by the UDB and the NSSF towards fulfilling that role in the Ugandan innovation system. Although the need for the development of a funding ecosystem for innovation remains significant.

- **Presidential Initiative programmes will need to be tasked with developing stronger linkages with national STI stakeholders and move forward more energetically with commercializing their research.**

These initiatives fundamentally constitute a mode of technology transfer and there are various channels and modes that can be used to manage transfer processes among willing partners. Due consideration should be given to enhancing the knowledge flows from the programmes among interested STI stakeholders, including firms, entrepreneurs and the general public. Translating the research outcomes of Presidential Initiative programmes into innovation and commercialization will require access to scientific data and data for feasibility analysis.

- **Intellectual property rights (IPRs) policy should focus on raising awareness on technologies in the public domain, on technologies protected by public licence copyrights, and on the use of compulsory licences and utility patents, and non-disclosure (trade secret) contracts**
  Regarding traditional knowledge and genetic resources, during the consideration of the specific technology or knowledge proposition, a fundamental choice needs to be made between either commercialization or protection of derived knowledge and technologies.

- **The interaction between National Curriculum Development Centre and stakeholders from sectors and industries is ineffective.**
  There is urgent need for an M&E framework that will develop virtuous policy learning cycles and provide incentives for improving cooperation between educators and industries.

- **Universities may need to develop on-campus hosting for startups and source research themes at graduate and post-graduate level from sectors and industries.**
  Publishing of research should not be the only means of securing academic career advancement, while collaboration with industry should be considered as equally relevant in this regard.

- **STI industrial and business parks and incubators/accelerators enable a more fluid and informal interaction of technologists, entrepreneurs and financiers, and must receive clear policy support.**
  However, they should not be operationalized as real-estate ventures, nor should plots/stakes be used as speculative real-estate investments. Incubation and acceleration activities have emerged in Uganda and have already produced success stories that provide useful experience on which to develop programmes to systematize support from the public agencies that are a part of the innovation system.

Part II

Innovation challenges in agriculture and ICTs

5. The agri-food industry

Innovation is the key for transforming and modernizing agriculture in Uganda.

Uganda has a vast array of policies and several public and private institutions that are aimed at supporting the agricultural industry. There is a need however, for more effective implementation and better coordination among the stakeholders to avoid duplication of initiatives and for the introduction of monitoring and evaluation tools. Research in agricultural science is well developed, with good quality institutions, such as the National Agriculture Research Organization (NARO) and Makerere University, which can provide advanced knowledge and skilled human capital for introducing innovation into the industry. Nevertheless, there is a definite need for greater integration with actors operating in the field, such as extension services and farmers. Extension services need to strengthen and transform beyond the distribution of subsidized inputs, towards improving access to knowledge and the provision of technical support to farmers. Many opportunities can arise from the diffusion of ICTs and their interaction with agricultural technologies.

Transforming agriculture necessarily means moving up the value chain.

Moving the agricultural-industrial sector up agricultural value chains, both domestically, regionally and globally, is an important factor for success. Uganda is still mainly concentrated in the production of primary commodities, but there is space for expansion in the transformation and commercialization phases. There is a strategic choice at hand because this cannot be done for all products and sectors. Uganda should identify a few selected crops and intermediary or final agricultural and food products in which it can exploit a competitive advantage in its own internal market, in the regional African market, and/or in the international market. Two factors will be key for the successful entry into new phases of the agri-food value chain:

- The strengthening of cooperatives and farmers' groups, because they can help to overcome the problem of the extreme fragmentation of land property; and
- The diffusion of digital technology which can facilitate financial inclusion, support the adoption of better agricultural practices and skills development, and allow greater transparency and traceability of products.

5.1 The agri-food industry and the Ugandan economy

Clear policy goals have boosted performance in agriculture since independence.

In Uganda, agriculture accounts for 72 per cent of employment (see table 5.1), mainly in small firms. It occupies half of the land area and provides half of all exports and one-quarter of GDP (see figure 2.5) (World Bank, 2018). Notwithstanding the decline of its share in GDP from 55 per cent in 1990 to about 23 per cent in 2016 (Uganda Bureau of Statistics, 2017), in several key national plans, such as Uganda Vision 2040, the NDP, and the Agriculture Sector Strategic Plan (ASSP), agriculture is still considered one of the leading sectors for spurring socio-economic growth and transforming Uganda into a middle-income country. This is based on the predominance of this industry within the economic system and on its past good performance. This good performance began during the years after independence in 1962, and continued into the 1980s, and was thanks to the expansion of the cultivated areas when conflicts had ended, as well as on clear policy goals. These policies were aimed at boosting productivity, transforming subsistence suppliers into economically viable businesses, increasing exports, and improving the efficiency and the effectiveness of agriculture services, such as research and extension.

Table 5.1: Working population by main industry, 14-64 years (%)[78]

Industry	2009/10			2012/13		
	Male	Female	Total	Male	Female	Total
Primary	64.4	74.5	69.6	66.8	77.0	72.0
Secondary	11.4	5.0	8.1	10.5	3.6	7.0
Services	24.5	20.5	22.2	22.8	19.4	21.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Uganda Bureau of Statistics (2017)

Support for a permanent process of transformation of the agricultural sector into a dynamic and competitive agri-food industry is key for Uganda's economic development.

Given its dominance in the domestic economic system, the transformation of the agricultural sector into a dynamic and competitive agri-food industry is key both in terms of economic growth and export earnings, as well as for its potential large social impact on production of food supply, poverty alleviation, income development, and employment generation, especially for youth and women. In the near future the main question to address will be how to transform agriculture from a mainly subsistence activity into a sustainable and growing business. All the phases along the agri-food value chain, from production of primary commodities to their transformation and commercialization, will need development, including any connected services such as R&D and logistics. In conjunction with this, it is important to understand which role technology and innovation could play in this radical transformation, keeping in mind the role STI has to play along the entire agri-food value chain. As of writing this policy review, transformational processes in Uganda have stalled (see figure 2.5 in chapter 2). A more detailed discussion is presented in chapter 2.

5.2 Main challenges for STI in agriculture

Ugandan agriculture enjoys favourable soil and climate conditions, and diverse agroecological zones and rich biodiversity, enabling it to produce a large variety of crops and livestock. The main staple crops are plantain and cassava, which have lost ground since the 2008 food crisis. Since then, the production of other food crops such as maize, potatoes and beans has slightly increased (see table 5.2). Notwithstanding its high natural potential, Ugandan agriculture is confronted with several challenges, including (World Bank, 2018):

- A predominance of smallholdings practicing rain-fed agriculture;
- Low, and even declining, total factor productivity (TFP);
- A lack of capacity to face recent climate variability and continued land degradation, as well as low rates of commercialization; and
- Insufficient development of the activities along the value chain beyond the primary production phase.

Table 5.2: Production of selected food crops (000 tons)

Crop	2008/2009	2012	2016
Plantain	4,297	4,503	3,396
Cassava	2,894	2,807	2,729
Maize	2,362	2,734	2,483
Potatoes	1,819	1,852	1,911
Beans	929	905	945
Other cereals	844	813	852

Source: UBOS (2017)

Smallholdings and customary tenure present serious obstacles to developing innovative commercial agriculture.

The agricultural sector is dominated by smallholdings, with average farm sizes ranging from 0.8 to 1.6 ha, and characterized by a lot of variation across regions, with the highest concentration of large commercial farms in the Northern and Central parts of the country (World Bank, 2018). Most of the small farms adopt labour-intensive technologies and depend on rainfall, without adequate water management, which is increasingly problematic due to climate change and climate variability.

More than 80 per cent of the land is held under customary tenure and is not officially registered. The consequences of this is vulnerability to expropriation, land disputes and lack of collateral for credit access. The uncertainty of the land system is an important barrier to the adoption of improved technologies, as well as the establishment and development of commercially oriented and innovative agribusinesses. Moreover, the customary land law is patrilinear and usually accords women fewer rights. Women rarely inherit land but more often receive rights of use through their husbands or other male relatives (Doss et al., 2014). Recently, the World Bank has supported the establishment of a Land Information System, offering services such as the digitalization of existing land titles and the registration of land transactions, with the aim of improving accessibility and availability of registration services. It is also promoting initiatives aimed at delivering formal land titles to farmers (World Bank, 2018). Access to finance, due to a lack of collateral, high transaction

costs, small and dispersed clients, and long lags between access to credit and expected revenues, are further challenges within agriculture.[79]

Productivity growth in the agricultural sector has made no progress since 1970 and growth has been based on the expansion of cultivated land.

According to recent estimates (World Bank, 2018), since 1970 Ugandan agriculture has registered a negative or nonexistent TFP growth. This is calculated as the residual obtained by excluding, from output growth, all measurable inputs, such as land expansion, increases in number of workers, machinery, and other inputs (e.g., fertilizers or seeds). This suggests a lack of technological progress and innovation. Moreover, since 2010, due to growing pest and disease incidence and policy distortions, TFP losses have been particularly large. The World Bank (2018) stresses the lack of innovation as a possible source of TFP reduction. Empirical studies undertaken at the level of individual farms and districts would better identify the causes of low productivity.

Commercialization and innovation require an active regulatory system at all points in the value chain.

Another obstacle to investments in improving technology and increasing commercialization is the weak regulatory control system along the value chain. The Agricultural Chemicals Board is in charge of controlling input quality, but it has very limited resources to test them in reality. The Enabling the Business of Agriculture initiative (World Bank, 2017), which provides a number of indicators to monitor the regulatory framework impacting on the agri-food industry, ranks Uganda 31 out of 62 countries and identifies seed and fertilizer registration and quality control as areas in need of improvement.[80] Commercialization is hampered by geographical dispersion of small farmers and the poor quality of infrastructures. Moreover, the lack of access to financial resources makes it difficult for small farmers to enter into the commercialization and transformation phases, notwithstanding opportunities in domestic and in international, regional and global markets.

Climate change increases the vulnerability of the agricultural sector in Uganda and hampers innovation while, at the same time, making it more urgently needed.

In recent years, in Uganda, as in many other parts of the world, the agricultural industry has become vulnerable to increasing climate variability and shocks. Average temperatures are increasing, and seasonal rainfalls are becoming increasingly variable and less predictable. Moreover, extreme events such as droughts, floods or landslides are also becoming more frequent. According to the Notre Dame Global Adaptation Initiative country index, which summarizes a country's vulnerability to climate change and other related challenges, Uganda ranks as low as 155 over 181 countries listed.[81] In addition, food security in Northern Uganda has been hugely impacted by the large influx of refugees from South Sudan and the Democratic Republic of Congo.

5.3 Policy background

The policy basis for the development of the agriculture sector and its contribution to overall development in Uganda is well-established in current policy documents.

Agriculture is a key area in policy interventions, considered by the national development plans, as well as by several specific sector development policies and strategies. The main recent plans dealing with agriculture are the *National Development Plan (NDP II)* and the *Agriculture Sector Strategic Plan (ASSP)*. In the NDP II (2015), agriculture is considered a central activity for economic growth and poverty reduction, a 'springboard' for the socio-economic transformation of the country. The declared objective is the modernization of agriculture: to transform it from a predominantly subsistence sector into a commercial one. The Plan promotes mechanization and commercialization, as well as the expansion of agro-processing activities, with the aim of increasing productivity and domestic value addition.

Among the interventions listed in the NDP II, there are investments in research and human resources, the introduction of improved technologies, the enhancement of extension services, increased access to high quality inputs, as well as promotion of sustainable land use and soil management. In terms of commercialization and value addition, NDP II focuses on: a) promoting private investments in agro-processing; b) supporting women and youth associations to engage in product transformation; c) intensifying the adoption of standards needed to improve market access and to enter into global

value chains; d) developing capacities of existing farmers' organizations and cooperatives to reach economies of scale; and e) deepening ICT access to facilitate information and knowledge diffusion.

The *Agricultural Sector Development Strategy and Investment Plan (ASDSIP)* 2010/11-2014/15 has four programmes: 1) enhancing production and productivity; 2) improving access to markets and increasing value addition; 3) creating an enabling environment; and 4) institutional strengthening. In the review of ASDSIP (Adupa et al., 2015), among the recommendations for future strategic areas of intervention is the establishment of a partnership mechanism between research and extension, with NARO contributing to capacity building in the extension system (see box 7.1 for a detailed account of NARO activities). A strengthening of collaboration with academic institutions in the establishment of agriculture incubators, and for training potential entrepreneurs, is anyway recommended in order to sustain the development of agro-businesses. The importance of investing in the promotion of internationally recognized certifications in products and systems to strengthen the capacity of exporting and processing is also stressed (such as the Hazard Analysis and Critical Control Point, International Organization for Standardization, and the Uganda Standards Certification Mark – 'Quality Mark').

The new ASSP 2015/16-2019/20 is a continuation of the ASDSIP and reiterates the objective of the NDP II to transform agriculture from subsistence farming into a commercially viable and sustainable sector that can create job opportunities, especially for youth and women, increase household incomes, and guarantee food security. Specifically, the ASSP indicates the same four programmes of interventions as the ASDSIP, emphasizing the need to increase production and productivity through increased access to quality inputs, better services, as well as knowledge and technological innovations (Ministry of Agriculture, Animal Industries and Fisheries, 2016).

Another programme with significant impact on agriculture is the *Operation Wealth Creation (OWC)*. This is a presidential initiative launched in 2013, aimed at providing a variety of agricultural and non-agricultural services to rural populations, such as support, infrastructures and housing (World Bank, 2018). Among the main areas of interventions, the OWC plays a key role in extension services. This can create problems with the crowding out of, and coordination with, other institutions previously involved in this area, such as the National Agriculture Advisory Services Organization (NAADS).

In addition to these main policies, there are other notable policies and strategies which are relevant for the agri-food industry. These include: a) the National Coffee Policy (2013) and the National Coffee Strategy 2040 (2015); b) the National Fertilizer Policy (2016); c) the National Agricultural Extension Policy (2016); d) the National Seed Strategy 2014/15; e) the National Irrigation Policy (2017); and f) the National Land Policy (2013).

Beyond national policies, Uganda is also involved in several regional, continental, and global partnership policies and programmes concerning agriculture. These include the EAC (e.g., the EAC Agriculture and Rural Development Policy), the Common Market for Eastern and Southern Africa (e.g., seed trade harmonization regulations), and the African Union (e.g., the Comprehensive Africa Agriculture Development Programme, a continental initiative to reduce poverty through agriculture, and the Malabo Declaration, aimed at targeting investments in agriculture and boosting intra-Africa agricultural trade) (Mugagga et al., 2018).

