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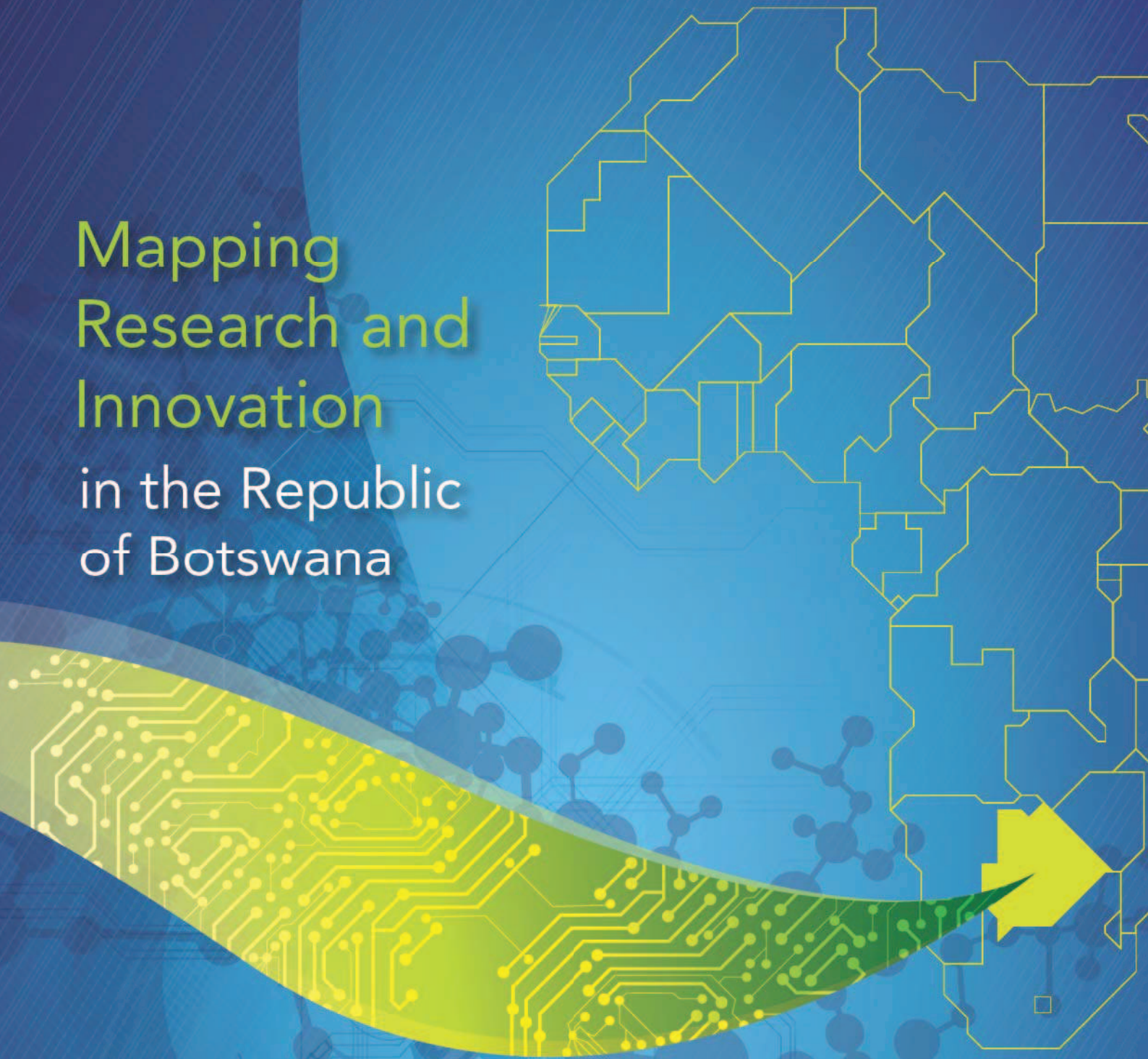
Mapping Research and Innovation in the Republic of Botswana



GO→SPIN Country Profiles in Science, Technology and Innovation Policy

Mapping Research and Innovation in the Republic of Botswana

GO→SPIN Country Profiles in Science, Technology and Innovation Policy

In cooperation with the Department of Research, Science and Technology from the Ministry of Infrastructure, Science and Technology the Republic of Botswana

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Acronyms and Abbreviations

AECID	Agencia Española de Cooperación Internacional para el Desarrollo (Spain)
ASTII	African STI Indicators Initiative (NEPAD)
AOSTI	African STI Observatory (African Union)
BNRDICC	Botswana National Research and Development and Innovation Coordinating Council
CESRIKI	Centre for Scientific Research, Indigenous Knowledge and Innovation (University of Botswana)
DRST	Department of Research, Science and Technology (Ministry of Infrastructure, Science and Technology, Republic of Botswana)
GDP	gross domestic product
GO→SPIN	Global Observatory of Science, Technology and Innovation Policy Instruments (UNESCO)
EPO	European Patent Office
FDI	foreign direct investment
FTE	full-time equivalent
ICT	information and communication technologies
IDRC	International Development Research Centre (Canada)
IPR	intellectual property rights
ISCED	International Standard Classification of Education
MDG	UN Millennium Development Goals
MIST	Ministry of Infrastructure, Science and Technology (Republic of Botswana)
NEPAD	New Partnership for Africa's Development (African Union)
NIF	National Innovation Fund (Republic of Botswana)
NRF	National Research Fund (Republic of Botswana)
OECD	Organisation for Economic Cooperation and Development
PPP	purchasing power parity (in US$)
R&D	research and development
RSTI	research, science, technology and innovation
SADC	South African Development Community
S&T	science and technology
SETI	science, engineering, technology and innovation
STI	science, technology and innovation
STIIP	Science, Technology and Innovation Information Platform
STP	science and technology potential
STPI	Science and Technology Policy Instruments (IDRC)
TIS	technology intelligence studies
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISIST	United Nations Information System for Science and Technology
USPTO	United States Patents and Trademark Office
WIPO	World Intellectual Property Organization
WoS	Web of Science

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Foreword by Irina Bokova

Science, engineering, technology and innovation hold key answers to the new, complex challenges facing Governments. These cannot be stand-alone processes but integrated into societies through partnerships, through strong links between science, policy and society, through effective national policies and robust systems of governance, and through science education. Innovation is not a decision but an ecosystem that is a foundation for knowledge societies and sustainable development.

Governments need tools to map the landscape of science, technology and innovation (STI) in their countries, in order to strengthen national frameworks and take sharper decisions. This is the importance of UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN), which allows governments to review their country's performance against established indicators while exploring best practices from other countries. GO→SPIN provides key information at a range of levels, from STI policies, operational instruments and legal frameworks to STI national systems and data – all in order to improve policy-making, implementation and evaluation.

GO→SPIN is a core part of UNESCO's strategy to support the development of science policy initiatives, working with governments and other partners. Reliable information is vital for integrating research and innovation as cross-cutting policies into national development strategies and for catalysing greater investment by governments in the sciences for sustainable development.

I am confident that this new online series of country profiles by UNESCO will provide a useful tool to Member States and the global science community as we seek to build more inclusive, knowledge societies.

Irina Bokova

Introduction

The growing complexity of science and innovation systems and the interface with society have been accompanied by a more complex policy environment. This results in a need for better coordination and coherence at national level. One the most crucial factors is the increasingly global nature of the issues with which national policy-makers are confronted. In a whole series of areas such as the environment, telecommunications, health, energy, education and intellectual property, it no longer makes much sense to construe problems in purely sectoral and national terms. In a world that is becoming daily more interdependent, policy-making is inevitably assuming an increasingly transversal and global dimension. In this context, science, technology and innovation (STI) policy systems have emerged as interconnections between knowledge, values, national and international socio-economic, environmental, technological and organizational components.

UNESCO has a long tradition of supporting Member States in policy development. With the convergence of S&T fields, the need to harness science, engineering, technology and innovation (SETI) for human and economic development and the transnational nature of today's challenges, STI policy processes have become a much more complex undertaking.

It is our vision that STI policies are transversal, cross-cutting policies that support and build the structural pillars for sustainable development. Therefore, UNESCO is conscious that monitoring and evaluating the impact of explicit and implicit policies and instruments is part of our work in supporting the design and implementation of STI frameworks in our Member States.

This first volume of the new online series of GO→SPIN Country Profiles in Science, Technology and Innovation Policy is dedicated to a study of the research and innovation landscape of the Republic of Botswana. It is the first in a series of country profiles prepared by the Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN), a new UNESCO initiative.

The GO→SPIN programme is helping Member States to reform and upgrade national science systems and governance, and to build capacity to monitor and evaluate performance through SETI and social indicators. In this way, the scope of standard SETI assessment can be widened, to take into account country-specific contexts, as well as emerging knowledge of technological advances that contribute to sustainable development. To complement efforts in promoting evidence-based SETI policy-making, the GO→SPIN will be a good basis for the promotion of scientific and technological foresight studies.

Through the GO→SPIN programme, UNESCO's Division of Science Policy and Capacity Building is working as a standard-setter, assisting in the elaboration of guidelines for SETI policy formulation, review and reforms, including monitoring and evaluation of policies and programmes. In this context, scientific advisory systems for governments and parliaments are necessary, as well as the availability of a wide range of scientific assessments to inform policy- and decision-makers and to bridge the gap between science and policy.

The Division of Science Policy and Capacity building has been collaborating with African Member States with the support of the Agencia Española de Cooperación Internacional para el Desarrollo (AECID) and its Spanish Fiduciary Fund allocated to the project entitled Capacity Building in STI Policy in Africa.

The common need expressed by African countries to enhance capacities in the design and evaluation of SETI policies, policy instruments and governing bodies, three sub-regional workshops were organized by UNESCO between November 2012 and June 2013, in Harare (Botswana), Dakar (Senegal) and Maputo (Mozambique). We applied the methodological approach developed by the GO→SPIN to train higher national officials in designing, implementing and monitoring different types of operational policy instrument. The training involved officials from Angola, Botswana, Burkina Faso, Burundi, Cape Verde, Cote D'Ivoire, Gabon, Malawi, Mozambique, Niger, Senegal, Zambia and Zimbabwe. There are plans to extend this training to other sub-Saharan countries and Arab States in 2014.

In November 2012, during the African Ministerial Conference on Science and Technology (AMCOST V), it was recommended that the African Observatory on STI (AOSTI), the African STI Indicators Initiative (ASTII) and UNESCO's GO→SPIN programme should increase coordination among their different surveys. Following this recommendation, an agreement between UNESCO and AOSTI was established in February 2013. The terms of this agreement place AOSTI in charge of following up each GO→SPIN survey for a group of West African countries. There are plans to extend this agreement to the entire continent.

The participating countries are currently completing a national GO→SPIN survey on SETI policies and policy instruments that will be part of both this new series of country profiles and the GO→SPIN online platform.

The present profile is based on the GO→SPIN survey prepared as a follow-up to the Harare sub-regional training workshop by the officers of the Department of Research, Science and Technology, which is part of the Ministry of Infrastructure, Science and Technology of the Republic of Botswana.

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The GO→SPIN training workshops were organized by the Division of Science Policy and Capacity Building with the financial support of AECID. Our sincere thanks go to the Government of Spain and to AEICD for their financial support and their presence in the workshops . We would also like to express gratitude to the senior officers from the Ministry of Infrastructure, Science and Technology from the Republic of Botswana: Hon Johnie K. Swartz (Minister); Lesego Motoma (a. P.S.), Tebelelo Tsheko (a. Dir.), Abraham Mathodi, Tlhabano Mmusi and Kesupemang Pitlagano (group responsible for the GO→SPIN survey): Chris Ibagen Segoea; Oabona Monngakgotla, Gaabadzo Moseki and Kealeboga Ranko (from DRST); to Guy Broucke, Science Programme Specialist from UNESCO Harare Office, and the personnel of the Science Policy and Reform Section: Sonia Bahri, Chief of Section, Juliana Chaves Chaparro, Sunday Fadina, Ahmed Fahmi, Edith Kiget, Kornelia Tzinova; and to the editors of this volume: Guillermo A. Lemarchand, a UNESCO consultant, and Susan Schneegans, UNESCO science editor.

About this series

GO→SPIN Country Profiles in Science, Technology and Innovation Policy is a series of reports published by UNESCO within its Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN). The GO→SPIN programme is run by UNESCO's Division of Science Policy and Capacity-Building.

The aim of this new series is to generate reliable, relevant information about the different landscapes of SETI policies around the world. The published information is based on replies to the GO→SPIN surveys, combined with government reports and statistical data from the UNESCO Institute for Statistics and other international sources.

Each country profile represents a comprehensive study of the national SETI policy, policy instruments, legal framework and funding mechanisms. A description of SETI policy-making and funding institutions is accompanied by an inventory of the country's R&D organizations and centres. Each report also provides an analytical description of SETI policies implemented in a given country.

THE GO→SPIN APPROACH

The strategy of the GO→SPIN programme is four-fold:

- *Capacity-building*: training high-ranking national officials in the design, implementation and evaluation of a variety of SETI policy instruments at national and regional levels;
- *Standard-setter:* providing a standard practice for surveys on SETI policies and operational policy instruments through the *Paris Manual*[1]
- *Data collection:* worldwide distribution of the GO→SPIN surveys, prioritizing Africa, Arab States, Asia–Pacific and Latin American and the Caribbean.
- *GO→SPIN platform:* creation of an online, open access platform for decision-makers, knowledge-brokers, specialists and general public, with a complete set of various information on SETI policies.

The online platform will provide an innovative cluster of databases equipped with powerful graphic and analytical tools. The platform has been devised for political leaders, planners, directors and administrators of S&T in government, parliament, universities, research institutions, productive enterprises concerned with innovation, international organizations working for development; research personnel and specialists whose field of study embraces S&T policies.

The platform will also be a useful tool for the democratization of decision-making and public accountability of SETI policies.

The GO→SPIN survey and the information generated are primarily intended for the use of specialists and governmental bodies responsible for national SETI policies. It is their function to analyse the results of the survey and draw appropriate conclusions when they are required to prepare decisions by political bodies in the field of science, engineering, technology and innovation. The survey is also of interest to national bureaux of statistics and international organizations for promoting scientific and technological cooperation among their member states. Collectively, these users are:

- the national developing planning agencies, more particularly the government bodies responsible for formulating and co-ordinating national SETI policies and other national bodies involved in the application of science and technology (S&T) to sustainable development;
- parliamentary groups especially concerned with STI policies;
- SETI information brokers, consulting groups and advisory bodies;
- teaching and research departments engaged in SETI policy studies;

1 The *Paris Manual* is being drafted by an international committee of experts put together by UNESCO in 2011. Once completed, the manual will define the ontological and epistemological bases of a common paradigm for evaluating STI policies and policy instruments worldwide.

- The governing bodies of R&D institutes and S&T services;
- The boards of management of productive enterprises heavily reliant on R&D or engaged in the transfer of technology and innovation;
- International governmental and non-governmental organizations concerned with SETI and their application to sustainable development;
- Other more peripheral users, such as university departments of political science, economics and social sciences and national and international documentation and information services;
- The mass media.

At individual level, the main groupings are:

- **Decision-makers:** i.e. those responsible for national SETI policies and the management of R&D (ministries of R&D or S&T, directors of bodies responsible for formulating national S&T policies, directors of R&D institutes, heads of productive enterprises heavily reliant on R&D, etc.)
- **Intermediate users:** i.e. those who serve as the link between decision makers referred to above and researchers in S&T policy; their function is to prepare decisions by the former using theories and methods put forward by the latter, this category is made up of experts, consultants, advisers, liaison officers, the staff of ministerial offices and of parliamentary committees, etc., and they usually require rapid access to factual data.
- **Researchers in SETI policies:** i.e. those who develop the theories and methods on which S&T policy is based (researchers in the philosophy, history, sociology and economics of science, engineering and innovation, in the transfer of technology and in the management of R&D.
- **The general public:** by making SETI information more accessible, the GO→SPIN approach introduces a new dimension to the democratization of SETI.

THE METHODOLOGICAL FRAMEWORK

Science, engineering, technology and innovation (SETI) are becoming increasingly important for socio-economic and sustainable development. During the past 60 years, both developed and developing countries have recognized this fact by increasing the number of SETI government bodies, establishing new SETI legal frameworks and implementing a diverse set of new SETI policy instruments. This has driven investment in scientific research, technological development and innovation (STI), led to an increase in the number of scientists and engineers and fostered exponential growth in the number of new scientific articles and patents worldwide (UNESCO, 2010).

The information economy is one of the key concepts invented to explain structural changes to the modern economy (Godin, 2008). The infrastructure to manage SETI information has been largely considered the core resource of national competitiveness in research and innovation (Neelameghan and Tocatlian, 1985). With the globalization of SETI information infrastructure has come a need to implement comprehensive strategies to connect, share and trade both domestic and foreign information at the national level (Lee and Kim, 2009).

The formulation of adequate SETI policies is critical to tackling contemporary challenges that include mitigating the consequences of global climate change; exploring new energy sources; generating innovation to foster social inclusion; promoting the sustainable management and conservation of freshwater, terrestrial resources and biodiversity; disaster resilience; and fostering the eradication of extreme poverty and hunger. These policies also need to be designed to achieve the UN Millennium Development Goals.

Over the past five decades, operational definitions have been elaborated within the framework of multilateral organizations to measure R&D and the broader concept of S&T. Statistical techniques have been developed to estimate private and public resources invested in these areas. For the former the

OECD has laid down a methodological framework in the *Frascati Manual,* the sixth edition of which was published in 2002 (OECD, 2002). For the latter, the Member States of UNESCO have adopted the *Recommendations concerning the International Standardisation of Statistics on Science and Technology* (UNESCO, 1978; 1982; 1984a; 1984b). Methodologies for generating data about R&D investment and human resources have been constantly upgraded and extended.

During the first African Ministerial Conference on Science and Technology[2] (AMCOST I), in 2003, countries committed themselves to developing and adopting a common sets of STI indicators. The New Partnership for African Development (NEPAD) established the African Science, Technology and Innovation Indicators Initiative (ASTII) with the objective of building Africa's capacity to develop and use STI indicators. More specifically, NEPAD aims to: (a) develop and promote the adoption of internationally compatible STI indicators; (b) build human and institutional capacities for STI indicators and related surveys; (c) enable African countries to participate in international programmes on STI indicators; and (d) Inform African countries on the state of STI in Africa. The first *African Innovation Outlook* was published in 2011, while the second volume is being published in 2013. The methodology employed – that suggested by ASTII officials – follows the recommendations of the *Frascati Manual* for R&D indicators and the *Oslo Manual* (OECD, 2005) for innovation indicators.

In 2009, the UNESCO Institute for Statistics organized an Expert Meeting on Measuring R&D in Developing Countries, in Windhoek (Namibia). During the meeting, the experts identified the difficulties and challenges faced by the majority of developing countries, which were not explicitly addressed in the *Frascati Manual* (UNESCO Institute for Statistics, 2010). The UNESCO Institute for Statistics is working towards a global standardization of STI statistics, including those items which are not taken into account in the *Frascati Manual*.

The availability of input and output R&D indicators alone does not suffice to evaluate SETI policies. Much more important than the particular value of one specific indicator at a given time is the long-term rate of change that long temporal series of indicators show (Lemarchand, 2010: 27–28). For that reason, long-term temporal series of indicators are necessary to analyse the impact of specific public policies. Improving the reliability of this analysis requires new ways of standardizing information about public policies and the policy instruments designed to implement them. Owing to the complexity of these issues, the 'science of science policy' has emerged in recent years as a new discipline where new analytic paradigms can be tested.

SETI policy debates are not yet dominated by a thoughtful, evidence-based analysis of the likely merits of different investment options and policy decisions. The latter are strongly influenced by past practice or data trends that may be out of date (Husbands Fealing *et al.,* 2011). The evolution of new policies has been accompanied by more difficult challenges related to planning and evaluating these policies; this indicates a need to improve the theoretical frameworks for policy formulation (Steinmueller, 2010).

Unfortunately, a number of factors prevent countries from reaching most of the objectives established by their own development plans: the lack of reliable information on SETI national potentialities; difficulties in coordinating the various SETI stakeholders; an absence of mechanisms for promoting a strong interaction between the *supply* and *demand* sectors in SETI, and; the absence of any explicit industrialization policy promoting endogenous innovation.

These difficulties mostly appear in small economies. For example, Flanagan *et al.* (2011) have explored the ways in which innovation policy studies treat actors, instruments, institutions and interactions, in order to arrive at a more useful conceptualization of the policy mix for innovation. They stress the need for a genuinely dynamic view of policy formulation and policy interaction. They conclude that 'despite the importance attached to "strategic policy intelligence" in recent innovation policy analysis, little empirical attention has been devoted to actual processes of policy learning.' In developing and exploiting technological opportunities, institutional competencies – namely. the governance of SETI

2 The final declaration of the AMCOST meeting in 2012 recommended coordination between the African Observatory on STI (AOSTI), ASTII and UNESCO's GOSPIN. An agreement between UNESCO and AOSTI in February 2013 assigned AOSTI to following up GO→SPIN surveys with a group of West African countries.

decision-making bodies – are just as important as the SETI incentive instruments they promote (Pavitt, 1996). Path dependency emerges, as the cost of institutional changes to SETI is often higher than that of accommodating new instruments and policies in existing structures (Van der Meulen, 1998). For this reason, the design, analysis and monitoring of any national SETI policy will strongly depend on the adequate mapping of: the structure of the SETI governing bodies; the SETI national legal framework and; of the implicit and explicit operational SETI policy instruments which are implemented (Herrera, 1971; 1972; Sagasti and Aráoz, 1976).

BOX A – THE POLICY-MAKING CYCLE

A stylized presentation of the policy-making cycle typically involves five stages:

- *Agenda-setting*: refers to the process by which problems related to SETI and the linkages between SETI and both society and the economy come to the government's attention;
- *Policy formulation:* refers to the process by which SETI policy options are formulated by the government;
- *Decision-making:* refers to the process by which governments adopt a particular course of action or non-action;
- *Policy Implementation:* refers to the process by which governments put SETI policies into effect and;
- *Policy evaluation:* refers to the process by which the results of SETI policies are monitored by both the State and societal actors. The result may be a re-conceptualization of policy problems and solutions, in which the effectiveness, efficiency and continuing appropriateness of policies and policy instruments are assessed and the results fed back into another round of agenda-setting.