The policies lack implementation measures, including M&E processes and adequate funding. A systemic view of agricultural innovation is missing, as well as an operational framework to ensure coordination and coherence.

From the analysis of the policy documents it is clear that the overarching objective – the need to modernize the sector and transform it from a subsistence industry into a commercial one – is regularly reiterated, but the implementation of measures to realize it is lacking. The recommendations of the review of the ASDSIP (Adupa et al., 2015) are that strengthening of linkages between some of the actors, such as NARO, the extension staff, and the academic institutions, will be key to improving the agricultural innovation system. In reality however, (as will be clarified in detail in section 5.4) very few initiatives are moving in that direction. Although the role of innovation and ICTs in agriculture is recognized as a key factor for modernizing the sector, there are no direct or specific measures to support innovation and enhance the diffusion of ICTs in rural Uganda. With regard to commercialization, the adoption of standards is identified as a key area, but again, there are no implementation programmes.

Finally, there is the problem of coordination and coherency between national plans and ad hoc initiatives, such as the OWC. This is particularly evident in the area of extension services, in which there are several uncoordinated actors, as will be explained in section 5.4.

5.4 The agricultural innovation system

The Ugandan agricultural innovation system includes many different institutions at national and sub-national level, some that generally regulate and support the sector, and others that are more directly involved with innovation activities.

Table 5.3 presents an overview of the activities undertaken by the main actors involved and of the linkages existing between them. The *Ministry of Agriculture, Animal Industries and Fisheries (MAAIF)* is responsible for policy formulation and implementation along the value chain of crops, fisheries, and livestock. According to the World Bank (2018), since 2001 MAAIF has been subject to several assessments and proposals of reform, the results of which have largely not been implemented. The MAAIF is organized into four directorates – crops, animals, fisheries, and extension services – and under its purview it has seven specialized agencies. Among them are three institutions with a mandate to develop, support and regulate specific commodities, namely the Cotton Development Organization, the Dairy Development Authority, and the Uganda Coffee Development Authority. These authorities do offer support to cooperatives and farmers in the fields of extension, research and export promotion. Then, there are the National Animal Genetic Resource Centre, the Coordinating Office for Control of Trypanosomiasis in Uganda, NARO and NAADS.

Other ministries with responsibilities in relevant areas for the agri-food industry are the Ministry of Water and Environment, which is responsible for irrigation and the adaptation of agriculture to climate change; the Ministry of Land, Urban Development and Housing, with responsibilities in land policy and management issues; the Ministry of Trade, Industry and Cooperatives, with competencies on issues related to trade and cooperatives; the Ministry of Finance, Planning and Economic Development, managing the access to financial resources, and finally the Ministry of Local Government, responsible for agricultural extension and for support to farmers' groups. According to the World Bank (2018), a challenge faced in the sector is related to the insufficient coordination between the latter two ministries, given that decentralized governments suffer from lack of funds and human resources. This is due mainly to the decentralization of service delivery responsibilities, combined with strong central control of fiscal resources.

In addition, there are several ad hoc technology and innovation initiatives promoted by the Office of the Prime Minister and the Presidency. In agriculture, the PIBID pilot project aims at developing market opportunities for banana and derived products, such as soups, porridge, cookies and bread (see section 3.5.4).

5.4.1 Extension

The agricultural extension system has limited resources and impact.

NAADS is another institution under the general supervision of MAAIF. It was established by the National Advisory Services Act in 2001 to deliver extension services, which previously, in the 1990s, were under the responsibility of MAAIF. The expectations for NAADS is that it would contract out demand-driven services. But contrary to the original design, the Government decided to add the distribution of state subsidized inputs to its tasks. This component rapidly became NAADS' main activity, until 2014 when the distribution of subsidized inputs became the responsibility of the OWC. From then on, NAADS was only providing some managerial support, such as input procurement (World Bank, 2018).

The responsibility over extension services returned to MAAIF, which re-created a Directorate for Extension. As confirmed by ASDSIP (Adupa et al., 2015), as well as by UNCTAD field interviews, the provision of extension services is a problematic area due to the very low ratio of extension staff to farmers and the poor availability of equipment. There is also the problem of coordination between the Directorate within MAAIF and the local governments, which are expected to increasingly assume responsibility over the area of extension services but suffer from lack of financial and human resources.

More generally, in recent history, the role of the extension system has been mainly to distribute free or highly subsidized inputs. It contributes in a limited way to its core function of knowledge transfer by maintaining rare and occasional linkages

Table 5.3: The agriculture innovation system of Uganda

Institutions	Main Activities	Linkages
Ministry of Agriculture, Animal Industries and Fisheries (MAAIF)	Policy formulation and implementation along the value chain of crop, fisheries and livestock	Some coordination of the activities of the directorates under its responsibility
Ministry of Water and Environment Ministry of Trade, Industry and Cooperatives Ministry of Land, Urban Development and Housing Ministry of Finance, Planning and Economic Development Ministry of Local Government	Policy formulation and implementation in specific activities relevant for agriculture	No coordination with MAAIF Ministry of Finance, Planning and Economic Development has budget responsibilities for all ministries
Office of the Prime Minister and the Presidency	Applied research in the Banana Industrial Development Initiative	No linkages with other actors in the system
MAAIF Directorates specialized in crops - Cotton Development Organization, Diary Development Authority and Uganda Coffee Development Authority	Support in the field of extension, research and export promotion and regulation of specific commodities	Linkages with cooperatives and farmers
National Agricultural Research Organization (NARO)	Research	Limited linkages with private actors and with Makarere University No direct involvement in the extension phase
Makarere University - College of Agricultural and Environmental Sciences	Research, education and business incubation	
Universities (four public, 10 private universities five specialized public technical colleges)	Tertiary education	No linkages with other actors in the system
MAAIF Directorate for Extension Services and Ministry of Local Government	Provision of extension services	No linkages with the research institutions Some linkages with cooperatives and farmers' groups
Cooperatives and farmers' groups	Capability building, certifications, knowledge diffusion, input and market access	Linkages with extension system
Incubation centers	Shared processing facilities and laboratories and technical support and mentorship for start ups	Linkages with the private sector, with universities and with international donors
Innovation platforms	Knowledge diffusion and adaptation, technical assistance	Linkages with local administrations, researchers, extension system, buyers, food processors and farmers
International donors	Support of initiatives in area such as R&D and incubation	Linkages with NARO, universities, ministries

with the research institutions. The experience of innovation platforms, described below, is a recent attempt to bring together researchers, extension staff and farmers with a positive potential impact both on the identification of research needs, as well as on diffusion, adaptation and implementation of research findings for farmers.

5.4.2 R&D in agriculture

While spending on R&D in agriculture has been growing, the lack of productivity growth indicates that there are major lab-to-field challenges.

In Uganda, agricultural R&D spending has been continuously increased and in 2014 expenditures (adjusted for inflation) were three times higher than in 2000 (African Science Technology and Innovation Indicators, 2016). This growth is the result of the increased support from the Government and from international donors, combined with the establishment of new universities. Among the institutes within MAAIF, NARO is in charge of agricultural R&D, controlling a network of seven national specialized research institutes and nine local institutes dealing with different ecological areas. NARO employs 893 people, including 293 scientists (97 PhDs and 171 with master's degrees) and 195 technicians (NARO, 2017). Also, thanks to the support received during the years from a wide range of international donors, NARO is equipped with good physical infrastructures and highly skilled human resources.

Based on its activities (see box 5.1 for a detailed description) and on its record of achievements, NARO is clearly a prominent institution in the field of agricultural research. However, it suffers from a limited capacity to react to the demand of its stakeholders (NARO, 2017). Its research agenda tends to be driven more by scientific curiosity and opportunities for publication rather than by demand from farmers. This is not surprising given the limited occasions for direct interactions with farmers on the field and the lack of direct involvement in the extension phase, as confirmed in the review of the ASDSIP (Adupa et al., 2015). Another reason for fragility is that its long-term sustainability can be affected by the volatility of international funding, given that in the past it has received a lot of support from donors (World Bank, 2018).

Box 5.1: The National Agricultural Research Organization (NARO)

According to the 2017 Annual Report (NARO, 2017), NARO has a budget of about $25 million and its key achievements have been 66 new production technologies, 36 improved crop varieties, 12 products identified for patents, licenses and commercialization, 70 articles published in peer reviewed journals, as well as seven completed PhDs and five MScs. To provide examples of outputs produced, in 2016/17, NARO's researchers obtained new crop varieties for beans, cassava, rice, maize, banana, sorghum, legumes, potatoes, barley for brewing beer, disease resistant coffee, and high productivity tea. They have also worked on tick vaccines and developed a fast-growing strain of Nile Tilapia fish.

NARO maintains some partnerships with private enterprises, universities, NGOs, international donors and other public institutions such as the National Agriculture Advisory Service.

Examples of collaborations include East African Breweries for the use of cassava chips in beer production and Kamtech Logistics for the production of ethanol from dried cassava. Another example is the involvement of NARO in a project with Serere Sorghum Producers and Processors Association, and with an NGO, to increase the utilization and commercialization of sorghum in products such as bread, cakes and flour (NARO, 2017).

With Makerere University there are a number of research collaborations, as well as joint initiatives, to organize events for knowledge and technology dissemination, such as the NARO-MAK Joint Agriculture Dissemination Conference, initiated in 2015. A further area of activity is the establishment of an effective IP management regime, which is considered key in the current knowledge driven economy. NARO has created an IP office with the purpose of maximizing the potential of internally generated IP and a Technology Innovation Support Centre to facilitate access to sources of technical and commercial information about existing patents and trademarks in order to avoid duplication of research efforts.

A key concern is insufficient linkages among various institutions and research agencies in the Ugandan agricultural innovation system. Without coordinated action on common objectives, including in R&D and STI activities, human capacity and funding is dispersed and fragmented, and results in sub-optimal outcomes.

Universities are key stakeholders in the innovation system for the agri-food industry because they provide higher education and, in some cases, they also have research capacity in the field and offer support to startup companies in related areas. According to the National Council for Higher Education (2018), in the area of agriculture, fisheries and forestry there are four public universities offering programmes, about ten private universities with accredited programmes, and five specialized public technical colleges.

Makerere University is the oldest university in the country, established in 1922, and ranked fourth in Africa according to Time's Higher Education.[82] In Makerere University, the College of Agricultural and Environmental Sciences, established in 2010, is organized into three schools: the School of Agriculture Sciences, the School of Forestry, Environmental and Geographical Sciences, and the School of Food Technology, Nutrition and Bio-Engineering. The School of Agricultural Sciences employs 122 researchers, 72 with PhDs and 45 with Masters degrees and is organized into three departments: Agricultural Production, Agribusiness and Natural Resource Economics, and Extension and Innovation Studies. It offers undergraduate and postgraduate programmes in Agriculture, Horticulture, Land Use and Management, Agricultural Rural Innovation and Agribusiness Management.[83]

Makerere University hosts the *Makerere University Regional Centre for Crop Improvement,* which focuses on delivering better crop varieties, is one of the four centres for excellence supported by the Africa Higher Education Centers of Excellence initiative launched by the World Bank. In the agricultural field, there is also the African Center of Excellence in Agroecology and Livelihood System, hosted by Uganda Martyrs University, which provides training, research and community engagement for development in agroecology, food systems, value chains and sustainable livelihoods for balanced development in the region.

The School of Food Technology, Nutrition and Bio-Engineering hosts the Food Technology Business Incubation Center,[84] established in 2009 within the framework of the Presidential Initiative for Value Addition, with support from the Rockefeller Foundation and the Norwegian and Malaysian governments. The tenants are usually (but not necessarily) young graduates from Makerere University. They are offered access to processing facilities and laboratories and are provided with technical support and mentorship to transform their ideas into commercially viable products. Usually, the incubator hosts between 20 to 30 startups at a time. Products developed so far include pineapple juice, soya bean products, smoked meat, lemongrass tea, amaranth products, canned maize, and beans. The incubator performs a useful role in improving the commercialization of traditional products through technical and business advice, and testing facilities and shared equipment. Nevertheless, fast-growing firms are not likely to emerge from the programme, because after they leave, startups lack most of the additional conditions necessary for their success. They need credit, subsidized space, and support to address more demanding (national or export) markets, because in the incubator the focus tends to be solely on the local market. It does appear however, that a new awareness is surfacing. This is evident in the new African Development Bank loan to the Ministry of Education to support the incubation activities of Ugandan public universities (Pietrobelli, 2018).

Together with NARO and the National Union of Coffee Agribusiness and Farm Enterprises, Makerere University is also one of the partners involved in the *Consortium for Enhancing University Responsiveness to Agribusiness Development Limited (CURAD*). This is a non-profit public-private partnership initiative aimed at supporting young entrepreneurs in the agribusiness industry to favour the development of new enterprises by creating an environment in which startups can be supported from innovative idea through to viable commercial business. CURAD is one of the six agribusiness incubators started by the Forum for Agricultural Research in Africa under the UniBRAIN-DANIDA programme, aimed at supporting agribusinesses led by women and young people. CURAD has nurtured more than 70 small- and medium-sized enterprises, contributing to the creation of more than 2000 jobs. It offers facilities, such as greenhouses, agricultural land and other basic infrastructures, which are needed by startups in their incubation phase

Box 5.2: Examples of innovation initiatives in agriculture

1. Real Agricultural Solutions for Africa (RASA)

RASA Ltd is a market-driven social enterprise that was started at the Consortium for Enhancing University Responsiveness to Agribusiness Development (CURAD) in 2013 by six students from Makerere University. Its main product is a coffee liqueur branded 'Legend', which is the first coffee liqueur produced commercially from local indigenous coffee beans. The company works with a vast network of small farmers, who supply coffee and receive support to improve productivity through access to in-kind credit facilities such as inputs, planting materials, training in agronomic practices and post-harvest handling.

Source: rasaltd.com

2. Ankole Coffee Producers Cooperative Union

The Ankole Coffee Producers Cooperative Union (ACPCU) is a cooperative started in 2006 in the mountains of south-western Uganda. It involves 8,200 members, organized into 20 primary cooperative societies. They export natural Robusta and full specialty Robusta coffee, characterized by full traceability and quality handling processes.

The cooperative offers services for:

- Members: capability building on agronomic practices, assistance for certification acquisition, and cash payment on delivery;
- Buyers: grading of coffee beans, packaging and transportation, and quality control;
- Cooperatives: capacity building, assistance in Fair Trade certification and in members' compliance; and
- Community: bursaries for children, medical checkups for members, construction of infrastructures such as schools and bridges using Fair Trade Premiums.

Source: www.acpcultd.com

3. The Mukono-Wakiso Innovation Platform

This innovation platform was initiated in 2013 with the involvement of NARO, the International Institute of Tropical Agriculture (IITA), Makerere University and the local government. A facilitator from Makerere University guided the platform members in identifying their most pressing needs, which emerged as: a) limited land, b) declining soil fertility, and c) climate change. Then the platform agreed to focus on an integrated system of crops, livestock, and trees, including banana, vegetable, poultry, and fruit trees.

The stakeholders involved in the platform assisted the farmers in identifying and using the knowledge available to address their problems, and in particular to manage a diversified system on small plots. Besides this, farmers were also trained in value addition, marketing, and business planning, to help them to better manage their businesses. Training was also offered in nutrition to stress the importance of eating a balanced diet and to encourage farmers to link production activities in crops, orchards, and animal husbandry.

Source: Dror et al., 2016

(Segawa Bugembe, 2018). Box 5.2 presents the experience of RASA/CURAD and two other innovation initiatives, namely Ankole Coffee and the Mukono Wakiso Innovation Platform.

Farmers' association and cooperatives are key stakeholders.

Farmers' associations are limited in number as they have been sidelined for a long time (World Bank, 2018). There has been a change in this attitude more recently, with many new cooperatives forming in several regions and for various products, such as coffee, rice, maize, sorghum, livestock and dairy. The reassessment of the role of cooperatives is also confirmed by the appointment of a Ministry for Cooperatives within the Ministry of Trade, Industry and Cooperatives. As confirmed by ASDSIP (Adupa et al., 2015), there are many benefits accruing from the establishment of effective farmers' groups for channeling inputs, facilitating credit recovery due to peer pressure, diffusing knowledge and information about technologies and market opportunities, and for sharing technical equipment and extension services.

Moreover, the existence of organized farmers' groups is also key for the development of agri-food businesses and further involvement in domestic, regional and global value chains, because small independent farmers are generally unable to respond to the demand coming from commercial buyers in terms of quality standards, certifications, and the size and timing of orders. Farmers' groups are among the stakeholders involved in *innovation platforms*, which have been supported by ASDSIP as reported in the 2015 review (Adupa et al., 2015). These platforms bring together local administrations, researchers, extension service providers, buyers, food processors and farmers, with the aim of identifying demand-driven needs, finding ready-made solutions, sharing existing knowledge and facilitating the implementation of existing solutions.

Finally, a role in the institutional framework is also played by the international donors. These have been substantially engaged in the sector, with a contribution between 2012 and 2017 above $100 million. Also notable is that within agriculture there has been an increase of aid in R&D projects from 8 per cent of total agricultural aid in 2012 to 11.5 per cent in 2017. Nevertheless, it needs acknowledging that the amount of aid going to the agricultural sector has decreased in total from about 8 per cent in 2012 to 7 per cent in 2017, largely due to the assistance required in the northern part of the country in response to the emergency situation there and the presence of refugee camps.[85]

5.5 The development of the domestic, regional and international value chains

While non-traditional exports are growing, coffee still has major unrealized export potential and presents opportunities for moving up the value chain.

In Uganda, over the last decade, agricultural products (primary and processed) have accounted for 54 per cent of total exports (UBOS, 2017). The traditional export crop, and indeed the country's main export, is coffee. Tea, tobacco and cotton all show a continuous increase since the beginning of the 1990s, with the exclusion of a slump in coffee exportation in the first half of the 2000s. Box 5.3 provides information about the coffee sector which represents more than one third of the total agricultural exports (see table 5.4). Since 2010, non-traditional agricultural exports began to dominate over traditional ones. Fish and fish products are the largest non-traditional agricultural exports, followed by sugar and confectionary, cocoa beans, vegetable oils, cereals (maize, sorghum, and rice), beans and flowers.

A lack of strategy on creating domestic demand and a consumer base for exemplary Ugandan agriculture products presents a missed opportunity for innovation.

Aside from the potential international demand, there is also an increasing domestic market for food due to high population growth, increasing urbanization rates, and the rapid expansion of a middle class, with similar processes also occurring in other countries in the region (Tschirley et al., 2015). Income growth and urbanization are also introducing changes in the type of products consumed and in the structure of the market, with an increasing demand for processed food. In Uganda, as well as in other neighbouring countries, urban areas are increasingly experiencing the supermarket revolution. This has a dramatic impact on the procurement system, with an increase in the size of orders, a more careful quality process control, and the introduction of strict quality and health standards. The modernization of the distribution system has a deep impact on small farmers, who need to invest and innovate to satisfy the new market requirements.

Box 5.3: The coffee sector in Uganda

In Uganda the coffee sector is dominated by a large number of small-scale producers, 90 per cent of them with farms ranging between half to 2.5 ha, although recently some large-scale producers have emerged (the International Trade Centre, 2012). Both Arabica and Robusta are grown, but Robusta is the most common variety, due to environmental and geographical conditions. In the international market, its price is lower than that for Arabica, which is generally grown at higher altitudes and lower temperatures. In Uganda, the production of Arabica occurs mainly in the eastern highlands and in the southwest where altitudes are higher, and temperatures are cooler.

Uganda exports the majority of its coffee to Germany, Sudan, Switzerland and Italy, mainly as unprocessed, green beans.[86] The main institution devoted to supporting the industry is the Coffee Development Authority, established in 1991, with a mission to promote the development of the sector. Its activities range from extension services and research, to export promotion and knowledge diffusion. For research, there is the National Coffee Research Institute, which is part of NARO.

Other relevant actors in the industry are the National Union Coffee Agribusiness and Farm Enterprise, representing over 150,000 farming households, the Uganda Coffee Trade Federation, grouping coffee processors and exporters, and the Uganda Coffee Farmers Alliance (UCFA), providing marketing support to farmers' organizations.

An assessment by the International Trade Centre (ITC) (2012) about the industry highlights several constraints to competitiveness. With regard to coffee supply, most coffee trees are old and therefore susceptible to diseases; and technologies for harvesting, drying, and processing tend to be rather obsolete and there is a scale problem. When it comes to research, the linkages with farmers are weak and research is not responsive to farmers' needs. There is a high dependence on a few international buyers and limited local understanding of the coffee export market and knowledge about international standards and certifications.

Table 5.4: Agricultural exports in nominal $ millions 1991-2017

	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016	2017
Traditional Export Crops	233	350	213	418	616	540	739
Coffee	209	286	118	285	415	372	555
Tea	9	28	34	55	77	72	80
Tobacco	7	17	39	59	77	64	53
Cotton	8	19	22	19	47	32	51
Non-traditional Exports	58	88	185	378	667	704	781
Fish and products	13	35	100	128	129	122	136
Sugar and confectionary	0	6	2	38	85	100	92
Cocoa beans	1	1	6	22	51	75	55
Maize	17	10	16	27	52	70	96
Animal and vegetabgle fats and oils	0	2	6	46	99	62	70
Sorghum	0	0	0	2	20	55	50
Hides and skins	7	9	11	12	55	51	53
Beans and other legumes	10	10	6	12	29	51	87
Flowers	1	6	22	24	26	25	28
Other non-traditional exports	9	9	16	67	121	93	114
Total Agricultural Exports	291	438	398	796	1,283	1,244	1, 520

Source: COMTRADE database

Market opportunities are available for ambitious innovators.

One example reported in the ASDSIP review (Adupa et al., 2015) offers a significant illustration of the potential of the market for innovators. In the Insigiro district in Western Uganda, farmers responded to demand from international buyers planting a variety of bananas with a longer shelf life, which were developed by NARO in collaboration with the International Institute of Tropical Agriculture in Nigeria. This example shows that a close collaboration between farmers and research institutions is key to meeting specific demand from the market and can guarantee access to a stable market with remunerating prices. In addition, it also indicates that different markets require different products and researchers should coordinate with farmers to address the specific needs of the different market segments.

In the domestic, regional and international market, there is an increasing market space for entering into new phases of the value chain with higher value added, including food processing and packaging. According to the World Bank (2018), processed agricultural products in Uganda, to date, is less than 5 per cent of total domestic production. In the same World Bank study, it is also stressed that food and drink processing (in particular, beer and soft drinks) represents 57 per cent of all manufacturing value added in the 2011/12 to 2015/16 period, while coffee and tea processing together accounts for less than 16 per cent of it.

To take advantage of a growing market for agriculture, it is key to strengthen the links along the value chain and within the whole agriculture innovation system, involving different stakeholders such as research institutions and providers of extension services.

As previously shown by the case of Insigiro district, a strong collaboration between research institutions, extension services and farmers are important for addressing the challenges posed by the market. Moreover, collective action and farmers' groups are key organizational structures for overcoming the limitations of small size. Important actors in the value chain are also buyers and processing companies. These can provide small farmers with access to knowledge and assistance to innovate and adapt their products to the needs of the market. They can also provide financial support, allowing small farmers to commercialize and earn more profits. In many sectors, foreign and local companies have started to invest in the processing and transformation phases, providing farmers with training to ensure good quality of primary products.

In the coffee value chain in particular, farmers are traditionally used to sun-drying the coffee and then selling it as dry cherries to small traders who tour the countryside. These small traders act as aggregators for larger traders or for exporters, who sell over 95 per cent of total annual coffee production as green beans (Management Innovations, 2015). Recently, several multinational companies have set up processing plants, extending their activity into grinding and roasting to produce branded shelf-ready products for export, as well as organizing coffee growers into groups, and offering extension services, access to high quality inputs, and credit to guarantee the consistency and the quality of the coffee beans (World Bank, 2018) (see box 5.4).

5.6 ICTs and new technologies in the agri-food industry

In Uganda, the interaction between agriculture and ICTs provides tangible solutions and opportunities, and guides policymakers to take a holistic approach to innovation policy, one which is closely coordinated on issues in these two particular sectors.

There is a huge potential role for ICTs in agriculture, in particular the diffusion of cell phones and tablets that enables access to information, market and finance, to help address some of the challenges relating to the small size and remoteness of farmers. They can help too with challenges created by climate change. Adoption of ICT solutions can provide farmers with information based on geomapping, as well as on registration of micro-climate changes, useful for choosing the right type of crop to grow. Provision of services that are not economic on an individual basis can be cheaper with ICTs. The World Bank (2018) presents an example of the use of hand-held soil scanners, owned by farmers' cooperatives, that send data collected in the field to regional offices, which analyze them and send back the results to the farmers with reccomendations about how to intervene in the field. Information on pricing of inputs and outputs, on where to find services, on buyers and logistic providers, can also be easily accessible via mobile phones. Another important area where ICTs can facilitate agriculture is in the diffusion of digital payment solutions, which offer farmers a safe and

Box 5.4: The Coffee Sipi Falls project in Western Uganda

Simon Levélt, a Dutch family business owning specialty tea and coffee shops, and Kawacom Ltd, a Ugandan private coffee processor, invested jointly in central coffee processing facilities and started providing training to farmers, many of whom are families led by women, on how to pick the beans and other agronomic techniques. Transportation is also offered to farmers located in distant villages to bring beans to the processing facilities. The improvement both at the level of production of beans and processing has led to a better price for the farmers. In the past, coffee producers in the region were accustomed to home processing their coffee. Thanks to the project however, they have learnt that a central mill can perform more consistently and professionally the different phases of washing, fermenting, and drying, needed to reach the standard of quality required by the international market.

The project unites 5,000 small holder coffee farmers with an average of 0.5 ha each. The farmers, keen to participate in higher value specialty markets, were trained in socially and environmentally responsible coffee growing practices and efficient farm management. In 2002, the project received its very first 'Organic' certificate. This has attracted additional certification from the UTZ standard, JAS and the Rainforest Alliance. The project has since expanded significantly and was reported to involve over 10,000 small holder farmers in 2015. Farmers receive higher prices for their higher quality coffee and participate in related social and environmental programmes.

Source: royalcoffee.com/cj1184-uganda-sipi-kapchorwa-fully-washed-crown-jewel/ and www.coffeehunter.com/the-coffee/sipi-falls-organic/

efficient way to transfer and receive money, thereby increasing financial inclusion in rural areas.

The ICT applications for agriculture currently available in Uganda include the following: a) Jaguza Livestock Application is a software for livestock record keeping, offering an offlline and online monitoring system to detect cattle movement and keep track of health and fertitlity status;[88] b) M-Voucher is a system used by farmers and agro-dealers to redeem electronic vouchers via mobile phones;[89] c) the market-led user-owned ICT4AG-enabled information service, MUIIS, is a satellite based project to make extension services more accessible to farmers;[90] and d) EzyAgric, which buys input, receives technological support, and maps the farm land, and was developed by Akorion, a startup based in Kampala (see box 5.5).

Box 5.5: Akorion – ICTs for agriculture

Akorion is a startup established by young graduates in 2014 with a grant from the United States Agency for International Development (USAID) and is now involved in the accelerator programme of Google for Africa. They offer GPS mapping with extension services and a market place to buy inputs. Moreover, they have developed a service delivery model in which community-based service providers are equipped with smartphones to deliver services on demand to individual farmers. So far, Akorion has served over 60,000 farmers and digitally profiled 42,000 in 480 villages, collaborating with 100 farmers' associations.

Akorion's objective is to digitize agricultural value chains to enable all commercial farmers and other agribusinesses to access high-quality production and marketing services through their EzyAgric platform. To enable service, EzyAgric is supplemented by an Electronic Village Agent Model – e-VAM. E-VAM is a delivery model in which community-based service providers, usually "super farmers", are equipped with smartphones in order to deliver services on demand by the other farmers. Services on offer are digitizing biological and production data, accurate GPS mapping of gardens (acreage), extension for diagnostics of diseases, and agronomic videos and interaction with agronomists. Other services include procurement of soil testing and genuine inputs (seed, fertilizer), purchase of agriculture insurance, access to reliable markets to sell and buy produce at competitive prices, digital records systems to track income and expenditure for informed decision making, and seasonal performance analysis.