Responsible and accountable SETI governance entails developing capabilities at each of these five stages.

SETI projects normally occur within a larger temporal framework administered by an organization or a government policy-making body. The early stages of a new SETI policy usually appear as successive expansions of the group of agents and stakeholders whose endorsement is needed to launch the initiative, whereas the latter stages focus on programme management, with feedback as to its success or failure at the policy level (Marburger III, 2011). Consequently, in order to provide an accurate landscape of the SETI policies and policy instruments in a specific national context, it is imperative to understand the long-term evolution of the SETI organizational chart, SETI infrastructure and legal framework (i.e. explicit policies), as well as the type of funding mechanisms implemented. The latter dimensions must be contrasted with detailed analyses of the long-term behaviour of political, educational, economic, productive and social macrovariables (i.e. implicit policies).

It is impossible to describe the current status of SETI without accurate data. Moreover, these data should be presented in such a way as to allow decision-makers and experts to estimate whether the status of SETI meets societal needs or expectations. Policy-makers benefit from additional policy tools to assist them in deciding about budget allocations or in the design of new SETI policy instruments, especially if these are real-time tools or new innovative prospective methodologies. Recent empirical studies show the relevance and long-term impact of appropriate SETI information services on SETI policies designed to improve national competitiveness (Lee and Kim, 2009).

It is also important to note the availability of a large group of public and private databases. These can be most useful tools for evaluating the performance of the SETI policies and providing adequate technology intelligence studies. There are robust, accessible systems designed to make rapid analyses and apply mathematical models to identify critical points or levers triggered by policy changes that can

directly affect the performance of innovation activities. For example, Zucker and Darby (2011) present a comprehensive survey of all available databases that may be used to analyse the impact of SETI policies (see Box B).

BOX B – USING MATHEMATICAL THEORY TO PROMOTE STRATEGIC NATIONAL INNOVATION

Recent developments in the mathematical theory of networks can be applied to formulating new SETI policies, in order to promote strategic innovation within national economies.

Hidalgo *et al*. (2007) found that 'economies grow by upgrading the products they produce and export. The technology, capital, institutions and skills needed to make newer products are more easily adapted from some products than from others. The study of this network of relatedness between products, or 'product space,' shows that more-sophisticated products are located in a densely connected core, whereas less sophisticated products occupy a less connected periphery. Empirically, countries move through the product space by developing goods close to those they currently produce. Most countries can reach the core only by traversing empirically infrequent distances, which may help to explain why poor countries have trouble developing more competitive exports and fail to converge to the income levels of rich countries.'

This type of analysis can be applied directly to formulating customized SETI policy instruments to foster the development of specific technologies, where the country has detected a potential new technological niche. The availability of access to new electronic international databases (Zucker and Darby, 2011), combined with the appropriate analytic software, might transform this type of analysis into a standard procedure for selecting national SETI priorities.

Access to appropriate, reliable data is also a prerequisite for responsible and accountable governance, which demands informed decision-making at the planning stage of SETI policy and foresight as to the possible short and long-term impact of policy decisions. Therefore, policy-makers not only need a clear picture of the national, regional and global situation. They also need to be able to estimate the impact of current SETI policies and plan on future policies. The analysis of any national or regional SETI policy strongly depends on the adequate mapping of the structure of SETI governing bodies, SETI national legal frameworks and the implicit and explicit operational SETI policy instruments. Gaps or blind spots in information can cause a specific field to be neglected, which can result in missed opportunities for socio-economic development.

POLICY INSTRUMENTS: LEVERS FOR IMPLEMENTING DECISIONS

A policy may remain a mere rhetorical statement if no means are provided for its implementation or to realize its potential effect. To do this, a number of things may be needed, which we will incorporate under the term policy instrument. A policy instrument constitutes the set of ways and means used when putting a given policy into practice. It can be considered as the vehicle through which those in charge of formulating and implementing policies actualize their capability to influence decisions taken by others.

The study of public policy instruments in national settings has contributed significantly to the understanding of policy, political systems and relations between State and citizen. Research on policy implementation usually focuses principally on the effects of a specific instrument, within a wider reflection

on whether the correct instrument has been chosen for the purpose. As far as new governance models is concerned, the search for suitable instruments is above all governed by pragmatism (Kassim and Le Gales, 2010).

SETI operational policy instruments are the levers by which the organizational structure ultimately implements the decisions on a day-to-day basis and attempts to produce the desired effect on the variables the policy has set out to influence. Throughout the analysis of an instrument's effectiveness, it is important to bear in mind the 'actors' or key decision-makers who are directly involved in the design and use of a policy instrument. An instrument does not act on its own accord. Rather, it responds to the will of the policy-makers and decision-makers using it.

A related concept can be found in the problem of *Ordnungspolitik* stressed by the German Freiburg School in the 1930s. Here, the focus was how to devise a framework or set of rules (*Ordnungsrahmen*) for an economy that would define the operating space for individual and private activities. The challenge for SETI policy instruments can be interpreted as a problem of transformation, namely the question of choosing the best policy instrument in order to reach the set target.

A policy instrument attempts to make individuals and institutions take decisions following the rationality dictated by the collective objectives established by those in power. It is the connecting link between the purpose expressed in a policy and the effect that is sought in practice. An SETI policy instrument includes, as a significant component, the manipulation of SETI variables.

One of the first and more relevant studies on SETI policy instruments was conducted in the 1970s by the International Development Research Centre. The principal objective of the study was to devise ways and means of understanding how a country's investment in S&T could be most effectively related to its objectives for industrial development. Sagasti and Aráoz (1976) developed an interesting methodological framework for making a survey and analysing the policy instruments of ten countries in Latin America, the Middle East, Southern Europe and Asia.

UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments[3] (GO→SPIN) has adapted and expanded the theoretical framework of Sagasti and Aráoz (1976), in order to implement a systematic survey in Africa, Arab States and in Latin America and the Caribbean. The information in the present country profile has been organized according to this methodological approach. Figure A presents the basic analytical units around which the present report is organized.

All national SETI policies, be they *implicit* or *explicit* (Herrera, 1971; 1972), attempt to harness a country's creative potential to its socio-economic, environmental and cultural objectives. An *explicit* SETI policy is a statement by a high-level government official or institution, such as a ministry or the planning secretariat, that deals with activities related to STI. The policy expresses a purpose (effects according to SETI variables) and may set objectives, define desired outcomes and establish quantitative goals. Policies also contain criteria for choosing from among several alternatives to guide decision-makers as to how SETI works. SETI policies might also be formulated by representatives of the private sector. A number of factors impinge on the efficiency of SETI governance, namely, the extent to which policy processes have the greatest effect with a given use of resources. It must be acknowledged that overall efficiency is not easily defined and measured in a multi-objective, multi-actor world.

3 See www.unesco.org/new/en/natural-sciences/science-technology/sti-policy/global-observatory-on-policy-instruments

Figure A: Organization of the analytical units of the SETI policies module. Adapted from Sagasti and Aráoz (1976)

The SETI organizational structure or chart usually shows the distribution of responsibility for implementing a given policy. Under the term 'organizational structure,' it is possible to distinguish at least four different levels: (1) policy planning level (policy design), (2) promotional level (funding), (3) implementation level (R&D and productive innovation) and (4) assessment or evaluation level.

The GO→SPIN methodological approach introduced a normalized way of encoding the different types of organization and their functions. By representing each national SETI organizational chart and by using the same set of coding tools (Lemarchand, 2010: 310), it will be possible in future to associate these charts and tools with specific topological metrics to identify patterns in performance. The latter will be very useful for defining a new set of SETI policy indicators able to reveal the level of complexity and functionality of each STI organizational chart. Table A shows a typical example on how different countries structure SETI policy design.

Table A: Models of governing bodies heading SETI policy design

Argentina	Scientific and Technological Cabinet (GACTEC) Ministry of Science, Technology and Productive Innovation
Australia	Prime Minister's Science Engineering and Innovation Council Commonwealth State and Territory Advisory Council on Innovation Coordination Committee on Innovation
Chile	Inter-ministerial Committee for Innovation National Corporation for the Promotion of Production (Ministry of Economy) National Commission for Scientific and Technological Research (Ministry of Education)
Croatia	Ministry of Science, Education and Sports National Council for Science National Council for Higher Education
Czech Republic	Ministry of Industry and Trade Council for Research, Development and Innovation Ministry of Education, Youth and Sports
Finland	Research and Innovation Council Ministry of Employment and the Economy Ministry of Education and Culture
Ireland	Inter-Departmental Committee on STI Department of Jobs, Enterprise and Innovation
Malaysia	Ministry of International Trade and Industry Ministry of Science, Technology and Innovation Economic Planning Unit
Republic of Korea	National Science and Technology Council Ministry of Science and Technology
Singapore	Economic Development Board Research, Innovation and Enterprise Council National Research Foundation
South Africa	Department of Science and Technology Department of Trade and Industry Department of Higher Education and Training

Source: UNESCO

Since its purpose is to guide decisions about the future that must be taken now, a SETI watch cannot seek to identify future developments in S&T independently of past and current developments, or independently of the material and human resources devoted to research and innovation. The prerequisites for any future is: knowledge of the present, knowledge of the current trends observed in a real world composed

of different nations and institutions and knowledge of the strength and weaknesses of the national SETI system in which the decisions informed by the GO→SPIN survey methodological approach have to be taken.

The diversity of institutions at the promotion level (funding) in a given country seems to be one of the most fundamental indicators of good practices. The GO→SPIN global database will provide empirical evidence to confirm or refute this and other hypotheses.

The so-called *legal framework* can also be considered as a legal instrument. This embodies the policy, or parts thereof, in the form of a law, decree or regulation. Formal agreements, contracts and international STI cooperation treaties may also be included in this category. A legal instrument goes one step beyond a policy by stipulating obligations, rights, rewards and penalties. The GO→SPIN systemic approach has developed a friendly platform offering direct access to the entire SETI legal framework, description and the full text of laws, acts, decrees and agreements adopted by each country. Table B shows different examples of the most important types of legal instrument.

Table B: Examples of SETI legal instruments

A law for the creation of national research labs, universities, national research councils, ministry of S&T, R&D Funds, etc., or a legal framework to regulate the organization of the national innovation system.
A law to regulate the imports/exports of high-tech products.
A law to regulate tax incentives to promote innovation within the private sector.
A law to regulate foreign direct investments promoting the establishment of new high-tech enterprises.
A law to regulate the protection of the national biodiversity and to establish norms on how foreign companies exploit the active substances available within each national territory (new rules for the protection of indigenous knowledge).
Laws to foster R&D activities within the private sector and the creation of technological funds associated with the most strategic sectors of the economy (energy, mining, agriculture, industry, communication, fishing, tourism, etc.).
National regulations and decrees to establish new national policies, creation of new funding mechanisms, import/export tariffs, etc.
Bi-lateral, regional and international agreements on SETI activities.
Contracts on technology transfer.

Source: UNESCO

GO→SPIN also includes a complete description of SETI operational policy instruments, which are the levers, or actual means, through which the organizational structure ultimately implements the decisions on a day to day basis and attempts to influence the behaviour of the various stakeholders targeted by the policy. Throughout the analysis of an instrument, it is important to keep in mind the actors or key decision-makers who are directly involved in the design and use of a policy instrument. An instrument does not act on its own accord. Rather, it responds to the will of the policy-makers and decision-makers using it. Table C shows different types of operational policy instrument, whereas Figure B shows various instruments that can be employed to effect at the different stages leading to market penetration of an innovation.

Table C: Examples of operational SETI policy instruments

Programmes and objectives	Policy instrument	Strategic objectives	Beneficiaries	Mechanisms for allocating funding
Scientific research and technological development	Competitive grants	Promote the endogenous production of new scientific knowledge in the exact and natural sciences. Promote regional networking.	Research groups at national universities and national research centres associated with similar research groups from other countries in the region, within formal partnership agreements	Competitive grants selected on a peer review basis; national research groups must be associated with similar groups from countries in the region which provide matching funding
Promotion of science education	Public subsidies for projects establishing science laboratories at public secondary schools	Improve scientific knowledge; methodological approach and critical thinking for secondary school pupils	Public secondary schools in less developed parts of the country	Public subsidies to mount new science cabinets and laboratories and new posts for science professors
Promotion of gender equality in research and innovation	Scholarships	Promote the participation of women in high-tech research and innovation	Young women enrolled in a PhD programme in basic and engineering sciences	Scholarships of up to four years and small grants for participation in international conferences
Protection of indigenous knowledge	Intellectual property rights, public law–national legislation and public subsidies	Protection of traditional knowledge to confer exclusive ownership and rights on local communities when the object of protection is a product or domesticated animal, cultivated plant or any micro-organism, or a design or an object of a functional or aesthetic nature, including any element of handicrafts, the act prohibits third parties from making, using, stocking, offering for sale, selling, commercializing, importing, exporting or identifying the active substances for commercialization, without consent	A local traditional practitioner, a local community or its representative may apply to register traditional knowledge	Public subsidies and tax exemptions to defend the Intellectual property rights of holders of indigenous and traditional knowledge
Attraction and reinvestment of foreign direct investment	Public financing Tax incentives	Strategies vary from country to country, examples being: (a) an Industrial policy based on attracting export-oriented industries; (b) promotion of structural change; (c) capacity-building to improve competitiveness, focusing on sectors or market niches; (d) internationalization of enterprises, and promotion of innovation; (e) prioritizing the generation of higher-tech goods and services (f) attracting selective FDI oriented towards ICTs, biotechnology, nanotechnology and financial services; (g) improving the business climate by refining legislation and simplifying formalities to facilitate corporate operations.	National Infrastructure (buildings, technology corridors, technological cities) and training of labour and professionals for the industry in question SMEs with export capacity	Soft-loans, tax incentives, grants For specific periods: tax discounts, exemptions, preferential rates, rebates on machinery and equipment
	Attracting R&D firms		Endogenous entrepreneurs High-tech emerging sectors: biotechnology, nanotechnology, new materials, ICTs.	The same tax incentives plus special competitive funding
	Other services	Structural change within a large country offers more opportunities for the domestic market, small and medium-sized countries generally focus on schemes conducive to the development of exports	Strengthening exports of industries and services considered to have strong potential in the country	Creation of a "one-stop shop" with representatives from different ministries/ agencies to deal with problems concerning programmes, public regulations and post-investment services

Programmes and objectives	Policy instrument	Strategic objectives	Beneficiaries	Mechanisms for allocating funding
Technological development	Non-repayable contributions	Increased competitiveness through innovation in products, services and processes	Micro-, small and medium-sized enterprises and broader enterprises certified as having attained international standards	By public competition; up to 50% of project cost
	Loans for technological development projects	Finance for middle-income technology production projects	Micro-, small and medium-sized enterprises with R&D departments or teams, collaborating groups and technical linkage units underwritten by the enterprise	Compulsorily repayable loans; up to 80% of the total cost, allocated on an open window basis, with a maximum of $... for three years
Technological modernization (improvement of products and processes, training)	Fiscal credit programme	Assistance in executing R&D	Physical or juridical persons who own enterprises producing goods and services	Subsidies through fiscal credit certificates obtained via public competition; up to 50% of the total cost of the project
	Loans for modernization Projects	Technological adaptation and improvements to products and processes with a low level of technical and economic risk	Enterprises with R&D department or groups; collaboration groups, and technical linkage units underwritten by the enterprise	Special compulsorily repayable loans allocated on an open window basis. Up to 80% of the total cost of the project, with a maximum of $...in three years
	Loans to enterprises	To finance projects for the development of new production processes, products and modifications thereto	Enterprises, without any restriction on size or sector; no finance provided for projects with a rate of return of less than 12%	Compulsorily repayable loans allocated on an open window basis. Up to 80% of the total cost of the project, with a maximum of $...
Promotion of the technological services market (research institutes and business research centres)	Subsidies for projects to develop business plans	Finance for business development projects based on R&D	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to 50% of the total project cost, with a maximum of $..., for up to one year
	Loans to institutions	To promote the establishment and strengthening of structures for the provision of technological services to R&D enterprises and institutions	Public or private institutions providing services to the private productive sector; projects may be presented on an individual or associated basis	Obligatorily repayable subsidies allocated on an open window basis, up to a maximum of $...
Training and technical assistance	Subsidies for training and retraining projects	Subsidies to support activities for training and retraining human resources in new technologies	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to a maximum of 50% of the total cost of the project, or $... for up to six months
	Subsidies for project Formulation	Support for the formulation of R&D projects, technology transfer or technical assistance	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to a maximum of 50% of the total cost of the project, or $... for up to six months
Technological advisory assistance programmes and those strengthening the performance of technical small and medium-sized enterprises	Technological advisory assistance programme	Support for the formulation of R&D projects, technology transfer or technical assistance	Micro-, small and medium-sized enterprises producing goods and services which incorporate technological added value	Subsidies allocated on an open window basis to individuals or groups, with a maximum of 50% of the total cost of the project, or $... and a maximum of $... per participating enterprise
Popularization and social appropriation of science	Competitive grants	Support for the organization of national exhibitions and science fairs	Science museums, educational institutions at primary, secondary and tertiary levels	Subsidies allocated on a competitive basis

Source: UNESCO, UN ECLAC, FONTAR (Argentina)

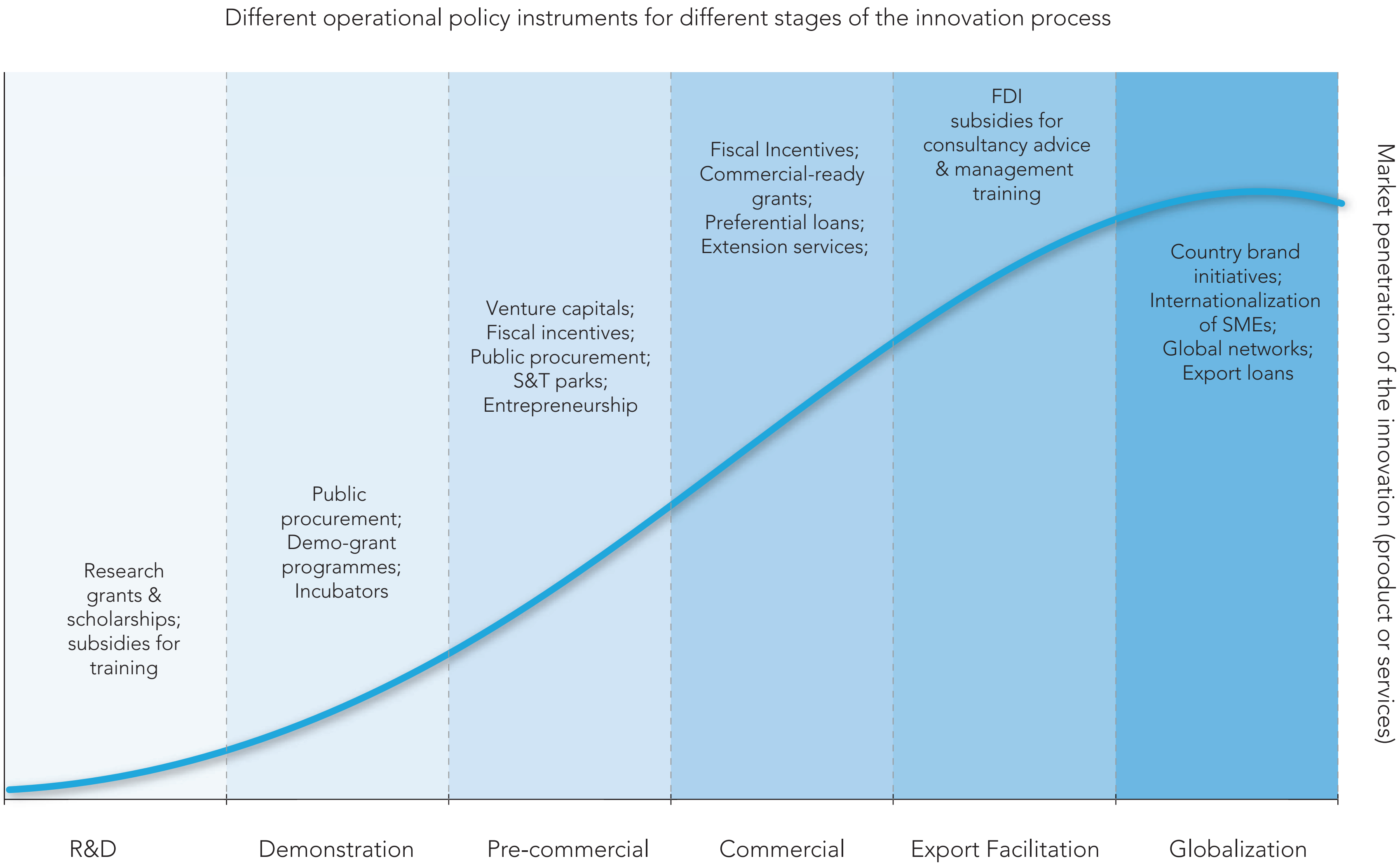
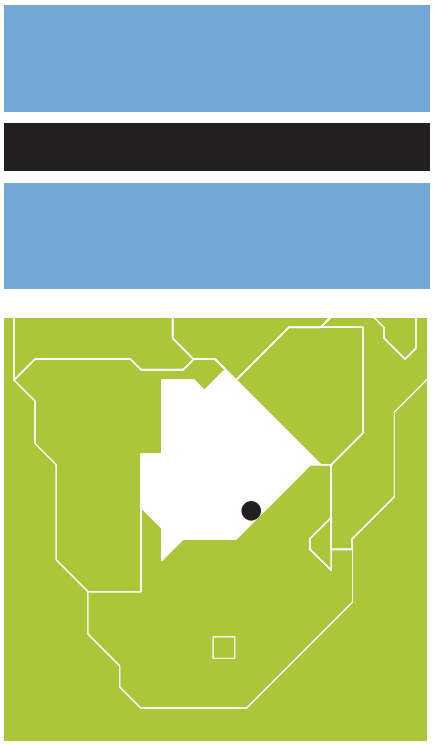


Figure B: Policy instruments for different stages of the innovation process and market penetration.
Source: UNESCO

Botswana: mapping the landscape of a small-country innovation system



OFFICIAL NAME: Republic of Botswana
(Lefatshe la Botswana), formerly Bechuanaland
CAPITAL: Gaborone
HEAD OF STATE AND HEAD OF GOVERNMENT (2013):
Sir Seretse Khama Ian Khama
NATURE OF GOVERNMENT: Parliamentary democracy
POPULATION: 2,053.200 (2012)
SURFACE AREA: 581,726 km^2
ETHNIC MAJORITY: Tswana
LANGUAGES: English (official), Setswana
RELIGIONS: Multi-religious (predominanty Christianity)
UNIT OF CURRENCY: Pula
DATE OF INDEPENDENCE: 30 September 1966
DATE OF CONSTITUTION: Effective 1966

HISTORY OF A PEOPLE

The Batswana, a term also used to denote all citizens of Botswana, refers to the country's major ethnic group (the *Tswana* in South Africa), who came to the area from South Africa during the Zulu wars of the early 1800s. Prior to contact with Europeans, the Batswana lived as herders and farmers under tribal rule.