Source: Interview held on 11 October 2019 and akorion.com/index.html

Box 5.6: Digitalizing B2B payments in the Arabica coffee value chain

Yo Uganda, with the support of the mobile telecommunication company MTN, has implemented an initiative for digitalizing payments to 3,000 farmers producing Arabica coffee, with the involvement of the coffee exporter Kyagalanyi Coffee and the washing station operations in Mount Elgon in Eastern Uganda. Yo's last mile platform allows real time visibility, supporting traceability of payments and the certification process. From the farmers' point of view, the digitalization of payments has eliminated the time needed to reach banks and the risks involved in dealing with cash. Moreover, it has enabled the pre-financing of farmers for the purpose of buying inputs, allowing a control on the type of inputs used and therefore impacting on the production quality and quantity. Besides making payments, the platform stores key data on producers, such as farm location, acreage, soil quality, the type of coffee produced, and transaction history, all of which are used to estimate production potential for each farmer and for certification and traceability purposes. Clearly, the platform plays a role that goes beyond payment digitalization and extends to key functions that improve the whole organization and management of the value chain.

Source: GSMA, 2017, www.yo.co.ug

ICTs have a key role to play in the development of agribusiness value chains because they can bring a wide array of benefits to small farmers, facilitating financial inclusion, and supporting the adoption of better agricultural practices and skills development. Besides, ICTs can also facilitate buyers and other leading actors, allowing more transparency and traceability and assisting the selection process among farmers (GSMA, 2017). Evidence from field research shows that the introduction of digital payments to farmers has a positive impact on operational efficiencies. The case of the Arabica coffee value chain in box 5.6 illustrates these advantages. Other successful cases of digitalization of the value chains can be found in sectors such as tea, sugarcane, and dairy (GSMA, 2017). GSMA (2017) estimates that the value of digital agriculture B2B payments could be as high as $616 million in 2017 and could reach $754 million in 2020.

5.7 Conclusions and recommendations

The Ugandan agri-food industry suffers from low productivity, and low engagement in the transformation and commercialization phases of the value chain, thus limiting its exploitation of its national market and export opportunities. The sectoral innovation system is populated by many private and public actors. The relationships among them are limited, with little or only occasional coordination of policies and many duplications of efforts. A number of key areas for future policy interventions stand out as follows:

- **Coordinating public interventions. The Office of the Prime Minister and the Presidency need to work with improved coordination, as do MAAIF, NARO, NAADS, MOSTI and others.**
  Government will need to coordinate and monitor programmes and carry out rigorous technical evaluations. Many policies see limited implementation, evident in the fact that from policy to policy, the objectives and instruments are reiterated but rarely applied. A key area for coordinated intervention is land property rights, in which ICTs can play an important role in reducing time and cost for data collection and delivery of documentation to landowners.
- **Developing an effective extension system through improved coordination and adequate funding**.
  Extension systems pose a serious coordination challenge for MAAIF and local governments. For the extension system to carry out its role of technical support and knowledge transfer, and not only as the distributor of free or subsidized inputs, it needs to have adequate finance, and capable and competent staff. Opportunities arise from the diffusion of ICTs which can help in collecting information, analyzing it, and providing advice to farmers with cost savings and in a scalable way. Public procurement can sustain the growth of startups developing applications in the area.
- **Creating linkages between research institutions and the field agencies and farmers, and supporting innovation platforms to strengthen capacity to innovate among farmers, traders and entrepreneurs in the agriculture sector.**

Research carried out at NARO needs to be driven by demand from farmers. This implies developing the right incentive system for researchers working at NARO and in the universities to facilitate their involvement in the field. For this purpose, access to research funds can require the involvement of researchers from NARO and the universities with technicians involved in extension services. Innovation platforms would involve a variety of actors beyond researchers, such as farmers, extension staff, researchers, and buyers. They also offer an opportunity for collectively accessing knowledge on inputs, credit, markets, and other types of services.

- **Strengthening value chains to exploit competitive advantages, domestically and internationally.**
  A value chain approach is needed to make progress in the transformation and commercialization phases. Policymakers and entrepreneurs will need to make strategic choices by identifying several agricultural products in which Uganda can exploit a competitive advantage in its own internal market, as well as in the regional African and the wider international market. Several factors will be key for the successful entry into new phases of the agri-food value chain. Strengthening cooperatives and farmers' groups can help to overcome the problem of the extreme fragmentation of land property and enable access to extension services and infrastructures needed in the transformation and commercialization phases. The diffusion of digital technologies will allow farmers to access land titles, to receive real time payments allowing them to save time, to improve management systems (e.g., inventory management), and build a digital profile to receive additional services, such as technical assistance and credit. Moreover, for buyers, ICTs can support traceability and certifications of products and it improves farmers' loyalty, creating incentives to offer support for the adoption of better agricultural practices and skills development.

- **Access to finance is critical for innovation in agriculture.**
  Access to finance is critical for investment in innovation, enabling better equipment and practices and for entering into new phases of the value chains. It is critical in addressing problems relating to a lack of collateral, the small size of farms, mobile money, as well as high transaction costs, due to the remoteness of clients. Such investment also enables the digitalization of land titles, and financing through the value chain. All are promising approaches to improving farmers' access to credit and insurance. The Government should sustain new firms with financial support schemes or special tax provisions.

6. The Information and Communication Technologies (ICTs) sector

ICTs play an important role in the daily life of the Ugandan population through Internet access and mobile payments. Innovative local solutions have also emerged in e-commerce delivery logistics. The ICT market also offers opportunities that increase the attractiveness of the country to ICT supply companies. The UNCTAD Rapid eTrade Readiness Assessment (2018) of Uganda suggests that there is great potential for e-commerce growth in Uganda, with many businesses seeing it as an innovative way to attract international customers and to increase their competitiveness.

ICTs play a key role in innovation by creating business opportunities, supporting the modernization of the economic system, reducing poverty, and generating opportunities for social and economic inclusion.

In Uganda there is a vast array of policies and institutions already in place that address the ICT sector. Nevertheless, a lack of coordination and a need for a more efficient use of scarce human and financial resources, as well as the better exploiting of complementarities among existing institutions and between public and private actors, are pervasive challenges. To fully develop the potential of ICTs and extend their diffusion across the country, also reaching rural and more disadvantaged areas, there is a need for greater public investments in infrastructures. The Government can play a key role in developing an adequate legal framework able to cope with the rapidity of the changes in this area.

Another area ripe for public intervention is education. Investment is needed to build digital skills and capabilities that are continuously changing. Finally, the Government can boost the ICTs industry with public procurement, investing in the digitalization of

the public sector. Private firms in the ICTs industry are quite dynamic. There are many ICT startups and incubators crossing over into areas such as agriculture, fintech and e-commerce. Their growth potential can be boosted by public procurement and the reduction of taxes in the early stages of firm development. These represent a serious obstacle to the innovation and diffusion of ICTs. The mobile money and Over-the-Top (OTT) taxes mainly penalize poor and vulnerable citizens.

6.1 Diffusion of ICTs in Uganda

The diffusion of ICTs and the resulting digital transformation depends on the success of ICT entrepreneurs, firms and industries, as well as on timely and supportive polices and policy decisions.

In the development of a knowledge-based economy, ICTs are at the same time a facilitator of social and economic development and an opportunity for new businesses and entrepreneurial ventures. ICTs are a fundamental pillar for the successful implementation of STI policies and for the development of an effective national innovation system.

The Ugandan Government prioritizes ICTs for their key role in driving economic development and supporting the transformation of the country into a middle-income economy, as indicated in Uganda Vision 2040 (Government of Uganda, 2007). It emphasizes the need to improve access to ICTs infrastructure and amplify usage, as well as the development of adequate skills in all segments of the population and in the different parts of the economic, social and public system. Also highlighted is the need for digital transformation to be supported by adequate laws and policies, including, among many others, the National ICT and the Telecommunication Policy.

In Uganda, ICTs have continued to grow over the last few years, driven especially by demand for both mobile and Internet services. In 2016/17, the contribution of the ICT sector to national GDP was estimated at around 2.3 per cent (UBOS, 2017). A picture illustrating the diffusion of different ICTs in Uganda is provided in table 8.1. Notwithstanding the continuous growth, both mobile and Internet penetration appears lower than the average in Africa. According to the Uganda Communication Commission (2018), there are 21.6 million mobile and about 18.5 million Internet users, with a rate of 47 per cent Internet penetration.

Mobile telephony is a key technology as it is enables digital inclusiveness, particularly for poor and marginalized sections of society. Mobile phones are also a starting point for digital literacy. Therefore, affordable and accessible mobile networks and services are a key element for STI-led development.

The Ugandan telecommunications market is rather crowded, with ten telecom operators. Two of them account for almost 90 per cent of subscriptions. MTN, a subsidiary of the South African MTN Group, is the largest operator, with more than half of the total country's subscribers, followed by Airtel, a subsidiary of Barthy Airtel, an Indian company. Other operators include Uganda Telecom and Africell, a subsidiary of a Lebanese mobile group that took over Orange, and smaller mobile companies, such as Vodafone, Smile Telecom, Smart Telecom, Sure Telecom, and K2 Telecom (ITU, 2017).

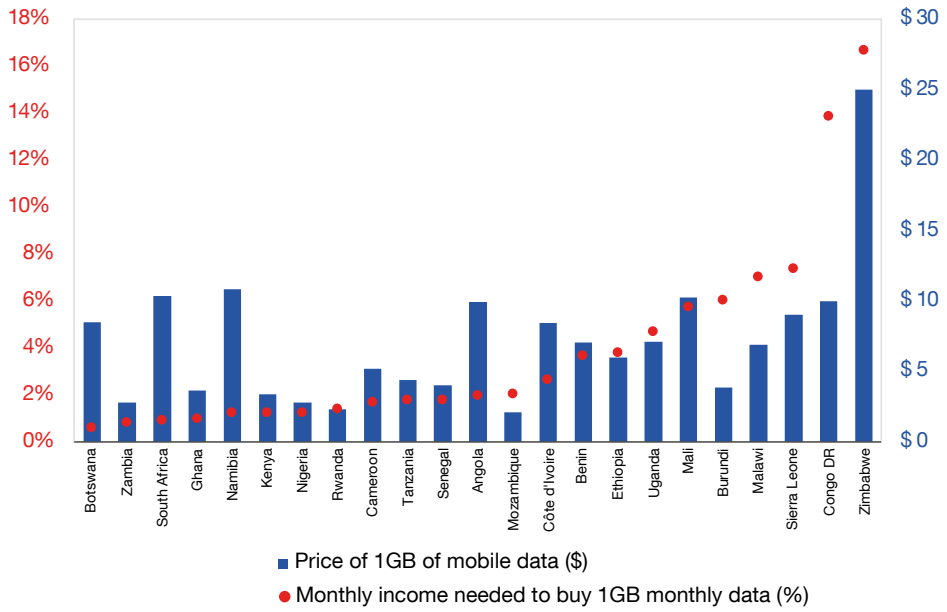
Table 6.1: Key ICTs indicators (2016)

	Uganda	Africa	World
Fixed telephone sub. per 100 inhabitants	0,9	1	13,6
Mobile-cellular sub. per 100 inhabitants	55,1	74,6	101,5
Fixed-broadband sub. per 100 inhabitants	0,3	0,4	12,4
Active mobile broadband sub per 100 inhabitants	33,7	22,9	52,2
3G coverage (% of population)	64	59,3	85
Percentage of households with a computer	7,6	9,6	46,4
Percentage of households with internet access	8,9	16,3	51,5
Percentage of individuals using internet	21,9	19,9	45,9

Source: ITU (2017)

Regarding costs, figure 6.1 shows that in Uganda the cost of using a mobile phone is much higher than in Kenya and other countries on the continent.[91] There are several possible reasons for this. One is that Uganda is landlocked and international links use over-ground cables from Kenya. Another is that several telecoms prefer to build their own networks, instead of using the national infrastructures developed by the Government, and therefore cannot achieve scale economies. Finally, a market with two dominant telecom operators may be insufficiently competitive. Use of mobile telecoms is further challenged by recent taxes on mobile money transactions and on the use of social media platforms, aimed at decreasing traffic on applications such as Facebook, Twitter and Instagram (Mothobi and Chair, 2018).[92] As a result, the cost of Internet access in Uganda using purchasing power parity exchange rates is more than double the cost in Kenya and more than three times measured as a proportion of monthly income.

Figure 6.1: Mobile data cost in Africa (2017)



Source: Ecobank Research (2018)[93]

The diffusion of ICTs' Networked Readiness Index (NRI),[94] provided by the WEF, sees Uganda as ranked 121st out of 139 countries surveyed, while Kenya is 86th (Baller et al., 2016). Table 6.2 and figure 6.2 offer details about each indicator included in the NRI, identifying Uganda as particularly weak in the skills needed by society to effectively use ICTs (126), as well as in the penetration and diffusion of ICTs at an individual level.[95]

Table 6.2: Networked Readiness Index: Uganda and Kenya (2016)

	NRI ranking	Environment ranking	Readiness	Usage			
				Overall	Government	Business	Individual
Uganda	121	101	124	120	97	105	129
Ethiopia	120	106	116	123	71	127	136
Kenya	86	81	105	84	45	50	107
Rwanda	80	27	115	83	16	60	127
Tanzania	126	112	130	126	100	122	134
Zambia	116	46	127	113	104	71	126

Source: reports.weforum.org/global-information-technology-report-2016/networked-readiness-index/

6.2 STI stakeholders

Uganda has a plethora of public, academic and private ICT stakeholders. However, their impact on the transformative processes in the Ugandan economy is marginal, as established in chapter 2.

The *Ministry of ICT and National Guidance* was established in 2006 and is responsible for providing strategic and technical leadership on all matters of policy, laws and regulations for the ICT sector. The Ministry is also in charge of ensuring the sustainable, efficient and effective diffusion and utilization of ICTs in all different aspects of life. It is organized into three directorates: 1) ICT Infrastructure Planning, 2) Information and National Guidance, and 3) ICTs Services.

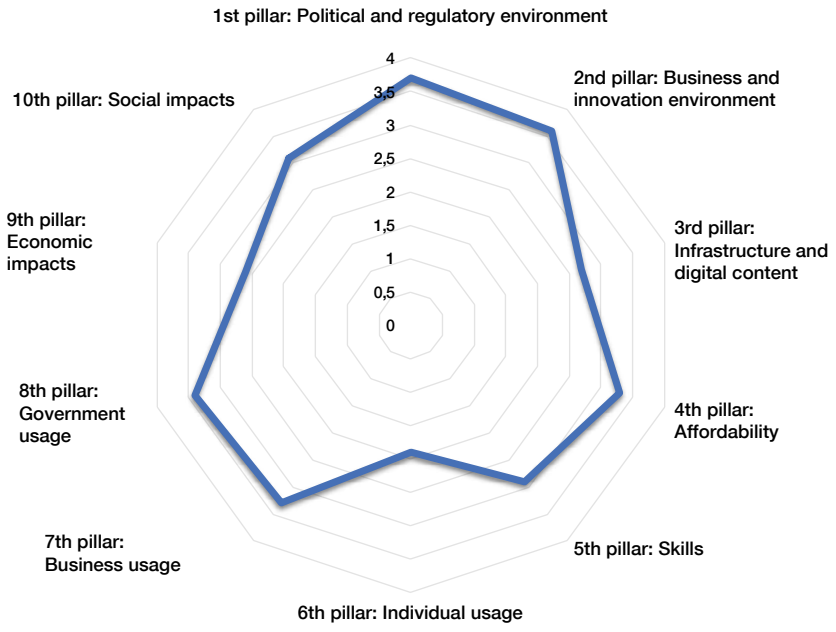
The *Uganda Communications Commission (UCC)* is responsible for the regulation of the communications sector, including telecommunications, radio, postal and data communication and infrastructure. The UCC is responsible, among other things, for licensing and standards, and tariff regulation, and it is also managing the Rural Communications Development Fund (RCDF), aimed at developing ICTs in the rural areas of the country.

The *National Information Technology Authority (NITA)* was established in 2009 with the mandate to coordinate, promote and monitor ICT development within the context of national social and economic development. Its functions include advising the Government on all matters relating to ICTs' development, utilization and accessibility; regulating and enforcing standards for hardware and software procurement for ICTs in the public sector; providing technical guidance on matters relating to e-government, e-commerce and other electronic transactions; and protecting the interests of users of information technology services.

In order to move forward, policymakers should consider the Ministry of ICT, the UCC and NITA as a single policy domain, with a keen eye for identifying points of collaboration with MOSTI and synergies that have direct benefit for the broadest citizenry in terms of access and affordability.

As is the case with the policy and institutional complexity in the oil and energy sector, the ICT sector public agencies each have their own mandates, policies and regulatory responsibilities. This risks the creation of a policy thicket, which may be difficult to navigate by outsiders,

Figure 6.2: The Networked Readiness Index – Uganda 2016 (score)



Source: reports.weforum.org/global-information-technology-report-2016/networked-readiness-index/

users and beneficiaries, and this can be a serious disincentive for innovation and private sector development. The coordination and directionality among their policies is achieved through maintaining coherence with the higher-level development policies expressed in Vision 2040 and NDP II. However, stronger horizontal coordination and interagency linkages and communication, formal and informal, may better serve the overall ICT and development agenda. In order to streamline implementation and clarify roles and responsibilities, for the sake of users and beneficiaries, policymakers could consider conducting a policy audit for the sector.

There are many private sector initiatives and associations in Uganda, and policymaking would benefit from better linkages and communication with active civic and business entities.

In the private sector there are several associations which play a relevant role in the ICTs sector. The *ICT Association of Uganda (ICTAU),* established in 2013, brings together ICT related private players to support the development of ICT industry in Uganda, to promote the establishment of ICT hubs, to accelerate the diffusion of ICT skills in education, and to increase ICT access for all Ugandan people. The *Alliance for Trade in Information and Technology Services (ATIS)* is an institution aimed at providing support to Ugandan ICTs companies which venture into the international market. The *Uganda Business Processing and Outsourcing (BPO) Association*, established in 2010, supports BPO in Uganda. It has members from different fields such as web designing, software development, human resources outsourcing and it has also created, in collaboration with NITA-U, Techno Brain, and a BPO incubator in Kampala, which is run by a private company. The aim of the Association is to support the development of the BPO sector in Uganda through advocacy on public policy, the provision of services such as research and market intelligence, and access to international networks of outsourcing associations, and training for industry practitioners.

Academic and training institutions teach computer science, but graduates may be lacking workplace skills needed to become quickly active in the private sector as ICT professionals. This increases the costs of hiring. Often, ICT firms will train new staff and young graduates at the firms' own cost in order to reach professional levels of performance and competency.

The Uganda Institute of Information and Communication Technology (UICT), established by the UCC in 2010, is a public tertiary institution that specializes in providing skills-based middle-level ICT training. It offers practical ICT training at certificate and diploma levels as an alternative to the theoretically grounded degrees offered by universities and other tertiary institutions. The Uganda Institute of Information and Communications Technology (IUCT) provides education and training

Box 6.1: The WIMEA-ICT Collaborative Project on Weather Information

WIMEA-ICT is a research and capacity building project funded by the Norwegian Agency for Development Cooperation (Norad). It is the result of cooperation between Makerere University and the Dar es Salaam Institute of Technology (DIT) in Tanzania, the University of Juba in South Sudan, and the Geophysical Institute of the University of Bergen.

Accessibility to reliable weather information is vital for decision-making in various sectors such as agriculture, disaster management, aviation, fishing, energy, mining, construction, defense, water resources and health. The methods of weather prediction and meteorological observation currently being used in the East African region are outdated and a timely dissemination of weather information is more or less absent. The project aims to improve the accuracy of and access to weather information in the East African region through suitable ICTs. It is expected to have a positive impact on productivity (in the agricultural, energy, water resources and construction sectors) and on safety (in the aviation, disaster management, fishing, health, mining, and defense sectors).

Source: wimea-ict.net/

in all fields related to the communication sector, including telecommunications services, computer engineering, and information technology and business management.

Uganda has 20 universities (five public and 15 private) running programmes in the field of ICTs (UNCTAD 2014). Among them is the *College of Computing and Information Science at Makerere University,* established in 2010, hosting one of the largest computing and ICT training, information science, research and consultancy colleges in Africa. The College is currently involved in a wide range of local and international ICT capacity building, in collaborative research projects, and in the provision of advisory services. Box 6.1 presents some information about WIMEA-ICT (Improving East Africa's Weather Information Management through the Application of Suitable ICTs), a collaborative project on weather information in which the College is involved.

Makerere University, in partnership with the Private Sector Foundation and NITA, among others, hosts the *Makerere Innovation and Incubation Center* (MIIC). The MIIC supports startups in the areas of fintech, software services, e-commerce, and data security, as well as agriculture and health, to develop their business plans, prototyping and financial planning. The tenants are mostly Makerere students and the incubator does not have strong links with the private sector and does not appear able to transform innovative ideas into proven commercially viable projects.

6.3 Policy background

Policies on ICT have been developed and implemented but are lacking impact assessments.

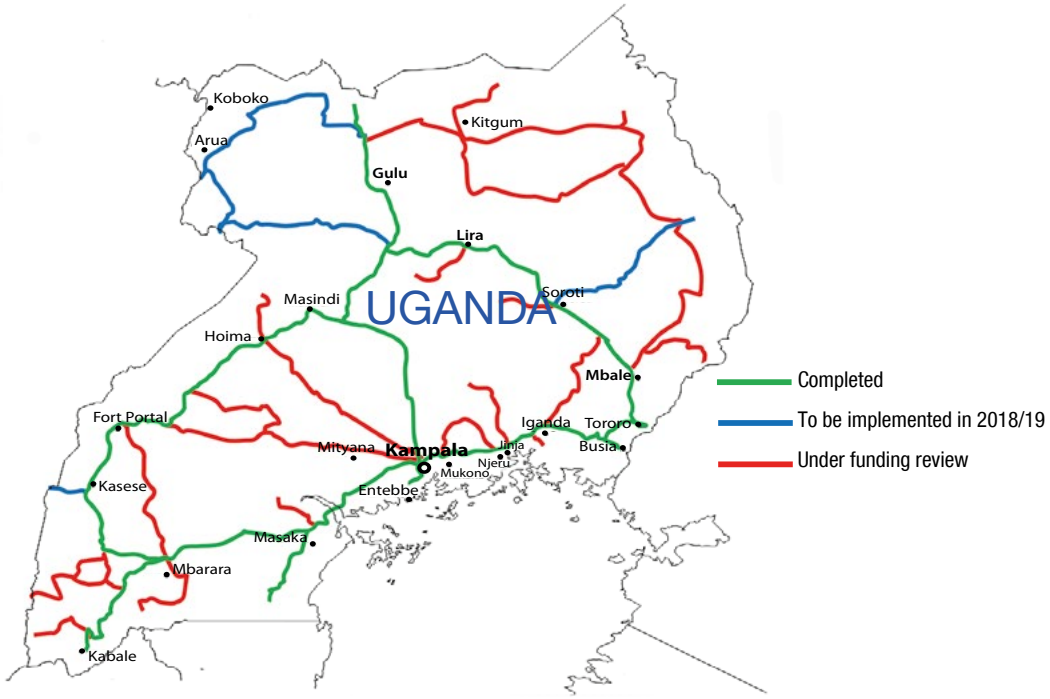
The *National ICT Policy 2014* is aimed at coordinating and harmonizing the disparate ICT efforts and policies across different ministries. Its objectives include building skills in the ICT field; promoting innovation in ICT products, services and applications; expanding ICT infrastructure; deepening the diffusion and utilization of e-services by the public and the private sectors; and promoting e-government initiatives. Another key objective of the National ICT policy is promoting universal access to technologies, with a special emphasis on rural areas and disadvantaged categories of the population (Ministry of Information and Communications Technology, 2014).

The Ministry of ICT is responsible for the *ICT Sector Strategic and Investment Plan* 2015/16-209/20. The plan identifies the priority areas for investments in ICTs: infrastructure, human capacity, policy, legal and regulatory framework, information security and e-government. The plan also indicates the main possible sources and funding models, namely: government financing through budgetary provision, Public Private Partnerships, Foreign Direct Investments, and support from development partners (Ministry of Information and Communications Technology, no date).

The diffusion of ICTs in rural areas is the main objective of the *RCDF Policy* (I, II and III) for the period of 2017/18 to 2021/22. The Policy is aimed at improving connectivity in rural areas, increasing access and affordability of devices and of online services and applications, as well as promoting equity in terms of opportunities arising from exploiting ICTs. Reviews of the first two RCFD policies show that infrastructures have been progressively extended in rural areas but, so far, the impact assessment of the outcome of the investments undertaken is still missing (UCC, no date).

The *National Broadband Policy* is aimed at promoting the diffusion of broadband Internet to enhance the socio-economic transformation process of the country. It states that high speed Internet infrastructure should be considered as key as any other infrastructures, such as roads, railways and power lines. The aim of the policy is to coordinate the development of the broadband network in order to avoid duplication of investments, improve the quality of the services and enhance cost affordability of the Internet services, favouring digital inclusion throughout the country (Ministry of Information Communications Technology and National Guidance, 2018). Due to the lack of a regulatory framework in the past, there are approximately 12,000 km of optic fiber network in Uganda, corresponding to an effective reach of less than 2,100 km, because of duplication in the covered segments. The consequence of this is the increasing costs for Internet access, as seen before. There is therefore a strong need for a framework that coordinates all the Government's interventions and regulation of the private sector in order to ensure sharing and complementarity of broadband networks.

Figure 6.3: National Backbone Infrastructure (December 2017)[96]



Source: www.nita.go.ug/projects/national-backbone-infrastructure-project-nbiegi

A related project, undertaken by the Ministry of ICT and NITA, is the *National Data Transmission Backbone Infrastructure (NBI)*, which is aimed at providing connectivity to Ministries and Regional Departments in the country. Figure 6.3 presents the map of the NBI, which connects 321 ministries, local government sites and other public entities, such as hospitals and universities. It appears that the Kampala network is well developed, though penetration in rural areas is still poor, with 60 districts out of 134 without access to broadband.

The *Regional Communication Infrastructure Program (RCIP)* under the responsibility of NITA, is funded by the World Bank and is aimed at mitigating the impact of Uganda's landlocked position, which keeps it dependent on transiting data traffic through neighbouring countries. The RCIP supports the Government of Uganda in improving: a) the coverage for IT infrastructure in the country; b) the delivery of public services by improving efficiency through government cloud infrastructure; c) the integration of the Government's IT systems d); the building capacity in management of IT programmes and projects; and e) the policy and regulatory environment for ICT in the country.

Finally, among other relevant laws for the ICTs industry, there are three cyber bills regulating electronic transactions, electronic signatures and computer misuses. Moreover, there is the E-Waste Management Policy that deals with the establishment of infrastructures, human resource development and promotion of awareness (United Nations Commission on Science and Technology for Development, 2010).

6.4 ICT companies, startups and incubators

The ICT industry has grown at an average rate of 19.7 per cent per year during the last five years. However, the business environment is not sufficiently conducive to startups, including in the ICT sector. Any success stories can be seen as accomplishments in spite of grave challenges, rather than outcomes of programmatic support from STI policy.

The growth of the ICT industry in Uganda has been supported by a competent level of ICT skills and driven by ambitious and resourceful entrepreneurs. Ugandan small- and medium-sized enterprises in the industry have potential to thrive and export (Netherlands Trust Fund IV, 2018). There are two common features among many ICTs that have transformative potential. The first is that they address an identified and specific socio-economic need. The second is that mobile money

Box 6.2: Ugandan innovation hubs and accelerators hosting ICT startups

Outbox is an innovation hub established in Kampala in 2013. It offers a shared office space, learning opportunities about how to run a business, legal training, marketing, product development, communication support, and funding opportunities to startups and early-stage entrepreneurs across a wide range of activities. These activities include fintech, health, transport, agriculture and education. Among its partners are Google for Startups, the United Nations Population Fund (UNFPA), The Indigo Trust, Mercy Corps, Facebook for developers, the Uganda Ministry for ICTs, and National Guidance.

Among its projects, there is the PiMaa 'Internet of things' project for building low-cost open source air quality sensors in collaboration with Open Data Collaboration Fund and Code for Africa. Outbox is also a partner in the MTN App challenge to support young entrepreneurs that are using mobile technologies to solve social challenges in health, education, finance, agriculture, and media and entertainment. In partnership with UNFPA and the Ministry of ICT, Outbox runs 'Up Accelerate', an initiative supporting young entrepreneurs in fields relating to sexual and reproductive health.