In the 19th century, hostilities broke out between the Batswana and Boer settlers from the Transvaal. After appeals by the Batswana for assistance, the British government put 'Bechuanaland' under its protection in 1885. The northern territory remained under direct administration and represents what is today known as Botswana, whereas the southern territory became part of the Cape Colony and is now part of the northwest province of South Africa; the majority of Setswana-speaking people today live in South Africa.

Despite pressure from South Africa, inhabitants of the Bechuanaland Protectorate, Basuotoland (now Lesotho) and Swaziland asked for, and received, British assurances in 1909 that they would not be included in the proposed Union of South Africa. An expansion of British central authority and the evolution of tribal government resulted in the 1920 establishment of two advisory councils representing Africans and Europeans. Proclamations in 1934 regularized tribal rule and powers. A European–African advisory council was formed in 1951 and the 1961 constitution established a consultative legislative council.

In June 1964, Britain accepted a proposal from Botswana for democratic self-government. The seat of government was moved from Mafikeng, in South Africa, to the newly established capital of Gaborone in 1965. The 1965 constitution led to the first general elections and to independence in September 1966.

Botswana has a flourishing multiparty constitutional democracy. Each of the elections since independence has been freely and fairly contested and has taken place on schedule. The country's minority groups participate freely in the political process.

The national legislature is a partially bicameral parliament, consisting of an elected National Assembly and a consultative House of Chiefs. The National Assembly consists of the president of the republic, the speaker and the attorney general, serving *ex officio*, and comprises 57 members in all. The legislative

term of the National Assembly is five years. The president may withhold his assent to a bill passed by the National Assembly, but if it is presented to him again six months later, he is required to give his assent unless he dissolves parliament within 21 days.

The House of Chiefs is a 15-member advisory body consisting of the chiefs of the eight principal tribes serving ex officio, four members elected by the subchiefs from among their own number and three members elected by the other 12 members of the House. Bills affecting tribal interests and chieftaincy matters must be referred to the House. Under the constitution, suffrage is universal over the age of 18.

Botswana is one of Africa's success stories. It has become a middle-income country in just three decades, through sound macroeconomic policies, good governance and careful investment of wealth from natural resources in social development. State revenue generation is high, due to well-negotiated partnerships in the extractive industry. Since the 1980s, the government has used a Sustainable Budget Index and environmental accounting programme to monitor how income from mining is reinvested in the national budget to promote Botswana's long-term development. Batswana citizens have almost universal access to education, health, water and sanitation (see Box 1).

BOX 1 – HUMAN DEVELOPMENT IN BOTSWANA

In Southern Africa, GDP is expected to grow by around 4% in 2013 and to accelerate to 4.6% in 2014. In Angola, Botswana, Mozambique and Zambia, growth is likely to remain buoyant (ADB *et al.*, 2013). The long-term evolution of GDP rarely tells the whole story about a country's level of development.

The concept of human development focuses on the end result rather than the means of achieving development. This holistic approach puts people at the centre of the development process. Since 1989, the United Nations Development Programme (UNDP) has been measuring the Human Development Index (HDI). The latter measures the average achievements of a country for three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. Data availability determines HDI country coverage. The three dimensions are normalized with the corresponding lowest and highest values obtained from a sample of 187 countries then combined into a single index. Each country will have a HDI value situated between 0 and 1. The global rank of countries is obtained by representing each individual HDI value in descending order.

Countries are classified as being of very high, high, medium or low development, according to their ranking. Africa's breakthrough came in 2013 when the Seychelles achieved very high human development with a rank of 46th place, ahead of wealthier states in Europe and the Middle East. Algeria, Libya, Mauritius and Tunisia were attributed high human development and Botswana and nine other African countries medium human development. The remaining 37 African countries fall in the low human development category, South Sudan being precluded from the study (UNDP, 2013).

Between 1975 and 2012, Botswana's HDI rose by 2.7% annually from 0.494 to 0.634, which gives the country a rank of 119th out of 187 countries with comparable data. The HDI of sub-Saharan Africa as a region has increased from 0.366 in 1980 to 0.475, placing Botswana above the regional average. Figure 1 shows the long-term evolution of HDI of Botswana.

Recent *Human Development Reports* published by UNDP have launched an Inequality Adjusted Human Development Index (IHDI) and Gender Inequality Index (GII) alongside the HDI. High inequality is undermining the positive impact of Africa's economic growth. The GII also reflects gender-based disadvantages in reproductive health, empowerment and the labour market. Countries with better gender equality tend to have low maternal mortality, low adolescent fertility and a high proportion of males and females with at least secondary education. Gender

inequality in Africa is linked to the persistence of discriminatory laws, norms and practices which restrict the access of women and girls to opportunities, resources and power. The GII of Botswana puts the country in the lower gender inequality group in Africa (see Table 1).

Batswana citizens enjoy almost universal access to education, health, water and sanitation. However, prudent macroeconomic management, democratic governance and sustained economic growth have not translated into broad-based development and socio-economic transformation. Botswana's economy is still dependent on minerals and there are persistently high levels of poverty, inequality, unemployment and a prevalence of HIV and AIDS. High unemployment is linked to a mismatch between skills development and market demands, on the one hand, and slow job creation in the private sector (ADB *et al.*, 2013). The public sector retains a large role in development. The state is pursuing economic diversification under a five-year national strategy which includes the promotion of greater local involvement in the processing and marketing of diamonds.

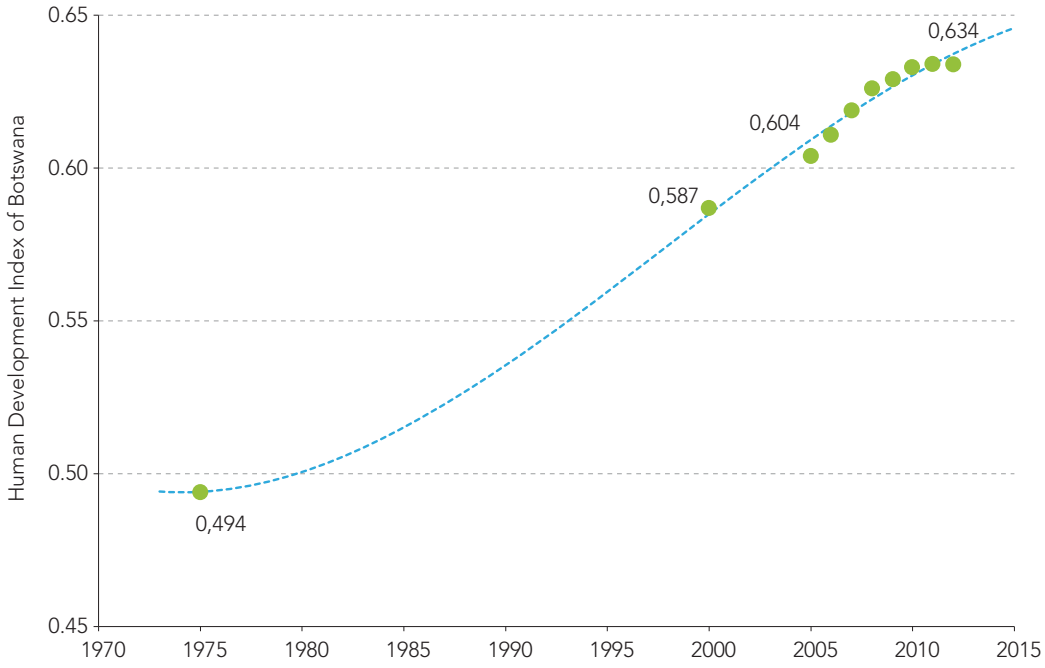


Figure 1: Long-term evolution of the Human Development Index (HDI) in Botswana. Source: UNESCO estimation, based on *Human Development Reports* published by UNDP between 1991 and 2012

However, prudent macroeconomic management, democratic governance and sustained economic growth have not translated into broad-based development and socio-economic transformation. Botswana's economy is still dependent on minerals and there is high poverty, inequality and unemployment and a prevalence of HIV and AIDS. High unemployment is linked to a mismatch between skills development and market demands, combined with slow job creation outside the public sector. The public sector retains a large role in development in the absence of a viable private sector.

According to the UN Statistics Division, the long-term evolution of the population in Botswana is reaching a stable regime with around two million people (see Figure 2).

Table 1: Quality of life in Botswana

Indicator	Value (2012)
Human Development Index (HDI)	
HDI [value]	0.634
HDI [world rank over 187 countries]	119
Health	
Public expenditure on health [% of GDP]	6.0
Under-five mortality [per 1,000 live births]	48.0
Life expectancy at birth [years]	53.0
Education	
Public expenditure on education [% of GDP]	7.8
Primary school teachers trained to teach [%]	97.4
Primary school dropout rates [% of primary school cohort]	13.2
Expected years of schooling [of children] [years]	11.8
Adult literacy rate, both sexes [% aged 15 and above]	84.5
Mean years of schooling [of adults] [years]	8.9
Combined gross enrolment in education [both sexes]	70.0
Inequality	
Loss due to inequality in life expectancy [%]	24.3
Gender	
Population with at least secondary education [ratio of females to males]	0.949
Adolescent fertility rate [births per 1,000 women aged 15–19]	52.1
Labour force participation rate [ratio of females to males]	0.879
Gender Inequality Index, value	0.485
Shares in parliament [ratio of females to males]	0.086
Maternal mortality rate [deaths of women per 100,000 live births]	160
Sustainability	
Carbon dioxide emissions per capita [tonnes]	2.5
Change in forest area, 1990/2010 [%]	-17.3
Demography	
Population, total both sexes [thousands]	2,053.2
Population, urban [% of population]	62.3
Population, female [thousands]	1,015.4
Population, male [thousands]	1,037.8
Income	
GDP per capita [2012 US$ PPP]	15,019

Source: UNDP (2013), UNESCO

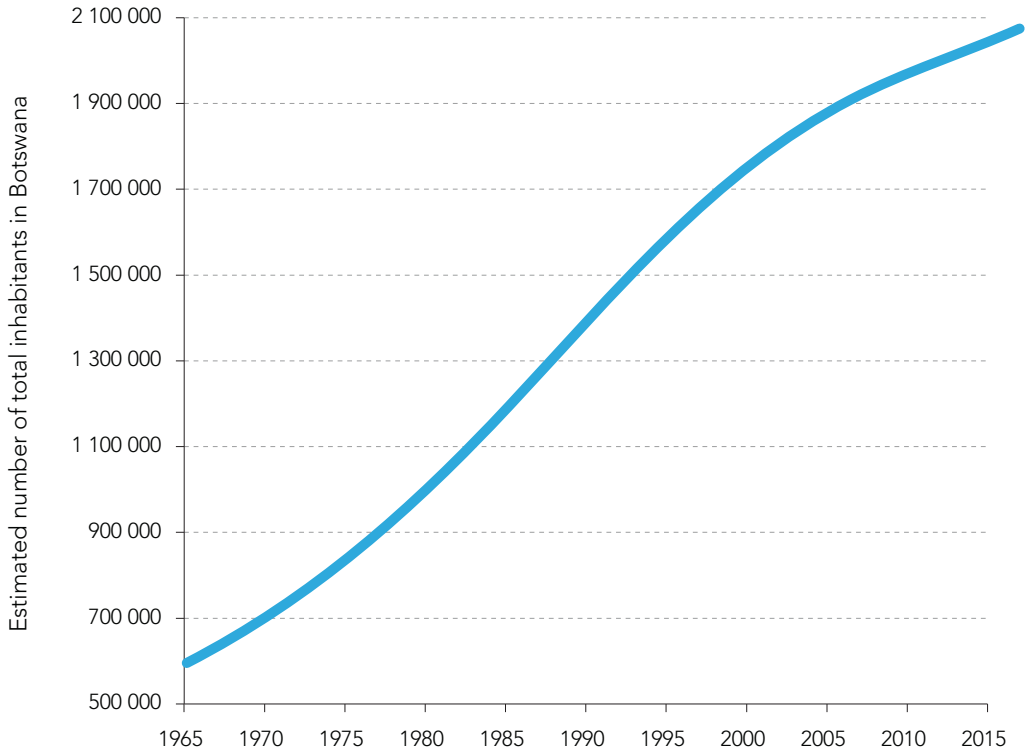


Figure 2: Evolution in the total population of Botswana, 1965–2013. Source: UNESCO treatment of data provided by the UN Statistics Division

THE ECONOMIC LANDSCAPE IN BOTSWANA

At the time of independence in 1966, Botswana was one of the poorest countries in the world. It had 12 km of paved roads, 22 university graduates and 100 secondary-school graduates. Today, Botswana has one of the highest income levels in sub-Saharan Africa in terms of GDP per capita[4]. Figure 3 shows the long-term evolution of GDP per capita expressed in constant 2012 US dollars. Botswana is one of the few countries in the world which can show a constant, sustained quadratic (parabolic) growth for almost 50 years, with an incredible accuracy (correlation factor R^2=0.99).

To show how growth in GDP per capita influences scientific productivity, Figure 4 represents the correlation between the number of scientific publications per million population and GDP per capita between 1966 and 2012. The graph shows a parabolic correlation, indicating that each increase in one unit of GDP per capita is reflected in a quadratic increase in the number of scientific publications per capita. This can be considered a self-organizing process, if we take into account that the first explicit S&T national policy was launched in 1998.

The objective of Botswana's monetary policy is to achieve price stability, defined as sustained inflation within a range of 3–6%, in line with the target of the Southern African Development Community (SADC). Botswana's inflation rate has, however, consistently overshot the upper target since 2007.

To sustain an appropriate level of interest rates that is consistent with the country's monetary policy, the Bank of Botswana also influences the quantity of loanable funds in the banking system through the sale and purchase of Bank of Botswana Certificates (BoBCs). In an environment of excess liquidity in the banking system, as currently prevailing in Botswana, there could be a tendency towards a bidding down

4 in PPP dollars

of interest rates, even when it is desirable to maintain them at a higher level. Under the circumstances, the Bank of Botswana mops up the excess liquidity by selling BoBCs to the commercial banks and pays an appropriate interest rate.

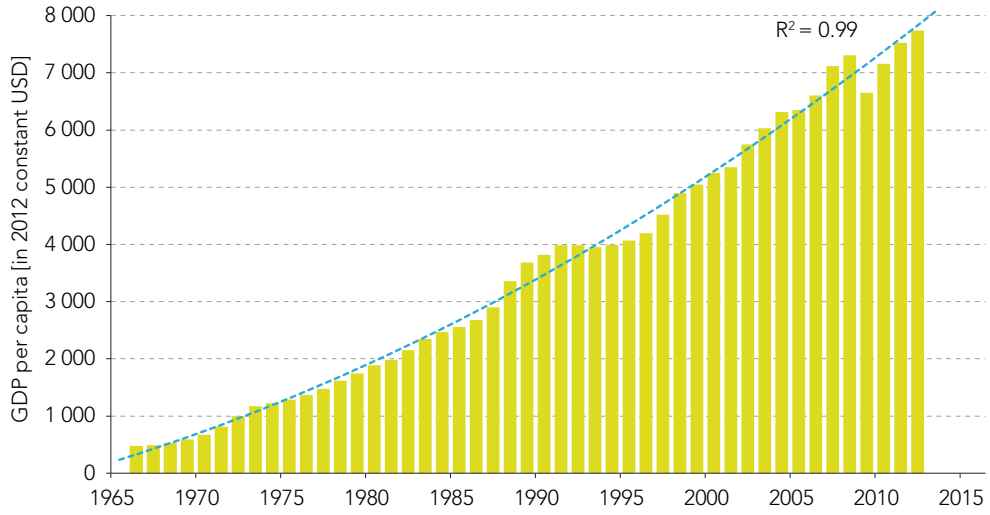


Figure 3: Long-term evolution of GDP per capita expressed in constant US$ (2012). The long-term behaviour shows a parabolic growth with a high correlation coefficient (R2=0.99). *Source:* UNESCO based on raw data provided by UN Statistics Division (Population), World Bank (GDP in US$) and US Census Office (US$ deflactor).

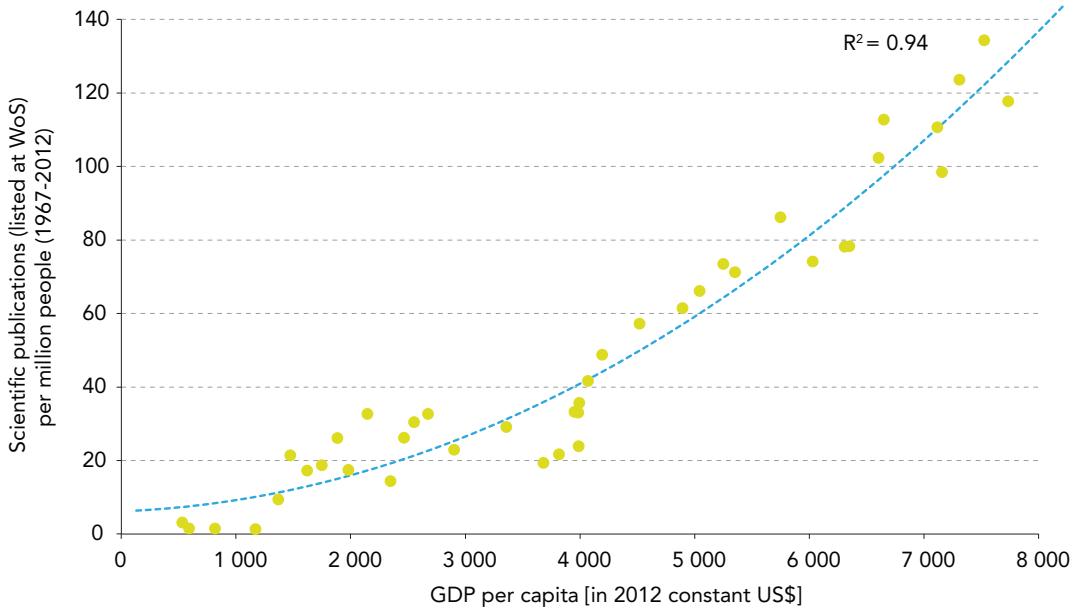


Figure 4: Parabolic correlation (R^2=0.94) between the number of mainstream scientific publications per million population and the GDP per capita in constant US$, 2012. This means that an increment in one unit of the GDP per capita correlates with a quadratic increment in the number of scientific publications per million population. Source: UNESCO, based on raw data provided by UN Statistics Division and Web of Science.

An increase in the cost of borrowing has an impact on the demand for credit and, in turn, on aggregate demand and, therefore, on inflation. If the cost of borrowing increases, borrowers may be forced to borrow less because the monthly debt service increases, among other consequences. Under the circumstances, borrowers are unable to borrow as much as previously. Consequently, the demand for goods and services

drops, with a dampening effect on inflation. Credit growth is, therefore, a useful indicator of prospective demand conditions and the likely impact on inflation. It is against this background that the Bank of Botswana has been specifying, up to 2007, a range of credit growth that is consistent with the inflation objective.

However, demand for credit depends not only on interest rates; it is also influenced by other developments in the economy. In Botswana, these other influences include structural changes in the financial sector, greater competition resulting in the introduction of new loan products, a general increase in income and the substantial loan amounts associated with large new investment projects. Moreover, in addition to domestic aggregate demand, there are other significant influences on domestic inflation, such as the exchange rate and foreign price developments, changes in administered prices and expectations for inflation. The real value of the Pula against major foreign currencies has remained stable and competitive.

Botswana's tax rates have generally been low compared to comparator countries. The well-administered tax system has been instrumental in boosting private sector investment in the country. The tax rate of 19.5% on profits is generous compared to the average of 68% for sub-Saharan Africa.

There is an urgent need to simplify the tax structure, in order to improve the compliance rate and reduce not only the costs of compliance and administration but also the demand for scarce accountants and tax administrators.

Competition for Botswana producers has got tougher because the common external tariffs of the Southern African Customs Union[5] have been reduced. Moreover, a programme of further reductions is planned.

Although the SADC Free Trade Area was launched in 2008, this will have a relatively minor effect on most of Botswana's trade, the principal exception being trade in agricultural goods. Botswana already enjoys free trade with South Africa, which represents about 75% of GDP for the entire SADC region. Botswana has also concluded a free trade agreement with Zimbabwe. Transport links with other small SADC economies are relatively poor.

The investment climate depends on a stable environment, including low levels of crime, corruption and road traffic accidents and respect for the rule of law. Crime levels in Botswana are substantially below those of other countries in the region.

Attracting foreign direct investment

Foreign direct investment[6] (FDI) is also usually considered a major source of growth. FDI is an important source of financing for transition economies, as it helps to cover the current account deficit and fiscal deficit (in case of privatization-related FDI), and supplements inadequate domestic resources to finance both ownership change and capital formation. Second, compared with other financing options, FDI also facilitates transfer of technology, know-how and skills, and helps local enterprises expand into foreign markets. It increases the activity of FDI-beneficiary firms but the effect can also spread to other firms and sectors through technological spillover and heightened competition, thus raising productivity in the entire economy. Countries can stimulate the inflow of FDI by creating a business climate that makes foreign investors that as if their capital is safe. Low tax rates or other tax incentives, protection of private property rights, access to loans and funding, as well as infrastructure that allows the fruit of capital investment to reach the market, are a few of the incentives that countries may offer.

5 Grouping Botswana, Lesotho, Namibia, South Africa and Swaziland

6 The International Monetary Fund defines (foreign) direct investment in its Balance of Payments Manual as the category of international investment that reflects the objective of obtaining a lasting interest by a resident entity in one economy (direct investor) in an enterprise resident in another economy (direct investment enterprise). A direct investor is defined by its ownership of 10% or more of the ordinary shares or voting power in a direct investment enterprise.