The Innovation Village is an incubator and accelerator for startups in sectors such as cleantech, health, agribusiness, fintech, media and education. It offers office space, an accelerator programme (the Challenge Driven Accelerator), a network of technical resources, as well as access to a network of potential investors. Among the companies incubated at The innovation Village are Xente and Wazi Vision.

- Xente, a firm developing e-commerce and e-payment solutions for small- and medium-sized enterprises. Xente aims to connect buyers and sellers to each other, and then connect them to licensed financial institutions for payments, credit, savings and insurance. By doing this, Xente works towards building a highly trusted and liquid market that will catalyze the adoption of digital commerce in Africa.
- Wazi Vision, a female-led company producing fashionable and affordable (between $20 and $100) glasses, made from recycled plastics, and sold online. Wazi Vision provides free eye testing in schools and in rural areas and has developed a mobile app that uses virtual reality to perform visual tests.

Source: Interviews held on October 17, 2018, outbox.co.ug, www.innovationvillage.co.ug

transactions are central to their business models to the point of having become the defining platform, rather than a transaction tool.

The development of such innovative firms requires support in everything from hosting in incubators and accelerators, to finance, and advisory services from mentors and international partners. Unfortunately, fiscal policy, detached from STI policy, sees startups and small- and medium-sized enterprises uniquely as a source of tax revenue. Box 6.2 offers some information about two innovation hubs and two e-commerce initiatives located in Kampala.

6.5 The fintech industry

Fintech, is a crossbreed of finance and ICTs. It has important social development impact on improving financial inclusion, in particular for women and vulnerable or underserved populations. From an innovation perspective, it presents numerous opportunities, as the ICT infrastructure has been established between government projects and telecom operators.

Over the past decade, the development of ICTs has stimulated the introduction of new financial services, and new business models to deliver them. Companies utilizing ICTs to offer financial services are denominated fintechs and they hold great potential for both increasing financial inclusion and promoting economic development (Cambridge Center for Alternative Finance, 2018). Digital financial solutions expand the access to potential customers, especially those who are unbanked or under-banked. One of the key advantages of fintech is that it can lower the costs of financial transactions by 80 to 90 per cent when compared to traditional financial products. In addition, fintech is a growing industry, potentially generating incomes, employment, and business opportunities for new companies.

Box 6.3: MamboPay: fintech for children

The company was established in 2015 to solve a very specific problem faced by children in boarding schools who are not allowed to have mobile phones but need to receive money from their parents. MamboPay issues digital vouchers and cards on which money can be sent from a mobile phone and then redeemed by students to pay for small expenditures. Given the success of the system, MamboPay has extended into a number of other scenarios, such as digital vouchers for paying school fees or for buying seeds or fuel, issued by NGOs and private companies on behalf of small farmers.

Source: Interview held on 19 October 2019; mambopay.net

Financial inclusion in Uganda is estimated at just 58 per cent (Finscope, 2018). Fintech firms are targeting the gap in access to finance by using innovative ICTs and business models. According to a recent study (Cambridge Center for Alternative Finance, 2018) there are currently about 70 fintech firms operating in Uganda and there are expectations for strong growth in the future. About 60 per cent of the fintech firms operating in the country are domestic, 21 per cent are companies from the region and the rest are global companies. Payment is the largest business area in the country, with a transaction volume of about $47 billion in 2016, followed by investments and savings, and lending and insurance.

In the area of mobile payments, there are companies such as Xente, Yo! Payments, DusuPay or EzeeMoney. Another operator in the area of mobile money is MamboPay (see box 8.3). Initially established to facilitate money transfer to children in boarding schools, it represents an interesting example of a venture aimed at improving financial inclusion. In the area of lending, there are several operators offering digital loans. Some examples are Numida, targeting small businesses, Borrocracy, offering peer-to-peer lending, Akellobanker, aimed at facilitating access to credit in rural areas, JUMO, a south African company operating across Africa, or First Access, which offers a credit-scoring function to borrowers. Finally, in the field of insurance, companies operating in Uganda are Yo Uganda, Mazima Retirement Plan, We Farm Limited, Money Duka Services and Craft Silicon (Cambridge Center for Alternative Finance, 2018).

A very innovative mobile money application trialed in Uganda is addressing the needs of refugees living in camps in the northern part of the country. The United States' NGO Refunite has developed an application, funded by the GSMA Disaster Response Innovation Fund, to allow refugees to earn instant money by training algorithms for artificial intelligence. The project involves 5,000 refugees from South Sudan and the Democratic Republic of Congo and besides offering the opportunity to earn a small income, it also provides an opportunity to develop IT skills among the refugees involved in the project.[97]

Well formulated policies addressing consumer protection, competition, data privacy, and skills and competencies among entrepreneurs, technologists and regulators will determine the commercial success of fintech and its societal contribution.

With a view to the future development of the fintech sector, a number of policy considerations become apparent. The first is the need to develop a consumer protection framework. This would also include data privacy, for addressing potential systemic risks and financial instability, for promoting competition in the fintech industry, and for providing specific skills and competencies (capacity-building) to regulators. The need for an appropriate policy and regulatory framework in the area of mobile financial services is also one of the conclusions in the National Financial Inclusion Strategy (The Republic of Uganda, 2017). In general, policymakers and regulators are confronted by the necessity to balance the opportunities and the challenges of fintech. As the industry continues to grow, they are aware of the need to rapidly improve their knowledge and their capabilities to deal with fintech issues that are, by their nature, complex, interdisciplinary and dynamic.

6.6 E-commerce

Affordable, competent and effective physical delivery is the development challenge for e-commerce in Uganda. While regulations are in place, the national transport and logistics infrastructure requires serious consideration.

E-commerce is indicated as a priority in the NDP II and, given the growing diffusion of mobile phones and electronic payments, there is an expectation for rapid growth in the sector. The UNCTAD Rapid eTrade Readiness Assessment of Uganda (2018) highlights a number of accomplishments and outstanding challenges. Most government institutions have included ICT in their strategic plans. However, there is some confusion about institutional mandates and overlaps between public agencies. The private sector is not adequately involved in policymaking related to e-commerce. A lack of trust in online transactions remain a key challenge. Job seekers, traders and entrepreneurs are not adequately equipped with e-commerce knowledge and skills, which are distinct from ICT skills. As Uganda is a landlocked country, the diffusion of e-commerce will depend on its ability to increase the efficiency in the postal network and courier sector and reduce costs, translating them into increasingly affordable customer service. In June 2018, Uganda moved in that direction by ratifying the WTO Trade Facilitation Agreement, which is aimed at simplifying and standardizing trade procedures and documentation related to import and export. With regard to laws and regulations, Uganda has a comprehensive framework already in place that includes the Electronic Transaction Act 2011, the Electronic Signatures Act 2011, and the Consumer Protection and Competition Bill 2015. So far, the contribution of e-commerce activity to national GDP is still relatively low.

The largest online retailer is Jumia, a Nigerian marketplace for buying and selling, operating in 14 African countries, including Uganda. Another interesting case is Xente, a startup incubated at the Innovation Village (see boxes 4.6 and 6.2), which has developed a platform that enables Ugandan businesses to sell their product online on any mobile channel and get paid from anywhere in the world via digital payments, including mobile money, bank cards, and even cryptocurrency. Xente is advocating financial inclusion and its aims mandate that at least 20 per cent of the products and services sold on its e-commerce platform should be produced by people who live on less than one dollar a day. Once the product is sold, Xente pays the money to the mobile money account of the seller (UNCTAD, 2018).

6.7 ICTs in the public sector

ICTs enable the Government and public agencies to, like private firms and entrepreneurs, innovate in the delivery of public service, paid for by taxpaying citizens. This provides an opportunity for the Government to act as a lead innovator and inspire and build awareness among citizens, as well to experience first-hand the challenges of innovation.

E-government is considered a key instrument in addressing corruption in Uganda, as well as in improving public service delivery. The diffusion of e-government should also contribute to increasing the productivity of the private sector, by reducing transaction costs with the public sector in areas such as tax assessment, payment and procurement.

The Government of Uganda is making progress in ensuring the diffusion of ICTs in ministries and local governments. According to a document of the Ministry of Information, Communications Technology and National Guidance (2018), to date, 248 websites have been developed across different public institutions, and there are 297 systems/applications for internal use, or for supporting the provision of services to the public.

Internationally, Uganda is ranked 135 over 193 in the United Nations' E-Government Index, which assesses national websites and how e-government policies are applied in general and in specific sectors.[98] Uganda is in a relatively better position in the E-Participation Index. The Index focuses on the use of online services, the interaction with stakeholders and engagement in decision-making processes, in which Uganda is ranked 87 over 193. An example of best practice is presented in box 6.4.

The National Data Transmission Backbone Infrastructure (see figure 6.3) allows the implementation of e-services through the e-Citizen Portal, which is a one-stop centre for public online services, such as the Electoral Commission Voters Register, E-Tax, E-Single Window and E-Visa, at the Ministry of Internal Affairs and the Inspectorate of Government Online Declaration System (IG-

Box 6.4: Innovation in public service in Uganda

The Disaster Communications Management, Prevention and Response system, was developed by the UCC in collaboration with the Office of the Prime Minister, the Ministry of Water and Environment, and the District Local Government of Butaleja. It is a jointly implemented pilot project setting up two flood early warning systems. One of the systems is installed in a primary school with the aim of warning the community before possible flooding.

The e-Voucher Farmer Scheme project, implemented by the Ministry of Agriculture, Animal Industry and Fisheries, is aimed at providing matching grants to farmers for buying online seeds, fertilizers and other inputs. The farmers view the vouchers directly online in a dedicated platform and then have three opportunities, linked with the crop cycle, to buy inputs from registered dealers. No cash is given directly to the farmers.

Source: UNCTAD (2018)

ODS). As a case in point, the e-immigration system has reduced the number of days to process a visa permit from 30 to four. The Government e-Payment Gateway is the portal that allows the use of mobile money to make a payment, therefore facilitating financial inclusion of the unbanked categories of the population. Other projects include the e-Voucher Farmer Scheme described in box 6.4.

Another interesting example is the Integrated Intelligence Computer Systems which, among other functions, tracks the distribution of drugs and other prescription products in health facilities. It is designed to improve access to malaria diagnosis in rural areas and improve drug management and monitoring. ICTs also enable utility firms, such as UMEME Limited, the electricity company, to develop pre-paid services with mobile money payment options, addressing the problems created by inefficient billing systems.

6.8 Conclusions and recommendations

ICTs are a major component of STI processes and play a key role in creating business opportunities, supporting the modernization of the economic system, reducing poverty, and increasing social and economic inclusion. Therefore, well-developed policy support is critical for the functioning of the entire national innovation system.

In the Ugandan ICTs innovation system there are many policies, institutions and private actors already in place, but coordination between them all requires improvement. The private sector is small but lively and is attracting educated and dynamic young people. These budding entrepreneurs need support to transform their ventures into viable and growing businesses. However, the most common and shared perspective among most startups and small- and medium-sized enterprises in the sector is that support from the public sector is limited.

For the development of an effective innovation system in the ICT sector the following policy actions are recommended:

- **Investments in infrastructures should extend to rural areas.**
  Public investment in infrastructures should extend their diffusion across the country, reaching rural and underserved areas and communities, in order to fully develop the potential of ICTs. Better and more diffused infrastructures will also reduce the cost of accessing Internet services.

- **Update and complete legal and regulatory framework.**
  A supportive and practical regulatory framework is key for building a favourable system for both private domestic and international investments in the ICT sector. In particular, fintech is an area in which regulation is needed.

- **Fiscal policy should not penalize the ICT sector.**
  Fiscal policy should privilege rather than penalize startup firms and entrepreneurs in the ICTs sector. It is considered highly desirable for taxes on the use of social networks and on mobile money transactions to be removed. They hit the poorest sections of the population,

create barriers for domestic entrepreneurial ventures and make the country unattractive for potential foreign investors.

- **Investments in education and digital skills require full policy support**.
  More resources are needed to build human capabilities and digital skills, which are continuously changing. It is also important to strengthen the linkages between universities, technical colleges and the private sector to develop curricula that builds skills needed in the industry.

- **Public procurement is an underused tool.**
  Investing in the digitalization of the public sector not only increases the efficiency of public administration but also guarantees an important demand to support the growth of local businesses.

- **Investment in e-government will stimulate growth in the local ICT sector.**
  The diffusion of electronic vouchers to pay school fees or grants for farmers is a great facilitator for making services accessible. It also creates business opportunities for domestic startups that come up with smart solutions.

- **Support incubators and startups with a commercial approach that involve public and private actors, and ensure elements of competition and merit in the selection process**.
  Incubators should address gaps in the system and facilitate networking within it. To survive and grow, startups need access to credit, subsidized space and support to address more demanding (national or export) markets.

Part III

Policy recommendations

7. Summary of policy recommendations

7.1 Long-term recommendations

1. STI policy should reinforce the expression of national vision as proposed in Vision 2040. It should express a corresponding sense of unity and ambition to work towards the common goal of STI-enabled sustainable development as set by the 2030 Agenda and the SDGs.
2. STI policy should have as its top-level objective the operationalization of the Ugandan National System of Innovation.
3. STI policy should face the challenge of clearly defining the STI policy domain with enhanced attention paid to the innovation component of policy and to the role of firms and entrepreneurs.
4. An innovation-focused mind-set should be instilled in existing and newly created institutions. This should allow a productive and central focus on firms and entrepreneurs as key innovators. It should also enhance awareness of the prime mandate of addressing societal needs and challenges for growth, development and sustainability.
5. STI policy should recognize the potential and central role of dynamic and energetic Ugandan entrepreneurs and involve them as key actors in the operationalization of the Ugandan National System of Innovation.