Many African governments have implemented investment-friendly frameworks to attract more foreign investment. Nonetheless, most foreign investment in Africa goes to extractive industries in a relatively limited group of countries. Thus, the broader development impact of FDI-backed projects is often limited. Attracting investment into diversified and higher value-added sectors remains a challenge for Africa. However, constraints on investment such as weak infrastructure and fragmented markets also adversely affect FDI flows to Africa. FDI levels still vary widely by region, sector and country.

Table 2 shows the long-term evolution of the FDI inflow, outflow and FDI Inflow/gross fixed capital formation[7] for Botswana between 1997 and 2011. These figures show a substantial increase in the FDI in Botswana in the past decade. However, the subjective perception of the international community ranks Botswana 101st out of 142 countries (see Table 3).

Table 2: FDI inflow and outflow for Botswana, 1997–2011

Year	FDI inflow [million current US$]	FDI outflow [million current US$]	FDI inflows/ GFCF*
1997	100	4	7.7
1998	90	3	6.6
1999	37	1	2.6
2000	57	2	4.1
2001	31	380	2.1
2002	203	43	3.1
2003	418	206	23.4
2004	391	-39	19.2
2005	346	57	17.8
2006	486	50	26.9
2007	495	51	24.4
2008	528	-91	-0.1
2009	968	48	29.6
2010	559	3	14.6
2011	587	4	15.5

* Gross fixed capital formation.

Source: UNCTAD World Investment Report (several years)

7 The gross fixed capital formation consists in investment in land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways and the like, including commercial and industrial buildings, offices, schools, hospitals and private residential dwellings.

The inflow of FDI is improving but there is a need to continue attracting investment. There are too many role players: Botswana Development Corporation, International Financial Services Corporation and the Botswana Export Development and Investment Authority. It may be necessary to rationalise the functions of these institutions by assigning their role in attracting investment to a single entity.

In an increasingly complex innovation landscape, developing effective governance requires better coordination at, and among, the local, regional, national and international levels. With the broadening of innovative processes, players and locations, the systems of governance that ensure these function properly are becoming even more important. As no single actor has the knowledge and resources to tackle the innovation challenge unilaterally, all countries – in one way or another – face the task of coordinating actors better in formulating and implementing policy.

THE CORRELATION BETWEEN GOOD GOVERNANCE AND SCIENTIFIC PRODUCTIVITY

Botswana is well-known for its political stability and good governance. Democratic principles are deeply entrenched after decades of successful democratic transitions. Botswana operates a multi-party democracy with a parliamentary system of government. Recently, for the first time, Botswana entered the world's top 30 countries for the lowest levels of corruption, ahead of Spain, Estonia and Portugal. Acemoglu and Robinson (2012) traced the roots of governmental stability to the existing institutions during the colonial period. At independence, the Tswana emerged with a history of institutions enshrining limited chieftaincy and some degree of accountability of the chiefs to their people. The Tswana were of course not unique in Africa in having institutions like this but they were unique to the extent that these institutions survived the colonial period unscathed. Historical evidence suggests that Botswana adopted political institutions consistent with its traditional sources of authority. The traditional leaders pursued policies that legitimized the political system, while the government did not devote any resources to military expenditure in the first decade after independence. The interaction among these factors explains Botswana's success (Beaulier and Subrick, 2006).

Some correlation between governance indicators and SETI productivity has been found within UNESCO's GO→SPIN programme, (Lemarchand, 2013). If we represent in a Cartesian graph (four quadrants) each country according to its positive or negative values for government effectiveness, against its positive or negative values for political stability/absence of violence, few countries appear in the first quadrant. The only African countries to figure here (positive values on both axes) are Botswana, Cape Verde, Ghana, Mauritius, Namibia, Seychelles and South Africa. In the second quadrant (negative values for political stability/absence of violence and positive values for government effectiveness), no African countries appear. The third quadrant (negative values on both axes) concentrates the great majority of African countries, whereas the fourth quadrant (positive values for political stability/absence of violence and negative values for government effectiveness) includes ten African countries.

If we represent all the countries in the world on the same type of Cartesian graph, a new pattern emerges. Those countries with the largest GDP per capita and largest number of scientific publications per million population will be situated in the first quadrant (Lemarchand, 2013).

Figures 5 and 6 show the evolution of these two governance indicators for Botswana between 1996 and 2012. Botswana showed positive values for both political stability/absence of violence and government effectiveness over the entire period. Consequently, it evolved in the first Cartesian quadrant.

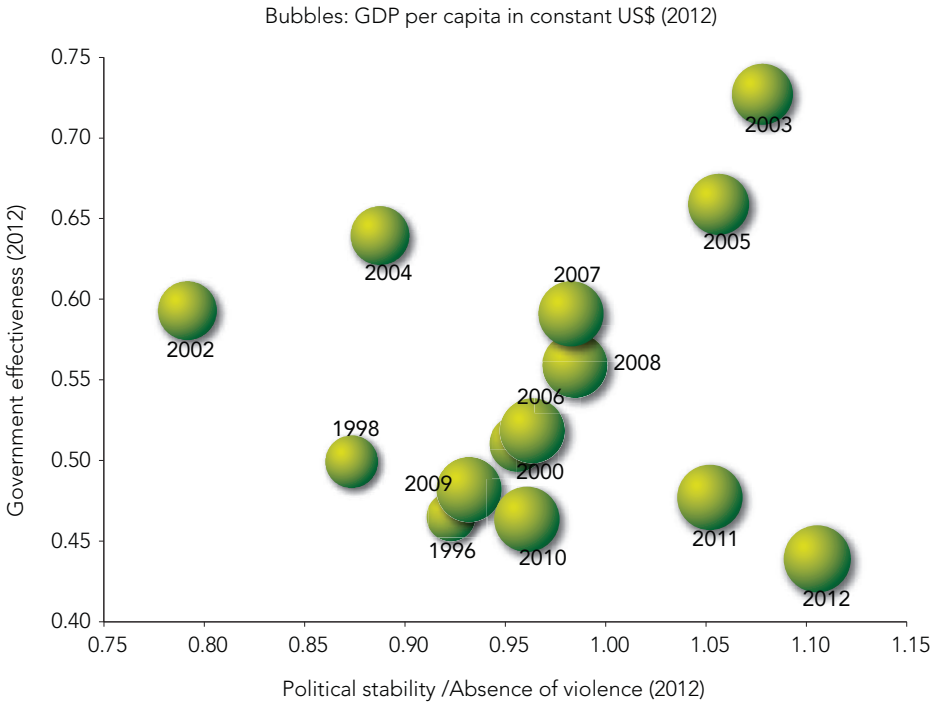


Figure 5: Evolution of government effectiveness against political stability/absence of violence in Botswana, 1996–2012. The size of the bubbles represents GDP per capita for the same years. Botswana is one of the few countries in Africa with positive values in the first two dimensions. This is a prerequisite for creating an environment conducive to sustainable development. Source: UNESCO treatment of data, based on information provided by the World Bank and UN Statistics Division

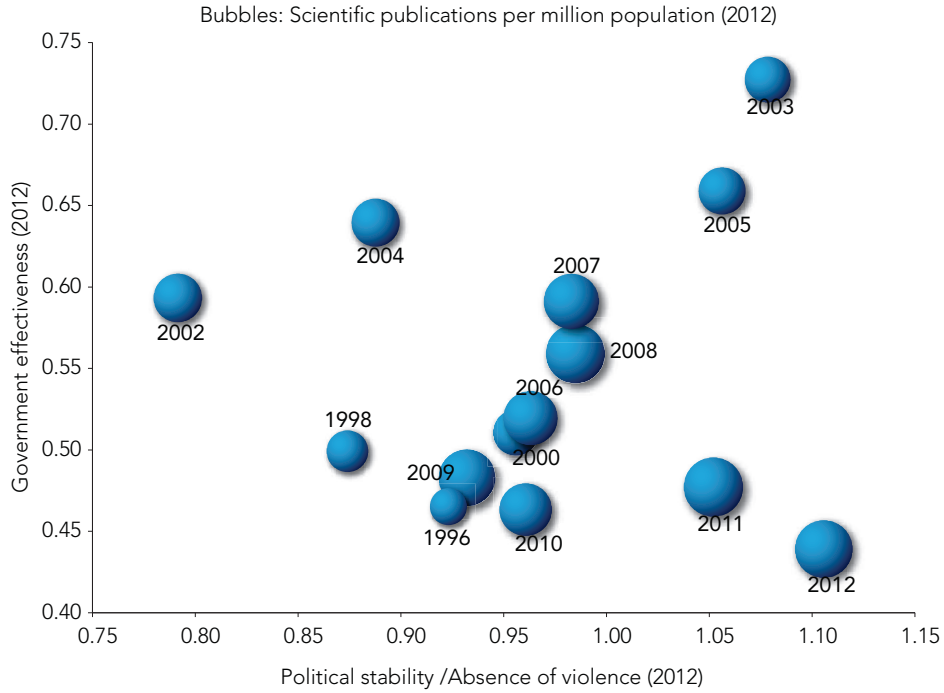


Figure 6: Evolution of government effectiveness against political stability/absence of violence in Botswana, 1996–2012. The size of the bubbles represents the number of scientific publications per million population for the same years. Again, Botswana is one of the few African countries with positive values in the first two dimensions. This is a prerequisite for creating an environment conducive to sustainable development. Source: UNESCO treatment of data, based on information provided by the World Bank, UN Statistics Division and Web of Science

Political stability and good governance over a period of decades are prerequisites for developing good public policies. Empirical studies carried out over the past two decades show that governments find coordination and coherence difficult, since their traditionally departmentalized structures are generally ill-suited to dealing with cross-cutting policy issues like innovation. Coherence involves not only coordination of a multitude of policy actions in the core set of innovation policies such as S&T and education but also an evaluation of their possible interaction with policies pursuing other primary objectives, such as tax policy, laws to encourage competition and regulations governing innovation (OECD, 2010).

BOX 2 : SMALL-ECONOMY INNOVATION SYSTEMS

Small economies like that of Botswana (Republic of Botswana, 2011; 2012) share characteristics which restrict the performance and evolution of their innovation systems. These characteristics have been studied in depth in the specialized literature (Wong and Singh, 2008; O'Malley *et al.*, 2008; Marcelle, 2009; Matengu, 2011; Roolaht, 2012). The functionality and impact of the policies proposed by Botswana are limited by these characteristics, which encompass the following:

- Small-scale innovation systems face considerable regional and cultural disparities, along with adverse cost levels affecting the productive system and posing organizational challenges at the company level. These disparities can even have a larger influence on innovation than they do in a larger country.
- Small-scale national innovation systems are relatively more dependent on the inflow of foreign direct investment (FDI) because local levels of investment capital are insufficient.
- The rapid development of small economies and their subsequent innovation systems is at least initially based predominantly on inward transfers of knowledge and technologies.
- Small-scale national innovation systems require well-developed policy schemes and integrated efforts in order to enhance the development of domestic R&D activities, innovation and entrepreneurship.
- International cooperation and foreign openness, along with enhanced cross-border ties beyond FDI and knowledge inflows, are essential substitutes for the restricted capabilities of domestic support.
- The success of small-scale national innovation systems is inherently more dependent on using limited resources and capabilities for well-defined, focused innovation than that of larger systems. Thus, priority-setting procedures are likely to be of crucial importance.
- Small-scale national innovation systems should build predominantly on human and social capital, in order to cope with inherent financial constraints.
- Small-scale national innovation systems offer flexible policy adjustment opportunities but these could be hampered by inefficient collaboration and disagreements concerning goal-setting.

DIVERSIFYING THE ECONOMY TO DRIVE GROWTH

Government spending has been dependent on revenue from minerals since diamonds were discovered in 1967. As the economy has become larger and more complex, average economic growth rates over the plan periods have declined. The average growth rate for the first three years of the *Tenth National Development Plan* (2009–2016) was lower than the rate for the previous plan, according to the *Mid-Term Review of Botswana's Tenth National Development Plan*, published by the Ministry of Finance and Development Planning in June 2013.

In an effort to reduce reliance on the mining sector, the government has made diversifying the economy one of the key strategic foci of the *Tenth National Development Plan* (2009–2016). This strategy is 'both a means and an end to accelerated economic growth', with private-sector participation being 'critical' to its success. To this end, the government adopted the Economic Diversification Drive in April 2010.

Diversifying the economy would normally necessitate high government spending. The government has come to the conclusion that the most effective way of driving economic growth is to enhance the role of R&D in fuelling entrepreneurship and private-sector growth. The government has recently established six hubs to foster diversification of the economy and R&D: an Agricultural Hub, an Innovation Hub, a Diamond Hub, a Transport Hub, a Health Hub and an Education Hub. The first five hubs are presented below. The Botswana Education Hub is discussed on page 21.

Creating an enabling business environment

If the private sector is to drive the accelerated diversified growth of the Botswana economy, macro-economic stability and the strong global competitiveness of Botswana goods are absolute necessities. Good governance and high-factor productivity will also create a environment for the private sector. To the extent that prosperity for all applies to current as well as future generations, the sustainable use of the environment remains important to the Botswana economy.

In the short term, the strategy for supporting the private sector has been based on government interventions like local procurement. The medium- to long-term strategy envisages the development of sustainable and globally competitive enterprises that need little or no government protection and support. Priority sectors for implementation under this drive are: primary production (e.g. grains, livestock development and horticulture); agro-processing (dairy, horticulture, meat, leather, etc.); beneficiation of coal, diamond and other minerals; recycling of material products – paper, plastic and others; arts and crafts; construction/building materials; textiles and clothing; renewable energy; banking, finance and insurance; services/support sectors – ICTs, transport and logistics, hotels, skills development, entertainment and restaurants.

The Cabinet Committee on Doing Business and Global Competitiveness has approved key strategies for the last part of the *Tenth National Development Plan*. These include the Introduction of a national single window to accelerate the clearing of imports and exports and the development of legislation to allow electronic commercial transactions which would facilitate imports and exports online. Taxpayers are now able to file and pay their taxes online, as well as apply and pay for permits and licenses online. This will have a positive effect on trade across borders.

The Companies Act was also amended in 2011 to allow applicants to register companies without the assistance of company secretaries, thereby reducing business start-up costs (see also page 86).

Foreign and domestic investment will also be attracted to increase economic output and thereby create employment. All efforts geared towards making it easier to do business will also create an environment that allows private sector activity to grow, attract investment and ensure continued economic growth. To this end, industry-relevant skills will be developed through the establishment of special economic

zones to attract the requisite investment for developing exports, diversifying the economy and creating employment. For example, a Leather Park will be established to facilitate the development of the leather industry in Botswana.

In terms of developing the human resources needed to improve Botswana's competitiveness, the government has introduced a point-based system to allow requisite skilled expatriates to work in Botswana.

The strategy also intends to deal with the mismatch between graduates' skills set and the demands of the economy, which contributes to the challenge of unemployment, particularly among youth. In August 2009, the Human Resource Development Advisory Council was established to drive implementation of this strategy.

The Botswana Agricultural Hub

Over the years, the government has focused more on the provision of basic social infrastructure than on production-specific infrastructure, particularly as concerns the agricultural sector. However, recent efforts will not only improve productivity but also enhance efficiency, while promoting the commercialization of agricultural products. These efforts include the construction of dams and the Zambezi Integrated Agro-Commercial Development Project.

Since diamonds were discovered in 1967, the contribution of the agricultural sector to GDP has drastically declined. Despite the farming industry's declining share of GDP, it remains vitally important to the economy. Productivity is inadequate, however, owing to a poor road network, a lack of abattoirs, periodic drought and other factors.

In line with the *Tenth National Development Plan,* the agricultural sector has been identified as one of the areas with great potential for diversifying the economy and creating employment, especially in rural areas. The Ministry of Agriculture is currently implementing several related projects and initiatives.

One of these initiatives led to the establishment of the Agricultural Hub, in May 2008, as a catalyst for the greater commercialization and diversification of agriculture, as well as greater food security. The hub aims to develop an enabling environment for commercial, private sector-led growth. It also plays a catalytic role by identifying bottlenecks to the agricultural sector's development and advising on how to rectify them. It is also responsible for identifying new agricultural investment opportunities and promoting foreign direct investment in agriculture.

The hub operates in conjunction with the Ministry of Agriculture and is in a position to interact fully with other hubs, ministries, parastatals, the private sector and others. The hub has been empowered to recommend, negotiate and intervene, to enable the timely implementation of the projects and schemes it is responsible for. As of 2013, these were the:

- National Agricultural Master Plan for Arable Agriculture and Dairy Development
- Proposed Zambezi Integrated Agro-Commercial Development Project
- Agricultural Infrastructural Development Initiative
- Establishment of Agricultural Service Centres (as part of the National Agricultural Master Plan)
- Facilitation of the establishment the Contributory Agricultural Insurance Scheme in Botswana
- Facilitation of the establishment State Farms around dams and sewage ponds (arable and horticultural)
- Restructuring of Botswana Meat Commission (GMR partnership)
- Restructuring of Banyana Ranch and other state-owned ranches (cattle sector).

The Botswana Innovation Hub

The Botswana Innovation Hub acts as an incubator of start-up companies. It also helps businesses network. As of December 2012, the governing bodies of the Botswana Innovation Hub had approved and registered 17 entities that will operate in a dedicated park. These include academic institutions like the University of Botswana (see page 76), companies active in custom design and the manufacture of drilling rigs, specialized mining exploration technologies, diamond jewellery design and manufacturing, as well as ICT applications and software.

The hub serves as a unique platform and catalyst for technology-driven and knowledge-intensive businesses and institutions, in order for Botswana to compete in the global market. This will assist in job creation and economic growth. The Botswana Innovation Hub strives to enhance national competitiveness specifically in areas which attract FDI and in technology transfer, as well as collaboration between universities and industry in R&D and the capacity for innovation.

Primary civil works for the Botswana Innovation Hub had been completed by 2013. These include the provision of water, storm water drainage, electricity and streets lights on the 57-hectare plot in Gaborone. This has created serviced land which is ready for intensive development. An additional 36-hectare plot has been sourced.

In order for the hub's impact to be felt in the economy, the *Mid-term Review* (2013) of *the Tenth National Development Plan* observes a need for the following:

- implementation of the *National Policy on Research, Science, Technology and Innovation*;
- forging of private-sector partnerships to intensify development of the rest of the leasehold plots in the park of the Botswana Innovation Hub, to create jobs and downstream benefits;
- finalization of the rationalization of research organizations to improve efficiencies and the quality of research institutions to attract high-quality researchers and engineers;
- establishing a superior ICT infrastructure in the park for tenants and better conditions;
- the hub focuses on identifying and facilitating the location of research and innovation-based enterprises in the hub that will contribute to economic diversification and technology transfer;
- the hub works with the Ministry of Trade and Industry and other stakeholders to establish the Botswana Innovation Hub Park as a Special Economic Zone, as was originally envisaged;
- the Clean Tech Centre of Expertise will be launched in 2013 through a partnership with the Botswana Innovation Hub, the Swedish International Development Cooperation Agency, Lund University and Krinova Science Park; and
- there will be a piloting of improved technologies introduced under the National Master Plan for Arable Agriculture and Dairy Development.

Diversifying the economy in the mineral, water and energy sectors

The Ministry of Minerals, Energy and Water Resources is responsable for the mineral, wáter and energy sectors in Botswana.

The mineral sector will continue its country-wide industrial mineral assessment programme as a vital means of diversifying the economy and empowering citizens working in small-scale mining.

The following will be necessary between 2013 and 2016:

- introduction of institutional reforms to transform the Department of Geological Survey into a research institute, the Botswana Geoscience Institute;
- facilitation of mineral projects financing for citizen-owned companies;

- government entertainment of negotiations for large projects in particular, including non-diamonds, to facilitate mineral investment and optimize economic benefits;
- review of Minerals legislation (Mines and Mineral Act, Diamond Cutting Act, Precious and Semi-Precious Stones Protection Act) to minimize areas of negotiation on strategic initiatives; development of a specific policy for adding value to other minerals will also be required; and
- development of an enabling environment and infrastructure for the export of coal.

In the water sub-sector, the multipurpose dams of Thune and Lotsane, as well as the Dikgatlhong dam, have been completed. The draft National Water Conservation Policy has also been finalized. Water management has been brought under one authority through the Water Sector Reforms Initiative, implemented in 2009. The Water Utilities Corporation is expected to take over all water and wastewater service delivery in the country by 2014.

In the energy sub-sector, an energy policy has been drafted which defines the long-term vision for development of the sector, in terms of electricity generation, transmission infrastructure and the storage and supply infrastructure for petroleum. The policy focuses on the supply of adequate, affordable and reliable energy. Another achievement has been the introduction of National Electricity Standard Cost in 2010 to reduce and standardize connection costs for households.

The Botswana Diamond Hub

With 16 diamond factories in operation and five additional plants being established, Botswana's Diamond Hub diversification programme is poised to move beyond the cutting and polishing stage. The diversification strategy hinges on four areas, namely:

- the promotion of cutting and polishing;
- establishing rough trading in the country, a vital step towards ensuring the long-term sustainability of Botswana's diamond industry;
- the development of a jewellery manufacturing industry; and
- the establishment of support services for the diamond industry.

The Botswana Transport Hub

The Botswana Transport hub seeks to re-position the country as a regional hub for rail, road and air transport. The hub will also support a competitive transport and logistics industry in Botswana.

The Botswana Health Hub

The Ministry of Health is responsable for a strategy defined within *Vision 2016* for improving service delivery and providing quality services across the health sector. The main objectives are to:

- enhance service delivery through strategic public–partnerships and the outsourcing of selected services;
- establish clinical and research centres of excellence that can serve both the region and international clients;
- promote 'medical tourism' to cater for local, regional and international healthcare needs; and
- identify ways in which the delivery of high-quality health services can contribute to economic diversification and employment creation.

The priority infrastrastructure involves a centre of excellence for cancer treatment; a high-quality facility for orthopaedic services; modern treatment facilities, including surgery for cardio-vascular diseases; organ transplant services; neurological treatment facilities; development of the pharmaceutical industry and; high-quality diagnostic facilities (imaging and laboratories).

Broadening access to information and communication technologies

According to the International Telecommunications Union (2011), 7.8% of the population had access to main telephone lines, 76% subscribed to a mobile phone and 4.6% used Internet.