7.2 Medium-term recommendations

6. STI policy should stimulate transformational processes manifested by the growth of the share of knowledge-intensive industries in GDP and an increase in productivity and value added across all sectors including agriculture, services and industry.
7. STI policy should work to enable technology-led development in agriculture, services and industry, by enhancing the technological and absorptive capacities of farms, firms and industries, as well as public agencies that deliver services to citizens and which work towards achieving socio-economic and environmental sustainability.
8. STI policy should link with STI stakeholders to jointly develop a Startup Act that should provide for appropriate fiscal support to nascent, innovative and technology-led firms and entrepreneurs.
9. STI policy should assist in the coherent development and delivery of public policy and interventions in agriculture. The Office of the Prime Minister, and the Presidency, MAAIF, NARO, NAADS, MOSTI and others, need to work with improved coordination in the agricultural sector. This should include developing an effective extension system through improved coordination among farmers and entrepreneurs, public agencies and researchers.
10. STI Policy should assist in creating linkages between research institutions, field agencies and farmers, and in supporting innovation platforms to strengthen capacity to innovate among farmers, traders and entrepreneurs in the agriculture sector.
11. Policymakers should use a value chain framework for analyzing the potential of agricultural and industrial products and services in order to define and exploit competitive advantages, domestically and internationally.
12. The state of the current business environment in Uganda requires significant improvement in order for firms and industries to contribute to achieving national development aspirations. Innovative and technology-enabled startups and nascent firms need a more supportive stance from the public sector. The ICTs sector and electricity production and distribution are considered primarily as business sectors and only to a lesser extent as enablers of development. A rebalance of perspectives should be a favourable development.
13. STI policy should support improvements of ICT infrastructure through public investment and improved coordination among stakeholders. This should enable better service, enhanced geographic access and more affordable prices. Investments in infrastructures should extend to rural areas. Investment in

e-government should stimulate growth in the local ICT sector through procurement and service contracts.

14. STI stakeholders, together with partners in the ICT sector, regulators and consumer interests, should engage with private sector telecom operators and ICT firms. They need to establish a way to reduce high prices for data telecom services, which are a strong disincentive to innovate for many entrepreneurs, firms and industries.

15. STI and development partners should review possibilities for accelerating the buildout of electric energy production and distribution capacities. A fourfold increase is necessary to achieve meaningful support of national development aspirations.

16. Transport and logistics should require investments in infrastructure, such as at the Malaba border with Kenya and in metropolitan Kampala. A TNA approach using a socio-technological systems framework should be considered.

17. Funding of STI activities, as opposed to policy design and implementation, should be located in separate agencies and managed according to current best practice, to enable a high level of accountability and quality reporting.

18. STI policy should engage with the financial services sector to develop their contribution as innovators and financers of innovation. Financiers should be incentivized to invest a minimum amount in diversified vehicles such as the NIF or venture capital funds run by public-private partnerships.

19. Policymakers should evaluate technology transfer activities for their contribution to the SDGs or for their commercial success, i.e., as products, processes or services delivered by firms, industries or public bodies, to the market or by providing a service to citizens.

20. Intellectual property rights policy should focus on raising awareness of technologies in the public domain, of technologies protected by public licence copyrights, and of the use of compulsory licences and utility patents, and non-disclosure (trade secret) contracts.

21. Preservation and commercialization of traditional and indigenous knowledge using IPRs should require a well-considered policy decision. Policymakers should be mindful that preservation and commercialization can be contradictory goals for traditional knowledge and genetic resources.

7.3 Short-term recommendations

22. MOSTI, and partnering ministries and agencies, should enter into a process of permanently developing their capacity to communicate and engage with firms, industries and civil society and other STI stakeholders and beneficiaries. Mainstreaming STI policy should require both a high-level and a broad public dialogue.

23. MOSTI, and partnering ministries and agencies, should build public awareness and contextualize sustainability issues regarding energy production and consumption against the actual development concerns. The country's contribution to greenhouse gas emission is negligible from a global perspective. While the potential for renewable energy production is high however, general awareness of possibilities is low.

24. MOSTI should evaluate its internal organization in the near-term, having acquired feedback on its initial years of operation. Monitoring and evaluation (M&E) processes should become a key policy management tool and this should be reflected in organizational alignment and acquired competencies. MOSTI should ensure that a funding plan for M&E activities are embedded in policy processes under its purview.

25. As M&E requires high quality data, MOSTI should strengthen the role of the Uganda National Council for Science and Technology (UNCST) in providing data on STI for evidence-based policy design and implementation.

26. MOSTI should communicate among its experts and policy partners to ensure that M&E is seen as a learning process, and not a system of punishment.

27. MOSTI should launch a multi-stakeholder policy process to address a key SDG issue in terms of effects on health and deforestation: charcoal (biomass) use, which represents 90 per cent of total energy consumption.

28. The National Innovation Fund should be guided by a clear innovation mindset. Selection criteria should target specific development objectives or SDGs. Monitoring and evaluation should be key implementation tools.

29. MOSTI should commit to building technical, financial, and administrative capacities required to manage the National Innovation Fund.

30. Publicly financed R&D activities, such as the Presidential Initiative programmes and university research, should be required to develop public access to scientific data, as well as documents showing feasibility analysis, evaluations and research outcomes. Research activities should be tasked with developing stronger linkages with national STI stakeholders and move forward more energetically into commercialization phases.

31. Curriculum boards should deliver meaningful assessments, revisions and updates in vocational training curricula by developing a more substantive interaction with sectors and industries.

32. The interaction between National Curriculum Development Centre and stakeholders needs an operational M&E framework that would develop virtuous policy learning cycles and provide incentives for improving cooperation between educators and industries.

33. Support for education and training in digital skills should be given highest priority through a multi-sector compact led by MOSTI and the Ministry of Education and Sports.

34. Universities should rebalance enrollment towards increasing STEM students and graduates. Universities should shift research to address the challenges of sustainability or challenges encountered in firms and industries. This will require better linkages with other STI stakeholders, an objective where MOSTI should play a central role through targeted communication, coordination and outreach activities.

35. Universities should develop on-campus hosting for startups and source research themes, at graduate and post-graduate levels, from sectors and industries.

36. The publishing of academic research as a primary non-teaching activity, should be de-prioritized in favour of research activities in collaboration with industry.

37. STI parks should be populated with tenants with varied competencies and profiles including firms from related sectors, financiers, and R&D institutions. STI park management should engage and learn from private sector accelerators and incubators and their effort to remedy the systemic fragmentation of the Ugandan innovation system.

38. STI policy should support the activation of STI industrial and business parks and incubators/accelerators as they enable a more fluid and informal interaction of technologists, entrepreneurs and financiers.

39. STI policy should give clear support to incubators and startups involving joint public and private actors (e.g., academia-firm partnerships) innovating for a market need or a social or sustainability objective.

40. STI policy should support innovative applications of frontier technologies and their use to promote an inclusive and sustainable development agenda. Policy decisions and policy itself should not prejudge decisions based on perceptions of inappropriateness of frontier technologies for low income or development levels.

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Annex 1: What is a national system of innovation?[99]

A national system of innovation (NSI) is a framework for developing and implementing STI policy. Its original objective was to better understand what causes the often-significant differences between countries in terms of their capacity to innovate and, as a consequence, to then develop. To answer this question, Lundvall (1992) proposed exploring the "elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge". In other words, policymakers are guided to develop an understanding of why the intensity and quality of relationships and interactions among institutions such as firms, academic establishments, and government bodies are critical to STI outcomes and consequently to economic development. If these relationships are weak and various policies act in isolation, the development effects of investments in STI will be sub-optimal.

Why are interactions the key issue? While innovation takes place essentially within firms, firms do not engage in learning and innovation activities in isolation. Firms interact with other firms, public institutions, and society at large, in order to participate in knowledge and technology creation and flows. The sum of their capabilities, interactions and knowledge flows, among themselves and with their environment, in any one country, is often referred to as the national system of innovation (NSI). An NSI exists regardless of the intensity of interactions, which can be weak in many developing and least developed countries, or the formal support that these interactions receive as a matter of government policy. The nature of the NSI in any country will largely depend on the interplay of many economic, social, historic and cultural factors. This means that its characteristics are dynamic and constantly changing. They are also affected by diverse public policy activities. The NSI is a framework for implementing STI policy. The relationship between STI policy and NSI is symbiotic and mutually reinforcing.

Annex 2: Sustainable Development Goals

The Sustainable Development Goals (SDGs) are the United Nations' blueprint to achieving a better and more sustainable future for all. Agenda 2030 and the SDGs succeed and broaden the mandates established in the United Nations' Millennium Development Goals. The SDGs address the key global challenges, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The Goals interconnect and aim to leave no one behind. They can be categorized by their central relevance for people (SDGs 1,2,3,4 and 5), prosperity (SDGs 7, 8, 9, 10 and 11) and planet (SDGs 6, 12, 13, 14 and 15), with two SDGs (16 – peace and justice, and 17 – partnerships) defining an enabling framework for implementation. The success of their implementation will be evaluated through a set of predefined 167 SDG targets. The achievement for each Goal is set for 2030 and will be measured through 169 targets-indicators.[100]

Annex 3: Objectives of the National Science, Technology and Innovation Policy (2009)

Objective 1: Create an enabling policy environment to foster STI and augment their contribution to national development.

POLICY STATEMENT 1: Assess, forecast and advise on issues regarding STI, taking into account current and future trends in development, transfer and diffusion of both local and foreign STI outputs.

POLICY STATEMENT 2: Provide a conducive environment for industrial development in Uganda.

POLICY STATEMENT 3: Facilitate and encourage science and technology (S&T) innovation through protection and use of Intellectual Property Rights.

POLICY STATEMENT 4: Guide the judicious use and application of traditional, conventional and emerging technologies for sustainable development.

POLICY STATEMENT 5: Mainstream and actively involve the special needs groups, men, women, and children in all STI activities in order to ensure that the resultant impacts are evenly spread across all sections of society.

Objective 2: Build the STI sector capacity to generate and transfer technology

POLICY STATEMENT 6: Provide financial support for STI activities to build capacity and put in place the necessary infrastructure.

POLICY STATEMENT 7: Build an educational and training system that produces human resources with capacity to generate and effectively apply STI based on the

current and future needs of society.

POLICY STATEMENT 8: Provide adequate and state-of-the art STI infrastructure to facilitate cutting-edge research and scientific innovations.

POLICY STATEMENT 9: Support basic, applied and development research for enriching the STI knowledge base and product development for enhancing indigenous knowledge and adaptation of imported technology.

POLICY STATEMENT 10: Support development and growth of small and medium-sized enterprises through provision of essential services and infrastructure.

Objective 3: Establish and strengthen the legal and regulatory framework to ensure ethics and afety in STI development and application

POLICY STATEMENT 11: Apply appropriate safety and health measures in the generation, development and application of STI in all its aspects.

POLICY STATEMENT 12: Establish mechanisms to ensure development and application of STI in accordance with acceptable morals and national societal norms.

POLICY STATEMENT 13: Promote the standardization of Ugandan products and services in line with required international standards.

Objective 4: Strengthen the STI coordination framework to enhance the sector's performance and contribution to national development

POLICY STATEMENT 14: Promote STI awareness and ensure public commitment and support for STI activities and programmes.

POLICY STATEMENT 15: Develop an STI information management system to facilitate the production, storage and dissemination of accurate, timely and up-to-date information on STI activities.

POLICY STATEMENT 16: Strengthen the central co-coordinating institution – (UNCST) – to effectively provide a sector-wide framework for policy, planning and coordination; and establish support linkages with local, regional and international development partners.

Annex 4: Ministry of Science, Technology and Innovation – Science, Technology and Innovation Sector Development Plan 2019/2020-2024/2025

Sector Objectives and Activities

The overall development and up-grading of the ST&I sector in the SDP will contribute to the overall goal of strengthening the national science and technology innovation system. The SDP is anchored around seven strategic objectives. Each objective comprises thematic areas and specific activities. These are:

Objective 1: Enhance sector policies, planning and coordination. This objective will be attained through pursuance of activities in three thematic areas.

- Thematic Area A: Improve data, information and analysis for evidence-based planning and policy making.
- Thematic Area B: Review and develop policies and strategies.
- Thematic Area C: Strengthen Sector Coordination.

Objective 2: Develop ST&I support infrastructure. This objective will be attained through pursuance of activities to:

- Thematic Area A: Improve science and technology innovation system infrastructure and support systems.

Objective 3: Increase funding for ST&I from public and private sectors. This objective will be attained through pursuance of activities in two thematic areas.

- Thematic Area A: Increase private sector funding for ST&I.
- Thematic Area B: Increase public sector funding for ST&I.

Objective 4: Improve ST&I advancement, outreach and human capital development. This objective will be attained through pursuance of activities in two thematic areas.

- Thematic Area A: Improved ST&I education and skilling.
- Thematic Area B: Improved advancement and outreach for ST&I.

Objective 5: Increase transfer and adoption of technologies for all categories of people. This objective will be attained through pursuance of activities in two thematic areas.

- Thematic Area A: Enhance international partnerships and cooperation in support of technology transfer and advancement.
- Thematic Area B: Support the commercialization of technology transfer.

Objective 6: Strengthen R&D capacities and applications in existing and emerging fields of science and technology. This objective will be attained through pursuance of activities to strengthen systems for ST&I R&D

Objective 7: Improve the legal-regulatory frame-work for ST&I. This objective will be attained through pursuance of activities in two thematic areas.

- Thematic Area A: Develop and implement legal regulatory measures to facilitate the promotion of the ST&I sector.
- Thematic Area B: Develop and implement legal-regulatory measures to guide the safe and appropriate use of new technologies.

Cross-cutting issue 1: Gender Mainstreaming Plan. The issue will be implemented through two intervention and will address four sectors (agriculture, health, energy and minerals development, and education).

- Intervention area 1: Science for Women and Persons with Disabilities
- Intervention area 2: Women in Science

Cross-cutting issue 2: Environment and Climate Change. ST&I activities will play an important role in helping Uganda to preserve its natural environment and adapt to climate change by providing R&D solutions for new technologies and innovations.

- Intervention area 1: prioritizing environmentally sound project applications for “green technologies” to the Research and Innovation Fund

- Intervention area 2: support for technology transfer centres
- Intervention area 3: science centres and museums

Cross-cutting issue 3: Youth employment. Interventions will address the full range of employability issues, from upgrading competencies in low-skilled youth to tertiary education.

- Intervention area 1: improve training and education in both technical BTVET and the secondary/tertiary educational tracks.
- Intervention area 2: career guidance and mentorship
- Intervention area 3: mass-skilling interventions for youth outside formal schooling programs

Cross-cutting issue 4: HIV-AIDs. Interventions will include research that leads to the use of remote electronic diagnostic tools and patient interfaces, as well as lower-cost locally produced drugs to treat persons with HIV-AIDs.

- Intervention area 1: promotion of R&D activities that are either directed specifically at HIV treatment and prevention
- Intervention area 2: R&D efforts in the field of health science aimed at reducing the cost of basic medical services to HIV-affected persons.