During the first half of the *Tenth National development Plan*, the e-government strategy was developed. The strategy outlines a pragmatic roadmap for the effective provision of government services online, in order to improve public service delivery and accelerate the uptake and usage of information and communication technologies (ICTs) across all segments of society.

As part of the implementation of e-government, the following systems and services have been implemented: the e-passport, development of the government portal, Short Message System (SMS) notifications for school examinations, renewal of drivers' licenses and vehicle registration; and the availability of downloadable business forms on the government portal and some ministries' websites.

The International Connectivity initiative has been implemented through investment in undersea cables. The aim of this project is to provide Botswana with high-quality bandwidth capacity for effective connection with the rest of the world.

The East Africa Submarine System (EASSy) cable connecting Africa to Europe via the eastern coast of Africa was completed in 2010 and the West Africa Cable System (WACS) connecting the west coast of Africa to the United Kingdom via Portugal during the first half of 2012. The arrival of EASSy and WACS capacity in Botswana has led to a reduction in Internet prices. These prices will drop further and translate into greater efficiency in the ICT sector and in the economy at large.

The Nteletsa II project has also been completed. It connects a total of 197 rural villages to the telecommunications network. This is part of the Rural Telecommunications Programme, the aim of which is to provide telecommunications services (data, Internet and voice) to rural and remote areas.

Nteletsa-I Resuscitation, which entails upgrading Nteletsa I infrastructure to the Nteletsa II standard, started in March 2011 and was scheduled for completion by December 2012. The majority of sites are already enjoying mobile network coverage under this initiative, with 60 out of 85 villages having been upgraded to the Nteletsa II standard.

R&D INDICATORS: A LACK OF TEMPORAL SERIES

The lack of any reliable temporal series of indicators prevents Botswana from developing adequate evidence-based SETI policies. These series are lacking for R&D activities, investment in innovation at firm level, entrepreneurship behaviour, inventory of SETI and industrial policy instruments, statistics on university graduates, masters and PhD graduates and so on.

Table 3: Selected subjective and objective measurements concerning Botswana

Subjective index: World Economic Forum Executive Opinion Survey 2012 (Max. value = 7)			Objective measurements		
Indicator	Value	Rank out of 142	Indicator	Value	Rank out of 142
Quality of the education system	4.0	55	Secondary enrolment, gross percentage (2008)	81.7	88
Quality of maths and science education	4.1	66	Gross tertiary education enrolment [%] (2008)	7.4	118
Quality of management school	3.9	92	School life expectancy, years (2009)	11.3	101
Internet access in schools	3.5	96	Individuals using internet, [%] (2011)	12.0	113
Availability of research and training services	3.7	95	Broadband internet subscriptions [%] (2011)	0.8	104
Extent of staff training	3.9	68	International internet bandwidth, kb/s per user (2011)	2.3	121
Availability of latest technology	4.6	93	Mobile broadband subscriptions [%] (2011)	8.4	91
Firm level technology absorption	4.4	98	Mobile telephone subscriptions [%] (2011)	142.8	19
FDI and technology transfer	4.1	102	Fixed telephone lines [%] (2011)	7.4	101
Capacity for innovation	2.8	96	Patent Cooperation Treaty Patent applications/million population	0.0	119
Quality of scientific research institutions	3.6	73	GERD/GDP ratio	0.5	55
Company expenditure on R&D	3.2	62	Citable scientific articles-H index (2012)	57.0	108
University–industry collaboration in R&D	3.7	63	Life expectancy at birth, years	53.1	132
Government procurement of advanced tech products	3.6	65	Women in labour force, ratio to men	0.9	27
Availability of scientists and engineers	3.5	112	Imports as a percentage of GDP (2012)	43.9	74

Source: Global Competitiveness Report, 2012–2013

In recent years, a growing number of surveys have studied the behaviour of entrepreneurship and innovation in different countries. Some of these provide valuable information on Botswana (World Bank, 2006; World Economic Forum, 2012; INSEAD *et al.*, 2013). Table 3 presents a series of subjective and objective indicators showing the perception of research and innovation in Botswana. The subjective indicators are based on a series of executive opinion surveys prepared by the World Economic Forum (2012), whereas the objective indicators (related to research and innovation) were originally produced by other agencies and have been compiled by the World Economic Forum. Similar surveys and data were

also produced by INSEAD et al. (2013). The scale for subjective indicators ranges from a minimum of 1 to a maximum of 7. A second column presents Botswana's rank out of 142 nations for each individual indicator.

MAPPING HUMAN RESOURCES

The first surveys of the number of researchers (head counts and full-time equivalents, FTE) were conducted by UNESCO in 1967 and 1973 (UNESCO, 1976). In those days, there were only 10 and 24 FTE researchers respectively and gross expenditure on R&D (GERD) represented just 0.1% GDP.

In 2004 and 2005, a more reliable survey was conducted by the Government of Botswana. This shows a total of 265 FTE researchers (Republic of Botswana, 2012). Figure 7 represents the number of FTE researchers over time. By making the hypothesis of a small parabolic growth over time, it was possible to fit all the data on the same curve. This small parabolic growth would be consistent with data for such indicators as the rise in GDP per capita, tertiary enrolment per 100,000 inhabitants (Figure 8), long-term growth in scientific publications and the correlation between GDP per capita and scientific publications per million population. An extrapolation of this curve shows a value of approximately 350 FTE researchers in 2013. This is consistent with the evolution in the number of scientific publications over time (Lemarchand, 2012; see also the scientometric analysis in the following section of the present publication). This estimation will soon be corroborated or refuted by a new R&D survey implemented by the Department of Research, Science and Technology.

Other figures obtained in the 2004–2005 survey show that 49.6 % of researchers worked for the higher education sector, 40% for the government sector, 9.2% for the business enterprise and 1.3% for the private non-profit sector. Some three-quarters of researchers (75.6%) have completed a bachelors or masters degree (ISCED 5A level) and 24.4% a PhD (ISCED 6 level).

According to the survey, GERD represented 0.52% GDP in 2005. Four-fifths of R&D (79.4%) was funded by the government; 15.6% by private enterprises, 1.2% by tertiary institutions and 3.8% by the private non-profit sector (UNESCO Institute for Statistics online database, accessed October 2013). See page 67 for an inventory of institutions performing R&D in Botswana, including universities.

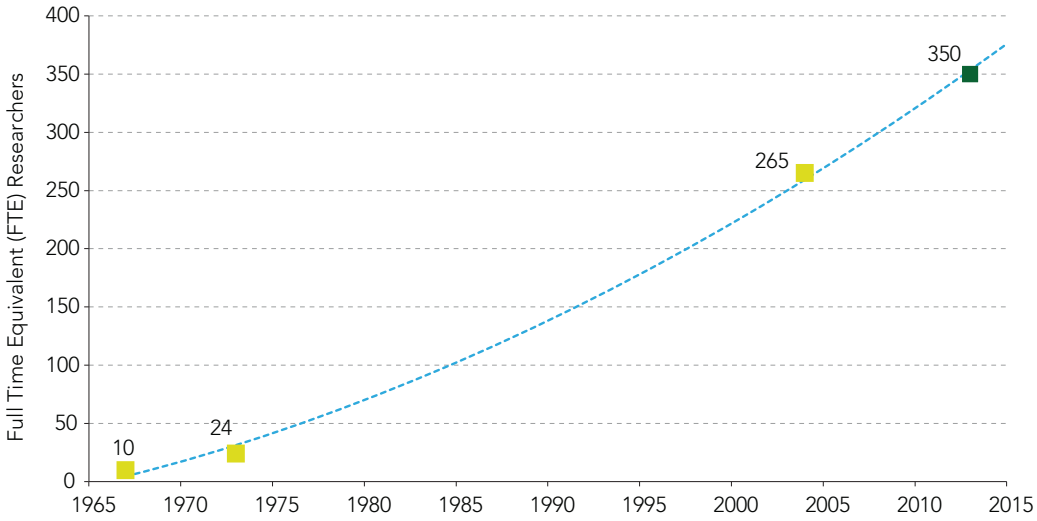


Figure 7: Number of FTE researchers (in Botswana, 1967, 1973 and 2005, quadratic extrapolation with an estimation for 2013. Source: UNESCO

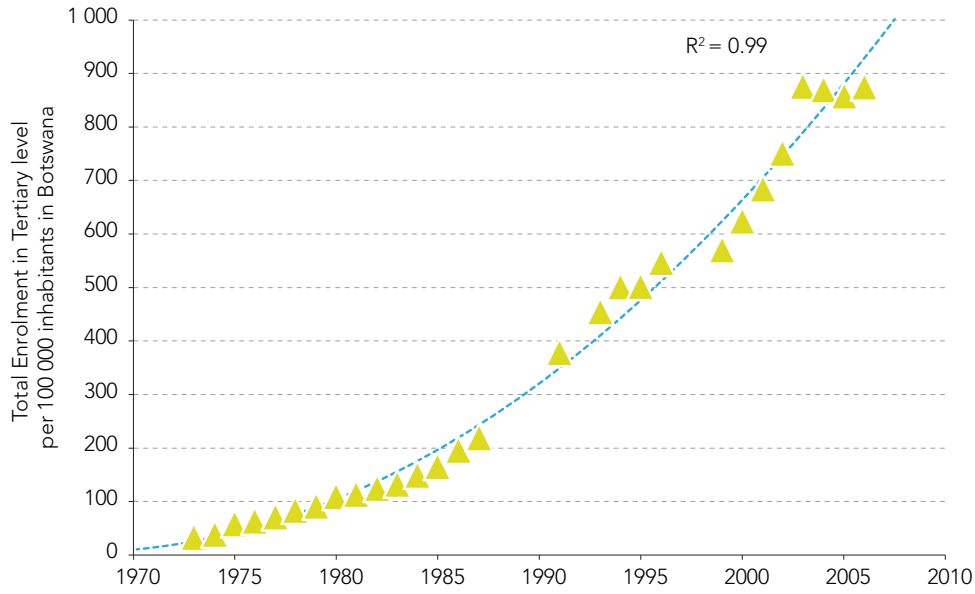


Figure 8: Total tertiary enrolment per 100,000 inhabitants in Botswana, 1970–2010. Source: UNESCO based on raw data provided by UNESCO Institute for Statistics

Botswana's education system

Botswana's education system is the prerogative of the Ministry of Education and Skills Development. The main institutions, policies and policy instruments are the following.

- Department of Curriculum Development, under the Ministry: responsible for developing curricula for primary and secondary schools;
- Department of Vocational Training: responsible for matters related to vocational training, skills training and development;
- Tertiary Education Council;
- Tertiary Education Policy;
- National Human Resource Development Strategy 2009–2022: lays down a strategic map for the development of human resources. The strategy is emphatic that the country aspires to transform its economy from being commodity-driven to a knowledge-based society; hence the need to develop a critical mass of appropriately skilled human resource;
- Human Resource Development Advisory Council;
- Scarce Skills Allowance: a monetary allowance advanced to personnel with qualifications in science and technology;
- National Human Resource Strategy, adopted in 2009;
- Revised National Policy on Education.

The Botswana Education Hub

The objectives of the Botswana Education Hub have been approved by the Government Implementation Coordinating Office. Its objectives are to:

- make Botswana a regional centre of excellence;
- promote economic diversification and sustainable growth through the provision of quality education;
- provide training and research in key strategic areas such as science, technology and engineering, conservation, mining, hospitality and tourism, finance, and business management;
- facilitate the alignment of skills development with socio-economic needs by providing training in fields of use to other hubs and sectors;
- promote quality and access to education from pre-primary to secondary, to ensure a sufficient pool of qualified students in key areas that can then feed into tertiary education;
- encourage local participation in the provision of quality education while attracting high-quality foreign faculty, students and investors; and
- make Botswana a preferred education destination in the region and beyond.

Table 4 shows how the education hub will coordinate its work with the five other hubs (see also page 80).

Table 4: Interaction between the Botswana Education Hub and other hubs

Agriculture Hub	Cooperation in the field of education and in underpinning research as a stakeholder contribution
Innovation hub	Promotion of an education services incubator, possible education hub presence; cooperation in the field of education and in underpinning research and innovation in education
Transport hub	Cooperation in the field of education and in underpinning research; providing the transport industry with skilled professionals and other workers
Diamond hub	Assistance in training and research for beneficiation and exports; Enhancement of the future value chain by meeting skill requirements
Health hub	Cooperation in the field of education and in underpinning research as a stakeholder contribution

Source: John *et al* (2014)

BOX 3: TEACHING SCIENCE IN SETSWANA?

Botswana is a multilingual country that uses the English language as a medium of instruction throughout the education system at primary, secondary and tertiary levels. The English language is officially recognized for both economic and political reasons. Even though it is encouraged by law as a vehicle for communication and the language of administration, English nevertheless remains a foreign language (Prophet and Badede, 2009).

The Setswana language, on the other hand, is spoken by about 80% of the population (Nyati-Ramahobo, 1999). The remainder speak languages that include Sekalanga, Sekalaka, Sekgalagadi, Sembukushu and Sesarwa.

Science teaching and testing in Botswana's junior secondary schools takes place in English, a second language for the majority of students and even a third language for many. The understanding of scientific texts has proven to be problematic for native speakers, suggesting that difficulties in comprehension will be even greater for students for whom English is their second language.

Prophet and Badede (2009) conducted an interesting study in six roughly comparable junior secondary schools in and around Gaborone. They were able to demonstrate that, by making small changes to the learning and testing material, students were better able to demonstrate their understanding of science. The study provided a clear indication that the wording of questions in science examinations at the Junior Certificate level did affect the performance of students and that simplifying the language of questions improved performance, sometimes quite significantly. The effect was even greater on pupils living in a rural environment, who were likely to have fewer opportunities to develop their linguistic skills in English. The study suggested that examiners could make three changes to improve the readability of multiple-choice, long and short essay questions: shorter questions, a change in tense and the use of simpler words and grammatical constructions.

The authors raised the point that textbook publishers needed to be aware of the specialized discourse of science. They recommended tailoring the language of textbooks to allow students to engage in critical thinking and use the scientific methodological approach.

Scientometric analysis of Botswana

USING INTERNATIONAL DATABASES TO MEASURE SCIENTIFIC PRODUCTIVITY

International databases represent one of the most relevant sources of information about the productivity of scientific knowledge (Lemarchand, 2013), although these are not usually open access. In particular, a very well-established class of indicators of scientific production can be estimated by counting the number of articles published in mainstream journals and the number of citations these receive.

One of the most complete databases is the Web of Science, which includes the original Science Citation Index (SCI), Social Science Citation Index (SSCI) and Arts and Humanities Citation Index (A&HCI). The Web of Science is now maintained by Thomson Reuters and covers 12,000 peer-reviewed journals. The other major database is SCOPUS, which is maintained by Elsevier Science and covers 18,000 peer-reviewed journals. The Web of Science dates from 1900 and SCOPUS from 1996.

By analysing the aggregated temporal evolution of the data available at the Web of Science, it becomes possible to study the evolution of cooperation patterns among countries, institutions and country groupings at regional level. Other analyses can detect the most developed disciplines in a particular country or university and assess the impact of scientific research on the basis of citation rates for scientific literature.

Domestic journals may reflect the peculiar circumstances of a country or specific national scientific agendas that are not considered by the mainstream journals. For this reason, publication in mainstream journals represents only a fraction of all the scientific productivity of a given country. Not all scientists from Botswana, for instance, submit their research results to mainstream journals listed by the Web of Science. The main advantage of using these databases is that information has been systematically collected and organized over several decades using similar methodologies; this allows a long-term analysis to be performed with relative confidence (Lemarchand, 2012).

Despite the fact that local and regional journals tend to be underrepresented in international databases, there is a good correspondence among the SCI, SSCI, A&HCI and other international databases on the production of scientific knowledge. De Moya-Anegón and Herrero-Solana (1999) and Lemarchand (2012) showed a strong correlation in the distribution of citable articles between the SCI Extended and other databases, such as PASCAL, INSPEC, COMPENDEX, Chemical Abstracts, BIOSIS, MEDLINE and CAB. These authors have obtained the following values for the correlation coefficient among the different databases: $0.957 \leq R \leq 0.997$. This fact supports their hypothesis that combining SCI, SSCI and A&HCI might still be a good indicator for studying mainstream scientific knowledge production, the impact of research (taking into account the number of citations), identifying the most productive institutions in a particular country, or the key foreign partners, as well as for studying co-authorship networks among different countries.

At this point, it is important to note that, during the analysed period (1967–2012), the number of journals and consequently the total number of published articles included in the Web of Science database was substantially expanded. Mabe (2003) showed that journal growth rates have been remarkably consistent over time, with average rates of 0.034 since 1800 to the present day. This study presents evidence that, during the entire 20th century, growth appears to have taken place within a system that is self-organizing and in equilibrium, with a 0.032 growth constant. Considering that the Web of Science database only includes a fraction of all the new published journals, the growth rate of databases may be even smaller than that estimated by Mabe (2003). Lemarchand (2012) developed a mathematical model showing the proportionality between the size of the national scientific network (e.g. the number of FTE researchers in a given country) and the corresponding scientific productivity, in terms of the aggregate number of publications per year and the number of co-authored scientific articles between pairs of countries. In this way, the productivity of scientific articles over time is a good proxy for estimating the progression in the number of FTE researchers.

Table 5 shows the distribution of mainstream scientific publications in 2012. Botswana ranks 21st among African countries and 115th globally. These figures tell only part of the story, however.

Table 5: Mainstream scientific publications, citations and rankings for all African countries, 2012

Country	Articles	Citable articles	Citations	Self-Citations	Citations per article	H* index	African ranking	World ranking
South Africa	13,627	12,766	7,608	2,346	0.56	231	1	34
Tunisia	5,170	4,820	1,152	390	0.22	85	2	52
Nigeria	4,748	4,552	782	230	0.16	89	3	53
Algeria	3,800	3,667	652	196	0.17	78	4	54
Morocco	3,282	3,037	1,753	359	0.53	99	5	56
Kenya	1,725	1,625	1,105	239	0.64	131	6	66
Ethiopia	1,164	1,110	314	107	0.27	73	7	76
Uganda	1,000	947	632	129	0.63	99	8	82
Ghana	981	929	404	96	0.41	73	9	83
Tanzania	902	846	540	177	0.60	93	10	86
Cameroon	850	796	267	63	0.31	72	11	87
Senegal	574	553	216	41	0.38	75	12	96
Sudan	534	509	196	56	0.37	52	13	98
Burkina Faso	449	427	187	61	0.42	62	14	101
Malawi	407	382	276	45	0.68	80	15	103
Zimbabwe	373	358	171	39	0.46	72	16	107
Côte d'Ivoire	365	353	112	22	0.31	68	17	108
Benin	343	324	101	42	0.29	49	18	109
Libya	336	323	75	25	0.22	35	19	110
Zambia	315	291	157	31	0.50	68	20	112
Botswana	290	278	89	8	0.31	57	21	115
Rep. Congo	287	267	136	19	0.47	49	22	116
Madagascar	246	236	115	19	0.47	56	23	121
Mali	225	217	172	29	0.76	55	24	123
Mozambique	191	187	155	28	0.81	53	25	127
Mauritius	184	175	42	11	0.23	41	26	129
Rwanda	177	163	53	11	0.30	36	27	130
Namibia	160	157	79	8	0.49	55	28	131
Gabon	134	124	85	10	0.63	61	29	135
Gambia	126	117	157	19	1.25	80	30	137
Niger	103	98	36	5	0.35	47	31	145
Togo	96	89	17	3	0.18	31	32	149
Swaziland	75	74	35	1	0.47	28	33	155
Angola	63	60	27	9	0.43	25	34	158
Democratic Rep. Congo	57	49	35	1	0.61	28	35	159
Sierra Leone	49	44	15	6	0.31	21	36	162
Guinea	42	38	17	2	0.40	34	37	166
Lesotho	38	37	14	2	0.37	22	38	170
Mauritania	37	36	17	1	0.46	25	39	171
Seychelles	37	34	25	3	0.68	33	40	172
Guinea-Bissau	37	35	38	14	1.03	40	41	173

Country	Articles	Citable articles	Citations	Self-Citations	Citations per article	H* index	African ranking	World ranking
Central African Republic	36	36	32	4	0.89	32	42	174
Burundi	33	31	9	0	0.27	24	43	175
Chad	25	20	3	1	0.12	27	44	182
Liberia	22	21	5	1	0.23	14	45	185
Djibouti	20	16	1	0	0.05	13	46	187
Cape Verde	14	14	8	0	0.57	12	47	192
Eritrea	14	13	0	0	0.00	25	48	193
Equatorial Guinea	11	11	11	4	1.00	15	49	196
Somalia	7	6	1	0	0.14	11	50	204
Comoros	6	6	2	0	0.33	10	51	207
Sao Tome and Principe	3	2	0	0	0.00	14	52	217

(*) The H index is an indicator of the impact of an individual's scientific output and also, in an aggregate manner, that of institutions and countries (Hirsch, 2005)

Source: SCOPUS database (accessed September 2013)

The long-term evolution of the ratio between the number of scientific publications published in mainstream journals and the corresponding population value can be studied to estimate the importance that a society attributes to scientific research. Figure 9 shows the long-term evolution of the four most productive African countries in terms of publications per million population between 1966 and 2012. Taking into account all African countries with a population of over 500,000,[8] Tunisia, South Africa, Botswana and Egypt appear as the most productive countries.

Figure 10 shows the long-term evolution in the number of scientific publications from Botswana listed in the Web of Science (1967–2012), whereas Figure 11 shows the long-term evolution in the number of scientific publications per million population. Both figures show continuous growth that correlates with GDP growth per capita (see Figure 3).

Table 6 shows the distribution of co-publications of Botswana with other countries for 1967–2007 and from 2008 to August 2013. One-third of the all publications have been produced by Botswana within the past five years. The key countries for co-authorship remained the same over both periods, namely, the USA, South Africa and the United Kingdom. Whereas, between 1967 and 2007, co-publications with the latter three countries represented only 25.9% of the total, this figure increased to 52.6% over the later five-year period.

Table 7 shows the list of the most productive institutions in Botswana for these same two periods. A quick analysis shows that the University of Botswana accounts for 65% of publications and the Botswana College of Agriculture for 5% over both periods. A strong partnership with the University of Harvard emerged between 2008 and 2013. Just eight institutions (usually related with medical research) account for more than 1 % of publications in the period 1967–2007 and nine between 2008 and 2013.

8 Seychelles, with a population of 84,000 (2009), has been removed from this sample because its small population generates a statistical distortion. From a numerical point of view, Seychelles has been the most productive African country for several years for scientific publications per million population. Unfortunately, this fact has no statistical value for the sample here.

Table 8 provides a list of Botswana's main international partners of over the period 1967–2013. Harvard University is the main partner, sharing 4.05% of all publications with Botswana. The other major institutions for co-authorship are the University of Pennsylvania in the USA (1.90%), University of Witwatersrand in South Africa (1.90%), the USA's Centre for Disease Control (1.87%) and two more South African partners, the University of Cape Town (1.54%) and the University of Pretoria (1.42%).

Table 9 shows the complete distribution of Botswana's scientific publications by subfield of science for the same two periods. Environmental science and ecology are consistently the main subfields between 1967 and 2013, accounting for almost 10% of publications. Between 1967 and 2007, these are followed by geology (8.37%), chemistry (8.29%), agriculture (7.01%), veterinary sciences (4.74%) and area studies (4.17%). The order changes between 2008 and August 2013 to infectious diseases (8.39%), public environmental occupational health (7.53%), immunology (6.49%), chemistry (6.40%) and geology (4.50%).

Figure 12 shows the temporal evolution in the shares of scientific articles for the six major scientific fields listed by UNESCO: agricultural sciences, arts and humanities, engineering and technology, exact and natural sciences, medical sciences and social sciences (UNESCO, 1978; 1984ab; 1988), which are also included in the *Frascati Manual* (OECD, 2002). This graph can be used to identify the potentialities and weaknesses of a country. A similar analysis for most innovative countries, including the Republic of Korea, China or Singapore, shows publication patterns whereby approximately 80% of publications are concentrated in just two fields: (a) engineering and technology and (b) exact and natural sciences (Lemarchand, 2013). The lack of publications in engineering and technology in Botswana is a major obstacle to generating innovation in the productive sector: mining, agriculture, industry, energy, etc.

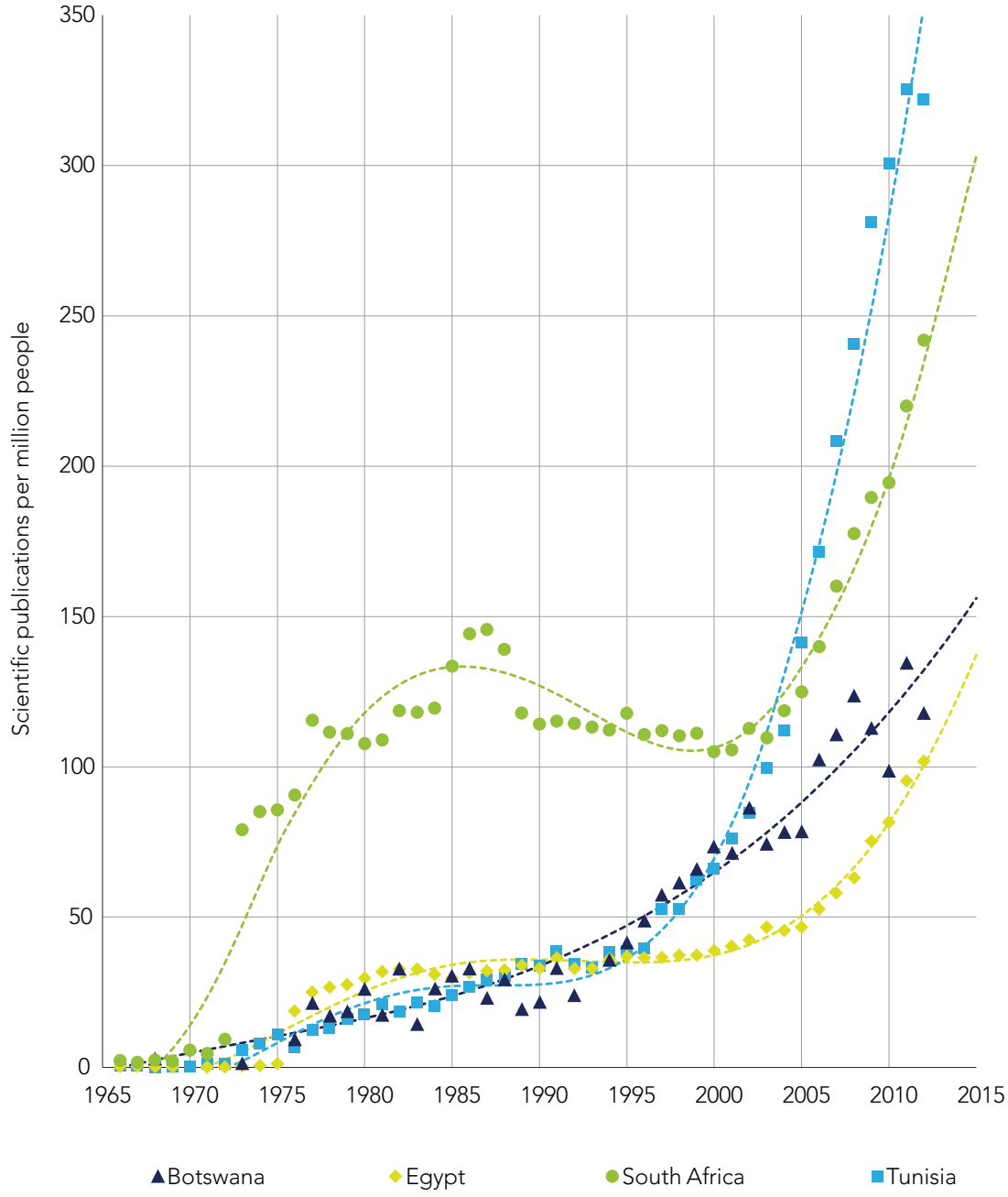


Figure 9: The four most productive African countries in terms of scientific publications per million population. Source: UNESCO estimations based on raw data from the Web of Science and UN Statistics Division.

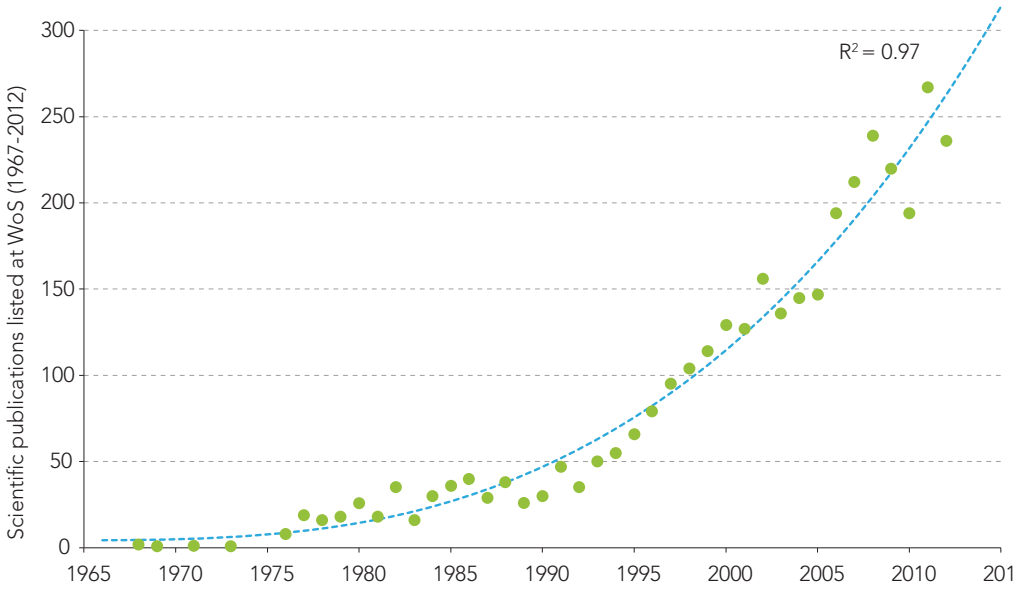


Figure 10: Long-term evolution (1967–2012) of scientific publications listed by the Web of Science for Botswana. The graph shows cubic growth with a correlation coefficient R^2=0.97. Source: UNESCO estimations based on raw data from the Web of Science

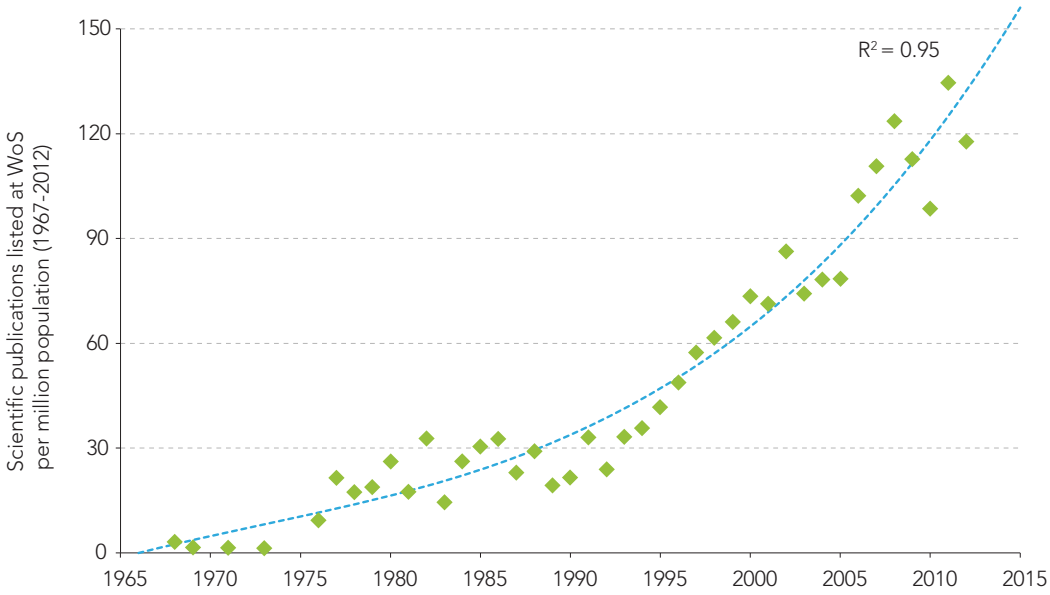


Figure 11: Long-term evolution (1967–2012) of scientific publications listed by the Web of Science for Botswana per million population. The graph shows quadratic growth with a correlation coefficient R^2=0.95. Source: UNESCO estimations based on raw data from the Web of Science and UN Statistics Division

Table 6: Co-authorship of Botswana's mainstream scientific publications, 1967–2007 and 2008–2013

Country	Publications (1967–2007)	Percentage	Country	Publications (2008–August 2013)	Percentage
Botswana	2281	100.00%	Botswana	1156	100.00%
USA	268	11.75%	USA	321	27.77%
South Africa	184	8.07%	South Africa	201	17.39%
United Kingdom	173	7.58%	United Kingdom	106	9.17%
Australia	65	2.85%	Canada	45	3.89%
Germany	53	2.33%	Kenya	38	3.29%
Canada	50	2.19%	India	33	2.86%
Norway	47	2.06%	Nigeria	33	2.86%
Netherlands	45	1.97%	Zimbabwe	32	2.77%
Sweden	42	1.84%	Germany	30	2.60%
Cameroon	40	1.75%	Australia	27	2.34%
Belgium	35	1.53%	Malawi	26	2.25%
Nigeria	35	1.53%	Norway	23	1.99%
France	33	1.45%	Cameroon	22	1.90%
Zimbabwe	32	1.40%	Tanzania	19	1.64%
Switzerland	30	1.32%	Denmark	18	1.56%
Kenya	29	1.27%	Mexico	17	1.47%
Tanzania	27	1.18%	Netherlands	17	1.47%
India	25	1.10%	Uganda	17	1.47%
Italy	20	0.88%	Ethiopia	16	1.38%
Zambia	20	0.88%	Italy	16	1.38%
New Zealand	17	0.75%	Sweden	16	1.38%
Japan	16	0.70%	Brazil	15	1.30%
Ethiopia	13	0.57%	Zambia	15	1.30%
Malawi	12	0.53%	Namibia	14	1.21%
Denmark	11	0.48%	France	13	1.13%
Israel	11	0.48%	Japan	13	1.13%
Peoples Rep. China	11	0.48%	Switzerland	13	1.13%
Swaziland	11	0.48%	Pakistan	12	1.04%
Uganda	11	0.48%	Saudi Arabia	12	1.04%
Namibia	10	0.44%	Ireland	11	0.95%
Chile	9	0.40%	Thailand	8	0.69%
Ghana	9	0.40%	Belgium	7	0.61%
Austria	8	0.35%	Finland	7	0.61%
Brazil	8	0.35%	Spain	7	0.61%
Lesotho	8	0.35%	Austria	6	0.52%
Mozambique	8	0.35%	Bangladesh	6	0.52%
Spain	8	0.35%	Greece	6	0.52%
Thailand	8	0.35%	New Zealand	6	0.52%
Malta	7	0.31%	Senegal	6	0.52%
Russia	7	0.31%	Sri Lanka	6	0.52%
Dem Rep. Congo	7	0.31%	Ghana	5	0.43%
Congo Rep.	6	0.26%	Peoples Rep. China	5	0.43%
Czech Rep.	5	0.22%	Swaziland	5	0.43%

Country	Publications (1967–2007)	Percentage	Country	Publications (2008–August 2013)	Percentage
Finland	5	0.22%	Argentina	4	0.35%
Malaysia	5	0.22%	Burkina Faso	4	0.35%
Mexico	5	0.22%	Hungary	4	0.35%
Philippines	5	0.22%	Peru	4	0.35%
Portugal	5	0.22%	Poland	4	0.35%
Turkey	5	0.22%	Portugal	4	0.35%
Argentina	4	0.18%	Russia	4	0.35%
Cyprus	4	0.18%	Slovenia	4	0.35%
Hong Kong/China	4	0.18%	Benin	3	0.26%
Indonesia	4	0.18%	Mozambique	3	0.26%
Jamaica	4	0.18%	Rwanda	3	0.26%
Latvia	4	0.18%	Sudan	3	0.26%
Niger	4	0.18%	Turkey	3	0.26%
Poland	4	0.18%	Côte d'Ivoire	2	0.17%
Senegal	4	0.18%	Czech Rep.	2	0.17%
Rep. Korea	4	0.18%	Egypt	2	0.17%
Sudan	4	0.18%	Estonia	2	0.17%
Colombia	3	0.13%	Haiti	2	0.17%
Croatia	3	0.13%	Jamaica	2	0.17%
Estonia	3	0.13%	Lebanon	2	0.17%
Jordan	3	0.13%	Malaysia	2	0.17%
Lithuania	3	0.13%	Singapore	2	0.17%
Pakistan	3	0.13%	Rep. Korea	2	0.17%
Peru	3	0.13%	Taiwan China	2	0.17%
Slovakia	3	0.13%	Tunisia	2	0.17%
Slovenia	3	0.13%	Dem. Rep. Congo	2	0.17%
Sri Lanka	3	0.13%	Albania	1	0.09%
Angola	2	0.09%	Algeria	1	0.09%
Bangladesh	2	0.09%	Barbados	1	0.09%
Burkina Faso	2	0.09%	Chile	1	0.09%
Egypt	2	0.09%	Croatia	1	0.09%
Gambia	2	0.09%	Cyprus	1	0.09%
Greece	2	0.09%	Dominican Rep.	1	0.09%
Hungary	2	0.09%	Iceland	1	0.09%
Iran	2	0.09%	Iran	1	0.09%
Kuwait	2	0.09%	Israel	1	0.09%
Lebanon	2	0.09%	Jordan	1	0.09%
Papua New Guinea	2	0.09%	Latvia	1	0.09%
Rwanda	2	0.09%	Libya	1	0.09%
Saudi Arabia	2	0.09%	Lithuania	1	0.09%
Remainder of co-authorship countries	28	1.32%	Madagascar	1	0.09%

Source: Web of Science

Table 7: Distribution of Botswana's mainstream scientific publications by source, 1967–2007 and 2008–2013

Institution (1967–2007)	Publications	Percentage	Institution (2008–August 2013)	Publications	Percentage
University of. Botswana	1501	65.80%	University of Botswana	749	64.79%
Botswana College of Agriculture	121	5.30%	Botswana–Harvard School of Public Health AIDS Initiative	59	5.10%
Ministry of Health	67	2.94%	Botswana College of Agriculture	50	4.33%
Princess Marina Hospital	56	2.46%	Ministry of Health	36	3.12%
Dept of Wildlife and National Parks	43	1.88%	Botswana Harvard School of Public Health	30	2.60%
Botswana Geological Survey	42	1.84%	Botswana–University of Pennsylvania Partnership	29	2.51%
National Veterinary Laboratory	41	1.80%	Princess Marina Hospital	24	2.08%
Ministry of Agriculture	39	1.71%	Botusa US Centre for Disease Control and Prevention, CDC Botswana	20	1.73%
Botusa Project	34	1.49%	Botswana Predator Conservation Programme	17	1.47%
Botswana Dept of Agricultural Research	23	1.01%	CIET Trust Botswana	15	1.30%
Botswana–Harvard School of Public Health AIDS Initiative	16	0.70%	CDC Botswana	9	0.78%
Botswana Harvard AIDS Institute Partnership	14	0.61%	Botswana Baylor Children's Clinical Centre of Excellence	8	0.69%
Ministry of Natural Resources and Water Affairs	7	0.31%	Ministry of Agriculture	7	0.61%
Nyangabgwe Hospital	7	0.31%	Cheetah Conservation Botswana	6	0.52%
Birdlife Botswana	6	0.26%	Dept of Wildllife and National Parks	6	0.52%
Botswana Vaccine Institute Ltd	5	0.22%	National Health Laboratory	6	0.52%
Gaborone Secondary School	5	0.22%	Botswana–Harvard School of Public Health AIDS Initiative	5	0.43%
Tonota College of Education	5	0.22%	Government of Botswana	5	0.43%
Dept of Veterinary Services	4	0.18%	Harry Oppenheimer Okavango Research Centre	5	0.43%
Ministry of Finance and Development Planning	4	0.18%	Dept of Water Affairs	4	0.35%
Botswana Technology Centre	3	0.13%	National University of Science and Technology	4	0.35%
Gaborone City Council	3	0.13%	Bank of Botswana	3	0.26%
Government of Botswana	3	0.13%	Botswana Institute for Development Policy Analysis	3	0.26%

Institution (1967–2007)	Publications	Percentage	Institution (2008–August 2013)	Publications	Percentage
Ministry of Local Government and Lands	3	0.13%	Institute of Health Sciences	3	0.26%
Molepolole College of Education	3	0.13%	Ministry of Finance and Development Planning	3	0.26%
Botswana Meteorological Service	2	0.09%	Botswana National TB Programme	2	0.17%
Botswana Society	2	0.09%	Botswana National Veterinary Laboratory	2	0.17%
Dept of the Environment	2	0.09%	Botswana Network on Ethics, Law and HIV AIDS	2	0.17%
Dept of Meteorological Services	2	0.09%	Dept of Public Health	2	0.17%
Dept of Water Affairs Botswana	2	0.09%	Ecoconsult Botswana	2	0.17%
Gaborone Private Hospital	2	0.09%	Geological Survey of Botswana	2	0.17%
National Museum of Botswana	2	0.09%	National AIDS Coordinating Agency	2	0.17%
Botswana College of Agriculture	1	0.04%	National Museum of Botswana	2	0.17%

Source: UNESCO, based on raw data from the Web of Science

Table 8: Foreign institutions and centres which accounted for more than one-quarter of Botswana's co-publications, 1967–2013

#	Institution	Co-publications (1967-August 2013)	Percentage
1	Harvard University	145	4.05%
2	University of Pennsylvania	68	1.90%
3	University of Witwatersrand	68	1.90%
4	Centre for Tropical Disease Control and Prevention	67	1.87%
5	University of Cape Town	55	1.54%
6	University of Pretoria	51	1.42%
7	University of Kwazulu Natal	46	1.29%
8	University of Oslo	42	1.17%
9	Brigham Women's Hospital	41	1.15%
10	University of Zimbabwe	37	1.03%
11	Children's Hospital of Philadelphia	32	0.89%
12	University of California San Francisco	30	0.84%
13	Johns Hopkins University	29	0.81%
14	University of Oxford	28	0.78%
15	University of Stellenbosch	27	0.75%
16	University of Yaoundé	27	0.75%
17	Beth Israel Deaconess Medical Centre	26	0.73%
18	Massachusetts General Hospital	22	0.61%
19	University of Malawi	22	0.61%
20	Dept of Animal Production	21	0.59%
21	Obafemi Awolowo University	21	0.59%
22	University of Washington	21	0.59%

N.B. This list encompasses those organizations with more than 20 co-publications listed by the Web of Science.