Annex 5: Characteristics of effective innovation funds

1. Innovation funds are a demand-based policy instrument, meant to capture the effective demands for innovation by business and society, and remedy the problem of innovation solely reflecting research and technology supply.
2. Innovation funds need to have three key design characteristics:
   a. They must operate on a non-reimbursable basis, instead of through credit. Therefore, a grant (subsidy) component is essential;
   b. The selection of projects coming from firms must be competitive with firms competing for the grant with the most innovative projects;
   c. There must always be a requirement of matching funds coming from the candidate firms, with the cost of the project shared by the innovating firms and the Innovation Fund. The amount of such privately provided funds may vary according to local conditions, technological risk or other factors, to be defined in advance, and not applied on an ad hoc basis to each selected project.
3. The efficacy of innovation funds to improve firm productivity and sales is strongly supported by a large body of evidence of impact evaluation studies (Crespi et al., 2014).
4. Innovation funds are an "entry level" innovation policy instrument, relatively easy to put together and implement, and ideal for building upon, when it comes to upgrading to more sophisticated policies. The nature and implementation of innovation funds can be made more sophisticated over time, and combine with additional policy instruments, but they are nonetheless essential.
5. Innovation funds are rarely exposed to rent-seeking risks, but they involve a non-negligible effort in public capacity building and private sector learning. The public sector in charge of implementing the fund needs to have (or build if they are not available) the competencies and the experience required, that are not normally found in the public administration. The enterprise sector also needs to learn how to operate within an innovation fund, how to design an innovation project proposal and how to implement it, while taking the necessary risk and developing the capacity to innovate and commercialize innovation. These skills are different from the skills required for a research project.

Notes

[1] Calculation based on World Bank GDP data in constant 2010 $.

[2] Bank of Uganda FAQ. Available at www.bou.or.ug/bou/faq/Related-faq/monetary-policy/index.html.

[3] For figures for 2017 see: databank.worldbank.org.

[4] Here and throughout this STI Policy Review we use the *International Standard Industrial Classification (ISIC), Revision 4* of three sectors: agriculture, industry and services. The plural, *industries,* refers to specific economic activities in any of the three sectors.

[5] The GII gathers data from more than 30 sources, covering a large spectrum of innovation drivers and results. The GII is positively biased towards official data and underweight on qualitative assessments, with only five survey questions included in GII 2019.

[6] See: www.wipo.int/global_innovation_index/en/.

[7] Figures for Ethiopia in 2018 are estimates.

[8] In commerce, the innovative entrepreneur performs an irreplaceable role of assessing, exploring or creating consumer needs and wants. The innovator will also assess the required technological, physical, financial and human resources needed to develop a product or service that will match demand in the market. If successful, the reward is financial or, at least, potentially monetizable in the future as many firms will incur losses during early growth phases. Regardless, the perception of the risk-reward balance governs the decision to venture or not. However, there are many societal challenges expressed as individual or collective needs, including aspects of environmental stewardship, for which perceptions of risks are too high or rewards are too low and resulting chances of positive commercial outcomes are insufficient to attract entrepreneurial activity.

[9] UNEP, who have been pioneering TNA processes, aim these specifically at climate change challenges by targeting the reduction of greenhouse gas emissions (mitigation) and/or adaptation to overcome a country's climate change vulnerabilities. For details on the methodology, see https://tech-action.unepdtu.org/tna-methodology/.

[10] UNCTAD calculations based on World Bank data.

[11] WHO Global Ambient Air Quality Database, see: www.who.int/airpollution/data/cities/en/.

[12] *Public Transport a Challenge: Does KCCA Care?* Available at www.kcca.go.ug/news/308/#.XoYX1nKxUuU.

[13] Chui M, Kamalnath V and McCarthy B (undated). An executive's guide to AI. McKinsey Global Institute.

[14] SAS Institute (undated). Artificial Intelligence.

[15] Health N (2018). What is AI? Everything you need to know about Artificial Intelligence. April. ZD Net.

[16] See: www.zdnet.com/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/.

[17] IBM (undated). Big data analytics.

[18] Kavanagh S (2019). How fast is 5G?

[19] Moore M (2019). What is 5G? Everything you need to know.

[20] See: www.digitaltrends.com/mobile/what-is-5g/.

[21] 3DPrinting.com (undated). What is 3D Printing?

[22] Owen-Hill A (2017). What's the Difference Between Robotics and Artificial Intelligence? July. ROBOTIQ.

[23] Rouse M (2018). Drone (unmanned aerial vehicle, UAV). Tech Target. October 2018.24 GlobeNewswire (2019). Genome Editing Market To Reach $10.1 Billion By 2026. February. Reports And Data.

[25] GlobeNewswire (2019). Genome Editing Market To Reach $10.1 Billion By 2026. February. Reports And Data.

[26] See: www.air.ug/.

[27] See: www.sautitech.com/startups/ketty-adoch-ai-for-earth-innovation-grant/.

[28] See: www.who.int/news-room/fact-sheets/detail/assistive-technology.

[29] See: www.unlock-bc.com/news/2019-09-17/uganda-announces-blockchain-freezone.

[30] See: cointelegraph.com/news/uganda-to-deploy-mediconnects-blockchain-platform-for-tracing-fake-drugs.

[31] See: www.reuters.com/article/us-uganda-coffee/ugandan-firm-uses-blockchain-to-trace-coffee-from-farms-to-stores-idUSKCN1PH1ZW.

[32] See: support.binance.co.ug/hc/en-us/articles/360006720911-Official-Launch-of-Binance-Uganda-Fiat-Crypto-Exchange.

[33] See: cryptobriefing.com/uganda-blockchain-hub/.

[34] Ibid.

[35] See: www.monitor.co.ug/News/National/251-drones-held-at-Entebbe/688334-5183860-omalwj/index.html.

[36] See: Digestafrica.com/ugandan-startup-drones/.

[37] The policy documents referred to in the Ministerial Policy Statement for Science and Technology MPS 2017 are: the five-year National Development Plan (NDP II: 2016/17 – 2019/20), the NRM manifesto, the 23 Presidential Strategic guidelines set out in June 2016, the National Science, Technology and Innovation Policy (2009), The Innovation Strategy for Africa (STISA 2024), the Sustainable Development Goals (Agenda 2030), and the recently adopted Paris agreement on Climate change.

[38] The United Nations and other international organizations, such as the Organisation for Economic Co-operation and Development (OECD), have played a key role in developing guidelines and standards to facilitate the collection of harmonized data. Alongside the work of regional groups and networks, such as the Network for Science and Technology Indicators (RICYT) in Latin America and the African Union's African Science, Technology and Innovation Indicators (ASTII) project, UNESCO Institute for Statistics (UIS) has taken a lead role in addressing measurement challenges in the case of developing countries (UIS, 2010; 2014).

[39] This may however indicate an issue with the survey implementation or methodology.

[40] *Source*: World Bank Enterprise Surveys (2013). Available at www.enterprisesurveys.org/.

[41] The evaluators concluded that the "… YLP had no statistically significant effect on socio-economic outcomes of the intervention group compared to the control group. However, the intervention has helped the treatment group to move from unskilled to skilled, and unpaid to

paid occupations, and they report enhanced ability to access credit facilities. Further, the asset portfolio of youth in the intervention group increased faster than their counterparts in the control group. The intervention reduced both tobacco and alcohol consumption among the youth in the intervention group, although the study noted a slight increase in domestic violence among YLP beneficiaries." See: https://bit.ly/2VJJs3P.

[42] This focus on individuals is probably underplaying the potential of collaborative innovation projects involving industry, university, foreign investors, and STI institutions. Such forms of joint innovative efforts are often typically financed by innovation funds.

[43] There is a corresponding Presidential Initiative on Poverty and Hunger with more than 12 initiatives aimed at increasing productivity and value addition.

[44] See: www.yowerikmuseveni.com/presidential-initiative-science-and-technology.

[45] International Organization for Standardization.

[46] Innovation is the process of using knowledge and technology to develop and improve services and processes, or improve the production or performance of products, that have value in terms of commercial impact or social benefit (UNCTAD, 2019). "An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)…" (OECD, 2018). Importantly, the new definitions include innovating for non-market benefit and innovation by different "units", which includes firms as well as government bodies and non-profit institutions serving the public.

[47] Figures in red are estimates.

[48] See: www.eia.gov/international/overview/country/UGA.

[49] IFC/World Bank press release. See: tinyurl.com/electricity-uganda.

[50] See: databank.worldbank.org. CO_2 emissions are currently 5.6 mt per capita in the European Union and 15.6 mt per capita in the United States.

[51] See: unreeea.org/resource-center/overview-of-the-ugandan-energy-sector/.

[52] Supplemented with energyeconomicgrowth.org/node/236. See: www.reg.rw/customer-service/tariffs/ and www.era.or.ug.

[53] This includes refined petroleum products, motor gasoline, jet fuel, kerosene, distillate fuel oil, residual fuel oil, liquefied petroleum gases and other refined products.

[54] See: energypedia.info/wiki/Petroleum_Resources_in_Uganda.

[55] See: www.eia.gov/beta/international/analysis.php?iso=UGA.

[56] Ibid.

[57] See: reports.weforum.org/global-competitiveness-index-2017-2018/appendix-a-methodology-and-computation-of-the-global-competitiveness-index-2017-2018/.

[58] The report includes measures of procedures, time, and cost of starting a business, construction permits, access to electricity, property registration, securing credit, protection of minority investors, tax payments, trading across borders, enforcing contracts, resolving insolvency, and labor market regulation (World Bank, 2018).

[59] See: gemconsortium.org/economy-profiles/uganda.

[60] See: www.gemconsortium.org/country-profile/117.

[61] Measured by whether early stage entrepreneurs indicate that their product or service is new to at least some customers and that few/no businesses offer the same product. See: www.gemconsortium.org/country-profile/117.

[62] See: reports.weforum.org/global-competitiveness-index-2017-2018/.

[63] This section is almost exclusively based on the NCST Innovation Survey (2016).

[64] Industry comprises mining and quarrying, manufacturing; electricity, gas, steam and air conditioning supply; remediation activities; and construction.

[65] Only 26.3 per cent of imports of transport equipment however, can be imported duty-free, compared to 81.6 per cent of non-electrical machinery and 70 per cent of other manufactures.

[66] See: www.ugandainvest.go.ug/parks/.

[67] See: www.bdc.ca/en/articles-tools/entrepreneur-toolkit/templates-business-guides/glossary/pages/business-accelerator.aspx.

[68] See: www.ftbic.mak.ac.ug.

[69] Source: Global Partnership for Education. Coordinated by USAID. See: www.globalpartnership.org/country/uganda .

[70] Uganda has never participated in the TIMMS (Trends in International Mathematics and Science Study) and this makes it impossible to draw rigorous comparisons with other countries in the region.

[71] Data in table 4.10 is an average for the period 2005-2018. While this may seem an excessively long period to average-out, in reality the indicators display minimum change year-on-year that may be equally attributable to noise or measurement error.

[72] See: www.softpower.ug/is-the-country-ready-for-the-new-o-level-curriculum-starting-2020/.

[73] See: unbs.go.ug/attachments/menus/34/UNBS-Annual-Report-2017-2018.pdf

[74] See: www.wipo.int/tisc/en/search/list.jsp.

[75] Figures developed by Kagan Binder PLLC Intellectual Property Attorneys and LSE (2006). Boosting Innovation and Productivity Growth in Europe: The hope and the realities of the EU's "Lisbon agenda". Paper No. CEPPA007. Available at www.kaganbinder.com/docs/7-EstimatedPatentCosts.pdf.

[76] The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization, to the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture of the United Nations Food and Agriculture Organization.

[77] There is no data available for years 2010-2012.

[78] The primary sector is understood to consist of subsistence and commercial agriculture, mining, forestry, grazing, hunting and gathering, fishing, and quarrying.

[79] In Uganda the total level of financial inclusion, i.e., both formal and informal, is estimated at just 58 per cent (Finscope, 2018).

[80] See: eba.worldbank.org.

[81] See: gain.nd.edu/our-work/country-index/rankings/.

[82] See: www.timeshighereducation.com/student/best-universities/best-universities-africa.

[83] Information is available at sas.mak.ac.ug.

[84] See: www.ftbic.mak.ac.ug.

[85] Data about aid are available at OECD: Query Wizard for International Development Statistics.

[86] Uganda Coffee Development Authority. Available at ugandacoffee.go.ug/sites/default/files/statistics/Coffee-Exports-by-type-by-Grade_2007_08_2014_15.xls .

[87] Information about ITC Trade Performance Index is available at www.intracen.org/country/uganda/sector-trade-performance and similarly ITC Export Potential information is available at exportpotential.intracen.org/#/home.

[88] Information is available at www.jaguzafarm.com.

[89] Information is available at startup.info/innovate/.

[90] Information is available at muiis.cta.int/index.html.

[91] Kenya is among the cheapest countries for mobile telephony in Africa, after Egypt, Tunisia and Ghana.

[92] Since July 2018, there is a tax of 0.5 per cent on mobile transactions and a daily fee of USh200 for accessing Facebook, Twitter, WhatsApp and Instagram. See: www.africanews.com/2018/05/31/uganda-s-parliament-approves-social-media-and-mobile-money-taxes/.

[93] See: www.ecobank.com/upload/publication/20180910054643018QJEBKEVZKD/20180910054635730h.pdf.

[94] The Networked Readiness Index is combination of indicators measuring a) the political, business and social environment; b) the infrastructure, affordability and skills; c) the individual, business and government usage and d) the economic and social impact. The detailed index about countries can be accessed at reports.weforum.org/global-information-technology-report-2016/networked-readiness-index/.

[95] Another indicator measuring access, use and skills is the ICT Development Index (IDI) provided by ITU, which ranks Uganda 152 over 176 and 20 over 38 in the African region. See: www.itu.int/net4/itu-d/idi/2017/index.html#idi2017byregion-tab.

[96] Current as of December 2017.

[97] Information is available at www.gsma.com/mobilefordevelopment/programme/mobile-for-humanitarian-innovation/refunites-levelapp-supporting-refugees-in-uganda/.

[98] EGCDI is the weighted average of three normalized scores of (1) scope and quality of online services, (2) development status of telecommunication infrastructure, and (3) inherent human capital. Available at publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2018.

[99] UNCTAD (2016).

[100] See: www.un.org/sustainabledevelopment/sustainable-development-goals/.

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