Source: UNESCO estimations based on raw data provided by the Web of Science

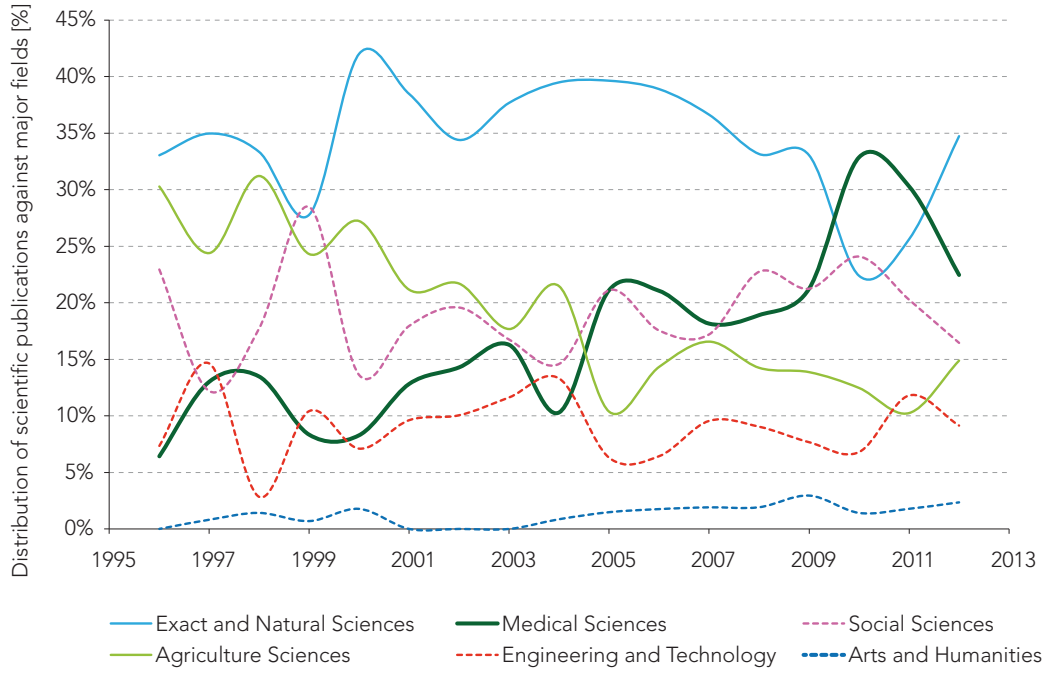


Figure 12: Distribution of publications for six major scientific fields, 1996–2012. Source: UNESCO estimation based on raw data provided by SCOPUS

Table 9: Distribution of Botswana's mainstream scientific articles by subfield, 1967–2007 and 2008–2013

January 1967– December 2007	Number of articles	Percentage over total	January 2008–August 2013	Number of articles	Percentage over total
Environmental sciences, ecology	213	9.34%	Environmental sciences, ecology	113	9.78%
Geology	191	8.37%	Infectious diseases	97	8.39%
Chemistry	189	8.29%	Public environmental and occupational health	87	7.53%
Agriculture	160	7.01%	Immunology	75	6.49%
Veterinary sciences	108	4.74%	Chemistry	74	6.40%
Area studies	95	4.17%	Geology	52	4.50%
Public environmental occupational health	91	3.99%	Water resources	50	4.33%
Water resources	88	3.86%	Science, technology and other topics	47	4.07%
Education and educational research	87	3.81%	Agriculture	43	3.72%
Engineering	82	3.60%	Education and educational research	43	3.72%
Plant sciences	80	3.51%	Pharmacology and pharmacy	41	3.55%
Infectious diseases	74	3.24%	Food science technology	40	3.46%
Information science library science	69	3.03%	Engineering	39	3.37%
General internal medicine	66	2.89%	Mathematics	39	3.37%
Mathematics	63	2.76%	Psychology	38	3.29%
Meteorology and atmospheric sciences	63	2.76%	Biochemistry and molecular biology	36	3.11%

January 1967– December 2007	Number of articles	Percentage over total	January 2008–August 2013	Number of articles	Percentage over total
Physics	63	2.76%	General internal medicine	34	2.94%
Public administration	61	2.67%	Virology	34	2.94%
History	59	2.59%	Health care sciences services	32	2.77%
Business and economics	55	2.41%	Information science/Library science	32	2.77%
Government law	55	2.41%	Plant sciences	31	2.68%
Biochemistry and molecular biology	52	2.28%	Respiratory system	28	2.42%
Zoology	51	2.24%	Linguistics	27	2.34%
Tropical medicine	48	2.10%	Meteorology and atmospheric sciences	26	2.25%
Food science technology	47	2.06%	Social sciences and other topics	26	2.25%
Immunology	46	2.02%	Biomedical social sciences	22	1.90%
Pharmacology and pharmacy	45	1.97%	Materials science	22	1.90%
Psychology	41	1.80%	Life sciences, biomedicine and other topics	21	1.82%
Science, technology and other topics	41	1.80%	Veterinary sciences	21	1.82%
Geochemistry and geophysics	40	1.75%	Physics	20	1.73%
International relations	33	1.45%	Public administration	19	1.64%
Energy and fuels	32	1.40%	Zoology	19	1.64%
Computer science	31	1.36%	Area studies	17	1.47%
Respiratory system	31	1.36%	Biotechnology and applied microbiology	16	1.38%
Virology	29	1.27%	Business and economics	16	1.38%
Microbiology	27	1.18%	Computer science	15	1.30%
Biomedical social sciences	26	1.14%	Cell biology	14	1.21%
Nursing	24	1.05%	Microbiology	14	1.21%
Physical geography	23	1.01%	Geography	13	1.13%
Biotechnology and applied microbiology	21	0.92%	Nutrition and dietetics	13	1.13%
Social sciences and other topics	21	0.92%	Tropical medicine	13	1.13%
Geography	20	0.88%	Energy fuels	11	0.95%
Entomology	19	0.83%	Nursing	11	0.95%
Mineralogy	19	0.83%	Paediatrics	11	0.95%
Remote sensing	19	0.83%	Geochemistry and geophysics	10	0.87%
Demography	18	0.79%	Women's studies	10	0.87%
Imaging science and photographic technology	17	0.75%	Literature	9	0.78%
Spectroscopy	17	0.75%	Sport sciences	9	0.78%
Anthropology	16	0.70%	History	8	0.69%
Construction and building technology	16	0.70%	Physical geography	8	0.69%
Archaeology	15	0.66%	Communication	7	0.61%
Marine and freshwater biology	15	0.66%	Evolutionary biology	7	0.61%
Nutrition dietetics	15	0.66%	Genetics and heredity	7	0.61%
Religion	15	0.66%	Governmental law	7	0.61%
Biodiversity conservation	14	0.61%	Oncology	7	0.61%
Life sciences, biomedicine and other topics	14	0.61%	Archaeology	6	0.52%
Materials science	14	0.61%	Behavioural sciences	6	0.52%

January 1967– December 2007	Number of articles	Percentage over total	January 2008–August 2013	Number of articles	Percentage over total
Social work	14	0.61%	Biodiversity conservation	6	0.52%
Health care sciences and services	13	0.57%	Forestry	6	0.52%
Sociology	13	0.57%	Integrative complementary medicine	6	0.52%
Sport sciences	13	0.57%	Mathematical computational biology	6	0.52%
Evolutionary biology	11	0.48%	Mineralogy	6	0.52%
Linguistics	11	0.48%	Rehabilitation	6	0.52%
Mycology	11	0.48%	Social work	6	0.52%
Nuclear science technology	11	0.48%	Anthropology	5	0.43%
Urban studies	11	0.48%	Construction building technology	5	0.43%
Arts, humanities and other topics	10	0.44%	Cultural studies	5	0.43%
Forestry	10	0.44%	Demography	5	0.43%
Paediatrics	10	0.44%	Endocrinology and metabolism	5	0.43%
Dentistry and oral surgery medicine	9	0.40%	Marine and freshwater studies	5	0.43%
Parasitology	9	0.40%	Religion	5	0.43%
Toxicology	9	0.40%	Spectroscopy	5	0.43%
Literature	8	0.35%	Allergy	4	0.35%
Mining and mineral processing	8	0.35%	Emergency medicine	4	0.35%
Women's studies	8	0.35%	Mining and mineral processing	4	0.35%
Family studies	7	0.31%	Obstetrics and genecology	4	0.35%
Crystallography	6	0.26%	Operation research management science	4	0.35%
Metallurgy and metallurgical engineering	6	0.26%	Optics	4	0.35%
Radiology, nuclear medicine and medical imaging	6	0.26%	Parasitology	4	0.35%
Social issues	6	0.26%	Pathology	4	0.35%
Transportation	6	0.26%	Thermodynamics	4	0.35%
Mathematical and computational biology	5	0.22%	Toxicology	4	0.35%
Medical laboratory technology	5	0.22%	Urban studies	4	0.35%
Obstetrics and gynaecology	5	0.22%	Crystallography	3	0.26%
Polymer science	5	0.22%	Entomology	3	0.26%
Telecommunications	5	0.22%	Family studies	3	0.26%
Art	4	0.18%	Film, radio and television	3	0.26%
Criminology and penology	4	0.18%	Metallurgy/Metallurgical engineering	3	0.26%
Haematology	4	0.18%	Psychiatry	3	0.26%
Integrative complementary medicine	4	0.18%	Arts and humanities	2	0.17%
Palaeontology	4	0.18%	Biophysics	2	0.17%
Psychiatry	4	0.18%	Cardiovascular system/cardiology	2	0.17%
Behavioural sciences	3	0.13%	Dermatology	2	0.17%
Biophysics	3	0.13%	Fisheries	2	0.17%
Mechanics	3	0.13%	Haematology	2	0.17%
Optics	3	0.13%	Instruments and instrumentation	2	0.17%
Otororhinolaryngology	3	0.13%	Medical laboratory technology	2	0.17%
Substance abuse	3	0.13%	Music	2	0.17%
Allergy	2	0.09%	Nuclear science technology	2	0.17%

January 1967– December 2007	Number of articles	Percentage over total	January 2008–August 2013	Number of articles	Percentage over total
Automation control systems	2	0.09%	Palaeontology	2	0.17%
Cell biology	2	0.09%	Physiology	2	0.17%
Endocrinology metabolism	2	0.09%	Research in experimental medicine	2	0.17%
Ethnic studies	2	0.09%	Sociology	2	0.17%
Genetics and heredity	2	0.09%	Anatomy and morphology	1	0.09%
Oncology	2	0.09%	Art	1	0.09%
Operations research management science	2	0.09%	Astronomy and astrophysics	1	0.09%
Philosophy	2	0.09%	Dentistry and oral surgery medicine	1	0.09%
Thermodynamics	2	0.09%	Electrochemistry	1	0.09%
Urology and nephrology	2	0.09%	International relations	1	0.09%
Anatomy and morphology	1	0.04%	Mechanics	1	0.09%
Asian studies	1	0.04%	Mycology	1	0.09%
Astronomy and astrophysics	1	0.04%	Neurosciences and neurology	1	0.09%
Cardiovascular system and cardiology	1	0.04%	Ophthalmology	1	0.09%
Communication	1	0.04%	Polymer science	1	0.09%
Dermatology	1	0.04%	Remote sensing	1	0.09%
Film, radio and television	1	0.04%	Substance abuse	1	0.09%
Gastroenterology and hepatology	1	0.04%	Surgery	1	0.09%
History of the philosophy of science	1	0.04%	Transportation	1	0.09%
Legal medicine	1	0.04%	Urology and nephrology	1	0.09%
Mathematical methods in social sciences	1	0.04%			
Microscopy	1	0.04%			
Music	1	0.04%			
Neurosciences and neurology	1	0.04%			
Ophthalmology	1	0.04%			
Pathology	1	0.04%			
Rehabilitation	1	0.04%			
Research in experimental medicine	1	0.04%			
Robotics	1	0.04%			

Source: UNESCO estimations based on raw data from the Web of Science

Historical background to SETI policies in Botswana

Although Botswana was making intensive use of advanced technology in the mining industry and in meat processing for export in the 1970s, the objectives laid down by the country's first development plans made no explicit mention of a strategy for developing a national S&T capacity. In the decades which followed independence in the 1960s, research was concentrated in the University of Botswana, the Botswana Agriculture College and in a series of government institutions like the Botswana Technology Centre (UNESCO, 1987).

In an attempt to remedy the complete lack of an S&T policy, the Government of Botswana approached the United Nations Financing System for Science and Technology for Development in 1982 for technical and financial support in designing a national SETI strategy. The appointed consultant suggested that a body be set up with responsibility for directing S&T policy (UNESCO, 1987: 83–90).

In the late 1980s, the coordination of SETI activities and strategies fell under the responsibility of the Ministry of Finance and Development. The Ministry coordinated and managed the economy, including as concerned development issues, human resource planning, financial policy-making and S&T policy (UNESCO, 1990: 27).

In 1998, the Ministry of Finance and Development Planning developed the country's first *Science and Technology Policy* to stimulate economic growth and raise living standards in Botswana. Sadly, the policy achieved little over the next ten years, failing to overcome the very problems it had been designed to address. These included insufficient investment in research, a fragmented national system of innovation, haphazard research, an unfavourable environment for technology transfer, scarce qualified human resources and inadequate infrastructure for research.

The biggest impediment to implementation of the 1998 *Science and Technology Policy* resides in the failure to establish the institutional structures encapsulated in the policy, combined with a broad lack of awareness among stakeholders of the policy's existence. The *Science and Technology Policy* can be credited, however, with the establishment of the following bodies:

- in 2002, the Ministry of Research, Science and Technology, directly responsible for coordinating STI and creating a favourable legislative environment through the Department of Research, Science and Technology, created in 2004;
- in 2008, the Botswana Innovation Hub, which serves as a platform for providing linkages between the public and private sectors (see also pages 15 and 81);
- the Botswana International University of Science and Technology, which has been mandated to integrate education, research and production (see page 75);
- the School of Medicine.

Since 2009, R&D in Botswana has been coordinated by the Ministry of Infrastructure, Science and Technology, mainly through the Department of Research, Science and Technology. Actual research activities are undertaken by other line ministries and departments, parastatal organizations, academia, non-governmental organizations and the private sector (see page 67 for an inventory of SETI institutions in Botswana).

In 2011, the Department of Research, Science and Technology reviewed implementation of the *Science and Technology Policy* as a prelude to updating the policy, in order to align it with other major strategic frameworks, such as Botswana's *Vision 2016* document outlined in its *Tenth National Development Plan* (2009–2016) and the United Nations' Millennium Development Goals. This process culminated in the launch of a *National Policy on Research, Science, Technology and Innovation* in 2011 (see Box 4). The new policy aims to respond to the challenges of rapid technological evolution, globalization and the achievement of the national development goals formulated in national high-level strategic documents.

With regard to funding, the *Implementation Plan of the National Policy on Research, Science, Technology and Innovation, 2012* (Republic of Botswana, 2012) observed that Botswana needed to 'significantly increase efforts in R&D and innovative activities. The establishment of a funding body that coordinates funding is largely overdue.' The *Implementation Plan* recalls that the policy 'advocates a national investment of at least 2% of GDP in R&D by 2016.'

The scarcity of finances in the face of competing demands on the public purse calls for innovative funding regimes and innovative funding infrastructure for research and innovation, combined with greater cooperation between public and private enterprises.

BOX 4 – UNESCO'S REVIEW OF STI POLICY IN BOTSWANA

UNESCO's Division of Science Policy and Capacity-building has been collaborating with the Government of Botswana through the Spanish Fiduciary Fund allocated to the project for Capacity-Building in STI Policy in Africa.

In May 2008, the Hon. Pelonomi Venson-Moitoi, Minister of Communication, Science and Technology, addressed an official request to UNESCO for technical assistance in reviewing Botswana's *Science and Technology Policy* of 1998.

The main reason for the review was to align the *Science and Technology Policy* with Botswana's *Vision 2016* outlined in Botswana's *Tenth National Development Plan* (2009–2016).

In September 2008, UNESCO ran a first subregional workshop for all SADC countries on STI policies and indicators, in collaboration with the African Union Commission. The workshop was hosted by the Ministry of Communication, Science and Technology and moderated by UNESCO staff, including specialists from the UNESCO Institute for Statistics. Botswana's presentation of the status of its *Science and Technology Policy* review process during the workshop served as the basis for defining a roadmap for cooperation during a bilateral meeting with UNESCO.

Within this roadmap, UNESCO contracted an expert in early 2009 to undertake a mission to Botswana, to provide the Department of Research, Science and Technology and national consultants with technical assistance. The expert met with the Intersectorial Steering Committee in charge of drafting a status report on S&T and the policy review.

After the Ministry of Infrastructure, Science and Technology was established in late 2009, UNESCO recruited another expert to help finalize the draft National Policy on Research, Science, Technology and Innovation and status report. In November and December 2010, the final draft of the policy was circulated to ministries and consulted by stakeholders. After some revision, the final policy was submitted to the Cabinet.

UNESCO continued providing the Ministry of Infrastructure, Science and Technology with technical support during the drafting of the implementation plan for the revised policy and elaboration of the operational guidelines for setting up the institutions proposed for the policy governance structure, among them the National Research Fund.

In February 2011, UNESCO staff participated with the consultant in a two-day national stakeholder consultation workshop financed by UNESCO at which both the revised policy and its implementation plan were presented. The Minister's Permanent Secretary observed in his opening speech that 'Botswana needs a robust, resilient system, with efficient and effective institutional structures that can withstand the dynamism of technological and scientific development.'

In November 2011, UNESCO was present at the official launch of both the *National Policy on Research, Science, Technology and Innovation* and its *Implementation Plan*.

In November 2012, in response to the common need expressed by countries participating in UNESCO's project for Capacity-Building in STI Policy in Africa for greater capacity in the design and evaluation of STI policies, policy instruments and governing bodies, UNESCO ran a subregional workshop for the SADC countries, in cooperation with the Zimbabwe Ministry of Science and Technology for Development. The idea was to train national specialists in how to use analytical tools and produce a national profile for integration in the Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN). The Ministry of Botswana made an immediate commitment to producing such a profile. Two UNESCO missions and much drafting later, the result is in your hands!

UNESCO's Spanish-funded project winds up in July 2014. For the last phase, the Government of Botswana has requested technical assistance in operationalizing, managing and assessing the National Research Fund.

Source: Juliana Chaves-Chaparro, UNESCO Associate Project Officer

The goals of *Vision 2016*

In 2016, Botswana celebrates the 50th anniversary of independence. By this time, Botswana aspires to have attained prosperity for all Batswana, according to its *Vision 2016* document, which aims to make Botswana 'an educated and informed nation' and 'a prosperous, productive and innovative nation'.

Vision 2016 sets out the following goals for the development of S&T:

- technology adopted from elsewhere should be adapted to local conditions;
- Botswana will nurture and develop the innovative elements within its society and contribute to the S&T civilization of the future;
- the government should fund research or provide incentives to encourage the private sector to develop capacity in R&D;
- a National Research Council should be established, the mandate of which would be to promote, facilitate and fund research in Botswana;
- a strong capacity in scientific and engineering disciplines should be developed to provide crucial long-term support for the manufacturing industry;
- policies should promote both labour-intensive technology and high technology.

Figure 13 presents a description of how the *National Policy on Research, Science, Technology and innovation* is contributing to the national development goals expressed in *Vision 2016*.

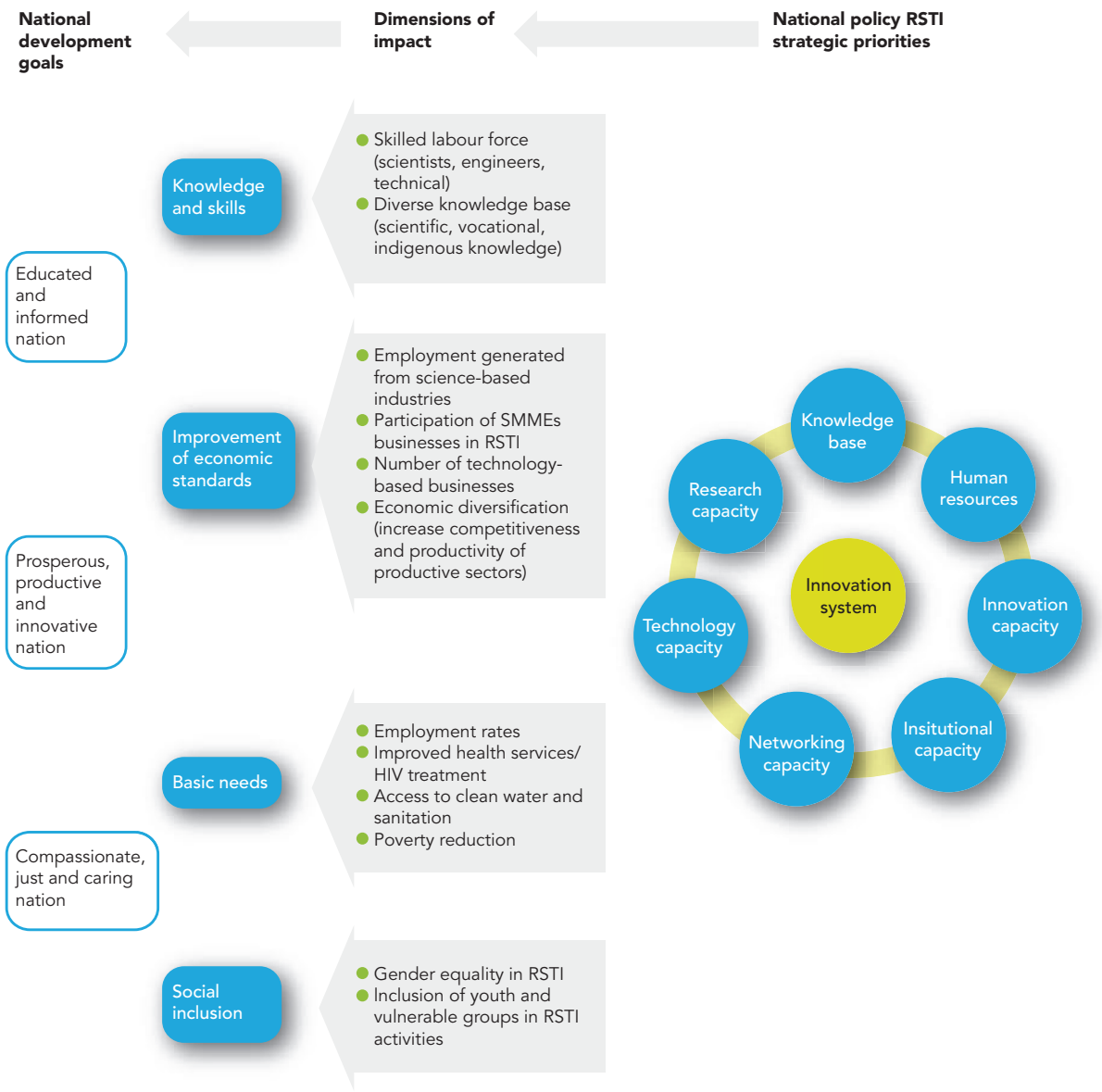


Figure 13: Contribution of the *National Policy on Research, Science, Technology and Innovation* to national development goals, according to *Vision 2016*. Source: Republic of Botswana (2012)

The SETI policy cycle

In 2011–2012, Botswana initiated a SETI policy review which culminated in the publication of a *National Policy on Research, Science, Technology and Innovation* (Republic of Botswana, 2011), accompanied by an *Implementation Plan* (Republic of Botswana, 2012).

Botswana's research, science, technology and innovation system combines the efforts of the government, private sector, research sector, academia, development partners and civil society. The government expressed the intention of taking an 'innovation systems' approach to the STI policy review. This approach was guided by the successful experience of other economies, as well as by the commitments made in the *Protocol on Science, Technology and Innovation* approved by the SADC countries in 2008, the SADC Regional Indicative Strategic Development Plan covering 2005–2020 and the *Science and Technology Consolidated Plan of Action* adopted by the continent's science ministers in 2005.

In particular, the *Implementation Plan for the National Policy on Research, Science, Technology and Innovation* sets out to address critical issues affecting capabilities in Botswana. It is guided by recommendations contained in two key documents: the *Science and Technology Policy* (1998) developed and approved by Parliament at the onset of the *Eighth National Development Plan* covering the period 1998–2003 and; the *Botswana Research, Science and Technology Plan* (2005).

The 1998 *Science and Technology Policy* devised multiple objectives and strategies intended to infuse the application of S&T to broadening Botswana's economic base and driving sectorial goals for socio-economic development. The *Policy* was intended for government use to guide future development of research, science, technology and innovation and as a tool for economic diversification and the enhancement of productivity.

The 2005 *Botswana Research, Science and Technology Plan* was developed by the Ministry of Communication, Science and Technology to outline priority investment areas in research and how these would contribute to *Vision 2016* and the National Development Plans. The *Botswana Research, Science and Technology Plan* also elaborated specific policy interventions and institutional developments that would support its implementation in the medium and long terms.

A review of the *Science and Technology Policy* was undertaken in 2009. The rationale behind this exercise was to assess the extent to which the goals of the 1998 *Science and Technology Policy* had been achieved over the subsequent decade. A secondary goal was to realign the strategic goals of the 1998 policy on the national development planning process: *Vision 2016* and *the Ninth* and *Tenth National Development Plans*. The revision of the 1998 Sci*ence and Technology Policy* entailed extensive consultations with key stakeholders and sectors. The key outcome of this review was a detailed analytical document of the landscape for research, science, technology and innovation in Botswana which identified challenges and gaps to be addressed by policy. It revealed that the setbacks hampering successful R&D were virtually the same as those identified in 1998, implying that the 1998 policy had made little impact on the creation of jobs and wealth.

The *National Policy on Research, Science, Technology and Innovation (2011)* is a revision of the 1998 Science and Technology Policy. It has been consolidated with the *Botswana Research, Science and Technology Plan* and the recommendations of the policy review in 2009. The *National Policy on Research, Science, Technology and Innovation (2011)* is the result of extensive consultations with stakeholders and indicates key assets for the transition to an economy led by research, science, technology and innovation.

The next stage will entail translating the policy into a series of implementation programmes and institutional structures that drive the commitments expressed in the policy. The Department of Research, Science and Technology currently plays the central role in achieving these goals.

All the policy documents agree on the need to prioritize collaboration and coordination among all stakeholders involved in, and affected by, research, science, technology and innovation, in order to attain broad national development goals. They also pinpoint Botswana's deficiencies and the urgency of establishing a coherent coordination framework, in order to drive new knowledge-based opportunities for developing all sectors of the economy.

With limited resources, it is important to focus on a set of strategic priorities that can lead and multiply investment in research, STI and propel productivity in other sectors. Based on the findings and recommendations of these earlier exercises, the triggers to improve Botswana's landscape for research, science, technology and innovation have been defined as: 1) a strong research capacity in both the government and private sectors; 2) creation of an environment conducive to the generation, application, adaptation, dissemination and transfer of suitable technologies; 3) promotion of innovation;; 4) development of adequate human resources; 5) development of an institutional capacity to coordinate, manage and finance research, science, technology and innovation; 6) promotion of networking and collaboration to maximise resources for research, science, technology and innovation and to generate synergies across sectors and; 6) expansion of the knowledge base for both indigenous and scientific knowledge.

AGENDA-SETTING

The Ministry of Infrastructure, Science and Technology sets the SETI agenda. The *Botswana National Research, Science and Technology Plan* (2005) maps priorities areas in which the country is deemed to have a socio-economic and competitive comparative advantage. Some of the priority areas identified in the *Plan* are:

- *Ecosystems:* healthy ecosystems are fundamental in the sense that they support human well-being and form the basis for Botswana's ecotourism industry. The ecosystem also helps in conserving raw materials which could be exploited in future.
- *Manufacturing, engineering and infrastructure:* Extensive research in this area will stimulate momentum for the country's economic diversification drive.
- *Processing and mining:* Botswana's economy has been largely dependent on the mining of minerals, especially diamonds. Extensive research in mineral processing and beneficiation will spur robust economic diversification.
- *Geomatics*: Botswana is geographically vast and sparsely populated, with a surface area of 582,000 km^2 people and a population of approximately 2 million. Furthermore, the country is very well-endowed with natural capital, particularly minerals and wildlife. This calls for sound spatial technologies (geographical information systems and remote sensing) to support effective management of this natural capital and enable access to scarce resources such as energy and water.
- *Biosciences:* technological advancement in biosciences will contribute hugely to agriculture, medicine, environmental management and probably manufacturing. Important applications for the country will comprise undertaking research in clinical sciences leading to the evaluation of new pharmaceuticals, nutrition and HIV/AIDS.

POLICY FORMULATION

SETI policy is formulated by the Department of Research, Science and Technology. This process has been driven by the country's high-level strategic goals outlined in the *Tenth National Development Plan*, *Vision 2016* and, to a large extent, the Millennium Development Goals. Botswana aspires to attain the status of a knowledge-based society. The *Vision 2016* objective of an informed and educated nation by 2016 underpins the strategy for the generation and advancement of robust SETI policy instruments.

The guiding principle behind policy formulation has been the need to build capacity, in order to stimulate the design and adaptation of appropriate technologies to local conditions and thereby address priority challenges for sustainable development. The approach to formulating SETI policy in Botswana is multidimensional and multisectorial. The process involves collaboration among various stakeholders in

the national innovation system. The extensive consultative process led by the Department of Research, Science and Technology within the Ministry of Infrastructure, Science and Technology has involved many stakeholders, including:

- Other line ministries
- Other government departments
- Research and technology institutions
- Academic institutions
- Non-governmental organizations
- Private sector
- Civil society.

DECISION-MAKING

Upon completion of policy formulation, the policy document has to be approved by the Cabinet and Parliament before it can be launched and implemented. The launch of the policy is done by the minister responsible for science and technology.

POLICY IMPLEMENTATION

Policy documents are implemented by:

- Department of Research, Science and Technology within the Ministry of Infrastructure, Science and Technology
- Other line ministries
- Other government departments
- Research and technology institutions
- Academic institutions
- Non-governmental organizations
- Private sector
- Civil society.

Policy formulation is directly followed by a policy implementation plan. The plan sets out strategic policy agendas. These are driven by key objectives and milestones with the inclusion of indicators and mention of expected outcomes and critical challenges. Key objectives are differentiated between, as follows:

- Immediate objectives (6 months to 1 year)
- Short term objectives (1 to 2 years)
- Medium term objectives (2 to 5 years)
- Long term objectives (5 years and more).

Specific programmes are assigned to each objective to drive its achievement. Programmes also assigned to relevant coordinating bodies to provide a strategic direction for programme implementation. The coordinating institution(s) is/are also helped by other institutions with a high stake in such programmes.

POLICY EVALUATION

The Department of Research, Science and Technology within the Ministry of Infrastructure, Science and Technology is charged with coordinating research, science and technology and providing strategic leadership.

This calls for a collaborative working relationship between the department and other stakeholders to ensure that the policy makes an impact. Constant national surveys and the establishment of a reliable database on innovation capacity provide the department with indicators as to whether the ideals of the policy have been met or not.

Figure 14 presents a schematic description of the SETI policy cycle established by the aforementioned *National Policy on Research, Science, Technology and Innovation* (Republic of Botswana, 2011; 2012).

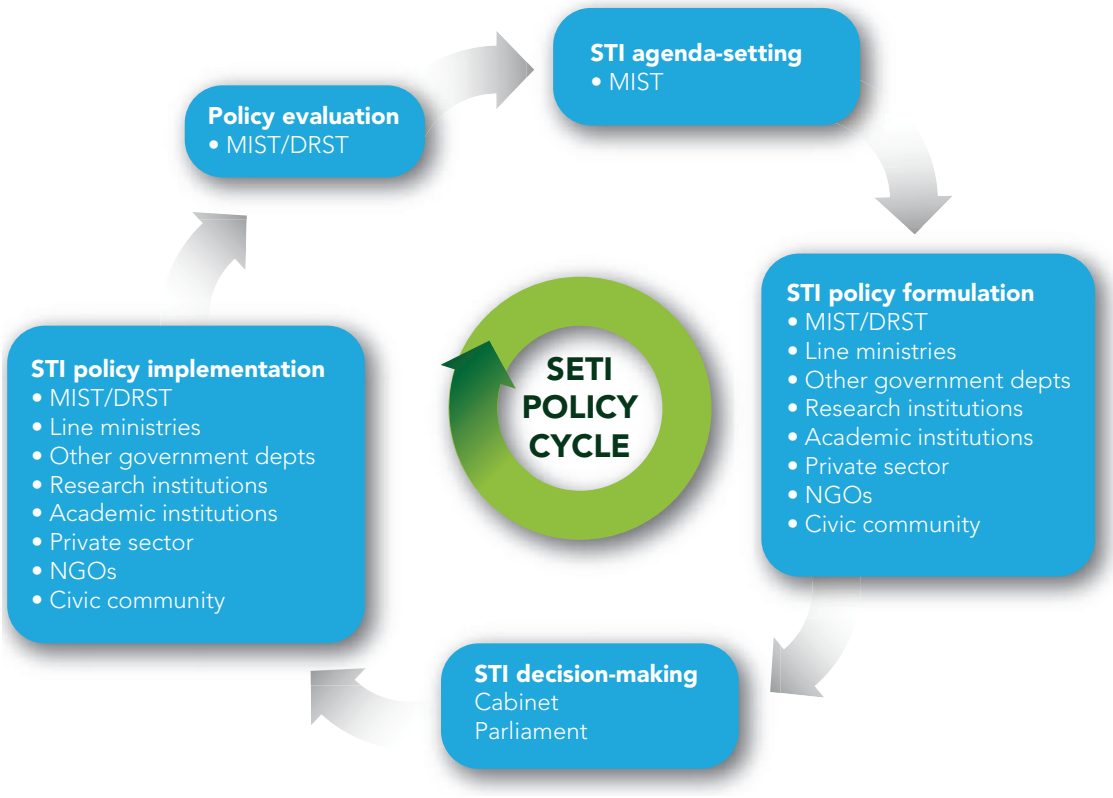


Figure 14: The SETI policy cycle in Botswana

The analytical content of Botswana's SETI policy

The present section analyses the formal content of the *National Policy on Research, Science, Technology and Innovation,* according to the standard categories employed in the GO→SPIN survey. The survey has been designed to allow for international comparisons of the SETI policies adopted by different countries. All the statements in the pages that follow have been reproduced without any changes to the official policy document (Republic of Botswana, 2011).

Statements from the *National Policy on Research, Science, Technology and Innovation* (2011)

1. **Policy vision:** Botswana will become a globally competitive nation with technological development, innovation and knowledge driving socio-economic growth.

2. **Policy mission:** To achieve a knowledge-driven economy through effective and sustainable science- and technology-based research and innovation.

3. **Policy goals:** (a) Increased national capacity for economic growth through research, infusion of indigenous knowledge into the national R&D agenda, innovation and sustainable technological development, use and application of science and technology to improve quality of life and (b) Increased national human resource capacity in research, science, technology and innovation.

4. **Policy objectives:** (a) To promote research and innovation in the areas of priority for the sustainable socio-economic development of Botswana and foster collaborative scientific research among academic, scientific institutions and the private sector; (b) To mobilize adequate resources, both human and financial, for research, technology development and transfer, innovation and development of technology-driven and knowledge-intensive industries; (c) To provide an enabling environment for the coordination, development and implementation of RSTI policy and promotion, support and participation in research and integration of S&T into all sectors of the economy and nurture creativity; (e) To cultivate a sense of responsibility among the scientific and technological institutions in the country to ensure attainment of high standards of quality, safety and quantity of research outputs as part of their social responsibility and commitment; (f) To promote the establishment of collaborations, partnerships and linkages among stakeholders, the private sector and the international science, research and development community; (g) To build a national culture of innovation and integration of traditional knowledge into modern science.

5. **Priorities at the strategic level of the SETI policy:** (a) Establishment of functional and organizational structures for implementation: Botswana National Research Development and Innovation Coordinating Council; Parliamentary Committee on Research, Development and Innovation; Directorate on Research, Science and Technology; National Research Fund; Botswana research centres of excellence; (b) Development of performance indicators on research, STI for monitoring purposes; (c) Development of networks and clusters in research, science, technology and innovation for both the public and private sectors; (d) Development of incentives for private-sector participation in research, science, technology and innovation; (e) Development of a Communication Strategy and Plan for research, science, technology and innovation; (f) Provision of mechanisms for enhanced access to funding of research, science, technology and innovation; (g) Development of a policy on indigenous knowledge systems; (h) Development of a policy on intellectual property rights; (i) Development of a Human Capital Development Strategy for research, science, technology and innovation; (j) Development of innovation capability surveillance.

Figure 15: Key policy actions established by Botswana's *Implementation Plan*. Adapted from Republic of Botswana, 2012:36

6. **Normative planning strategies of the policy:** (a) A well-resourced and coordinated national innovation system as a tool for economic growth developed; (b) A platform for a coordinated engagement of all the relevant stakeholders in the S&T arena created; (c) A diverse national innovation system covering critical and strategic sectors of the economy developed; (d) At least 2% of GDP invested in R&D in partnership with the private sector by 2016; (e) Funding mechanisms to promote participation in R&D in place; (f) Private-sector participation in R&D increased; (g) A research agenda driven by social, economic and business/commercial challenges and opportunities according to the national priorities; (h) Research collaboration, public and private sectors, research and academic institutions and civil society strengthened; (i) A critical mass of human resource skilled in S&T fields developed to spearhead the transformation of Botswana into a knowledge society; (j) Strong university–industry research collaboration created; (k) Knowledge-based businesses to contribute significantly to employment levels created by 2025; (l) An informed society that has RSTI as its way of life; (m) Globally competitive home-grown environmentally sustainable technology-derived products, systems and services available to the market; (n) Safe and expanded use of emerging technologies; (o) Research guided by national priorities and ethical considerations conducted; (p) Indigenous knowledge systems to inform modern science, sustainable technological development and innovation developed; (q) Enabling environment for accelerated national scientific and technological creativity and innovation for economic development in place; (r) Intellectual property protected; (s) Efficient delivery of research outputs through effective use of ICTs; (t) Appropriate ICT infrastructure in place to support research collaborations; (u) Equitable participation of men and women, youth, physically challenged and marginalized groups in S&T fields; (v) Outcomes of research, development and innovation to contribute to economic growth and development; (w) A set of indicators to assess the return on investment for R&D; (x) Scientific prospecting and

intelligence to guide future developments in S&T fields; (y) Establishment of functional structures and mechanisms for the successful implementation, funding and management of research development and innovation agenda.

BOX 5 – INCLUSIVE POLICIES FOR WOMEN, YOUTH AND VULNERABLE GROUPS

The *National Policy on Research, Science, Technology and Innovation* (Republic of Botswana, 2011) defines as one of its normative planning strategies the equitable participation of men and women, youth, physically challenged and marginalized groups in S&T fields.

According to the policy, the Interests of all citizens are to be considered at the highest levels of decision-making through focused strategies to address inequality, irrespective of gender or social standing. In this regard, the Government of Botswana will ensure that all policies are non-discriminatory on the basis of race, sex, gender, age, handicap and other vulnerabilities to ensure equitable participation by all citizens in S&T.

Women represent half the population (52% in 2006, according to the Human Resources Development Strategy). They constitute a pool of under-tapped talent for STI. The Government of Botswana is committed to instituting affirmative action to raise the participation of women in S&T fields from an early age, in order to exploit the country's human potential to the full. Targeted schemes will provide equal opportunities for men and women to engage in careers in science and engineering.

Youth in the 12–29-year age bracket constitute one-third of Botswana's population: 38% in 2001, according to a report of the Central Statistics Office. This age group has the potential to contribute to economic diversification through high-quality R&D and the establishment of technology-based businesses. The government and private sector are expected to harness this potential to create the requisite pool of scientists and technologists for transforming the nation into a knowledge-based society.

Youth will be encouraged to embrace S&T at an early age, in order to create a sustainable pool and equitable supply of highly knowledgeable, skilled people, a vital ingredient for developing and taking up technology. A favourable environment will be created for young people that is conducive to the pursuit of careers in science, engineering, design, technology and mathematics. The private sector is expected to participate in providing opportunities for youth, to nurture the talent of those with a head for business. Youth themselves will benefit from both existing and new programmes targeting the young.

Through its policy, the Government of Botswana will ensure that strategies are implemented to reduce exclusion and disparities between the able-bodied and physically challenged from childhood onwards, as far as S&T are concerned. As technology develops in Botswana, the physically challenged and other vulnerable groups will be empowered to participate in R&D, become pioneers in technology-based businesses and use assistive technologies.

7. **Policies related to the supply side of SETI (*commitments*):**

    a. Government commits to intensifying support for creation of the requisite skilled human capital and high level of education and training aligned on national priorities in S&T to engage citizens in knowledge-based jobs, transform Botswana into a knowledge society and influence investors' business case and options in favour of Botswana. The support will entail continual review and implementation of policies, curricula and strategies that support access to equitable and high-quality education to specifically encourage innovation and interest in science and mathematics at a tender age.

b. Vocational training will be strengthened to create a strong technical cadre base to effectively support R&D and technology transfer. This will serve as a strong foundation for building the human capital pyramid from undergraduate engineer and scientist levels to the PhD qualification.

c. Collaboration among the public, academic institutions, industry, research organizations, innovation hubs, science and technology parks according to the needs of industry and the market will attract incentives in the STI funding model to promote efficiency in the use of human resources and funds. Postgraduate studies up to doctorate level in S&T are emphasized for staff development in institutions of research and higher learning. The government and the private sector will create more opportunities for higher-level training through provision of competitive bursaries and support for research projects according to national priority areas. Public institutions and the private sector are expected to collaborate on postgraduate training programmes to ensure that their research activities solve real problems.

d. Opportunities for professional development and lifelong learning in S&T areas will be created by Government in partnership with the private sector through the provision of incentives that encourage employers to support employee training in S&T fields. Employers are conversely expected to ensure that their investment in the development of capable human resource is safeguarded through retention strategies that advocate for continuous improvement in conditions of service.

e. The Government of Botswana recognizes that financial resources are fundamental to strengthening the national innovative capability and subsequently increasing the national capacity for economic growth. In recognition of the costly nature of the processes of research, development and innovation, government, in partnership with the private sector, undertakes to invest at least 2 % of GDP in R&D by 2016, consistent with the commitment of SADC. This will be steadily increased in time to reach the necessary levels for sustaining Botswana's global competitiveness.

BOX 6 – SAFETY, ETHICS AND NATIONAL QUALITY STANDARDS

Botswana's *National Policy on Research, Science, Technology and Innovation* imposes mandatory safety and quality standards on all R&D to ensure that the products, systems and services arising from R&D are safe for humans and the environment (including animals), as well as internationally credible and acceptable. The government will continue to support the bodies responsible for national standards to ensure that locally produced products, systems and services are globally competitive.

Research and productive institutions are to adopt accreditation systems for their laboratories and products to maintain high-quality services, raise the profile of their laboratories and products and enhance cooperation between local institutions and regionally or internationally renowned ones.

The government will ensure that research programmes do not compromise the national pledge to sustain Botswana's pristine environment and enhance quality of life. The research processes and outputs shall be monitored to uphold the principles of environmental protection, sustainable natural resource management, information management, governance and support.

Botswana upholds the principle of 'Botho,' meaning integrity and dignity for all. All researchers are obliged to observe ethical considerations in the conduct of R&D. Codes of conduct for research faithful to this principle will include honesty, objectivity, integrity, openness, non-malfeasance, utility and respect for research participants, fairness, and respect for intellectual property rights, confidentiality, responsible publication and legality. The government will develop a research and development bill, regulations and code of conduct to guide the moral

and ethical considerations related to research and provide a clearing house to promote compliance and facilitate the amicable settlement of disputes related to research, as well as documentation. Currently, there are no national guidelines in Botswana pertaining specifically to research ethics and no laws regulating the behaviour of interest groups that may influence the conduct of research (Hyder *et al.*, 2013).

With one of the highest rates of HIV in the world, a stable democracy and a national commitment to public health, Botswana has attracted global attention over the past three decades as a hub for behavioural, epidemiological and clinical research related to HIV/AIDS and other comorbid conditions. Postgraduate opportunities in the country's institutions of tertiary education have also expanded in the past decade, resulting in a growing national research portfolio. The rapid increase in the volume and complexity of research conducted in the country has necessitated the strengthening of the national regulatory system for research and has generated a demand for a trained national workforce able to conduct reviews of ethics or serve as investigators and staff at all levels of the research enterprise (Barchi *et al.*, 2013). The regulation of research on human subjects is inadequately covered by an outdated law on anthropological research, although, at the time of writing, efforts are under way to draft a new legal framework.

Reviews of the ethics of health-related research in Botswana are currently conducted by a government-appointed national research ethics body, the Health Research and Development Committee, which functions as an Institutional Review Board/Review Ethics Committee at the University of Botswana, with administrative support from the Health Research Unit at the Ministry of Health. The Health Research and Development Committee is increasingly reliant on the Institutional Review Board/Review Ethics Committee for research conducted by faculty and students at the University of Botswana but retains authority for final review and approval of all international protocols (Barchi *et al.*, 2013).

The government will continue to regulate, monitor and manage risks related to clinical trials involving medical drugs, medical devices and procedures, as well as any emerging technologies with the potential to improve livelihoods, such as nuclear technologies, nanotechnology and biotechnology. Such trials need the approval of the National Drug Regulatory Unit or relevant structures, as may be provided for in law over and above the approval of the Health Research and Development Committee.

Recently, the University of Botswana's Office of Research has stated its aim of increasing the capacity of students and staff to conduct ethical research and ensuring that research on human subjects done at the university follows international guidelines for ethical research (Hyder *et al.*, 2013). In line with In this vision, the university has identified two main research commitments: first, it will undertake pioneering research relevant to local needs, and second, it will ensure that this research conforms to the highest ethical standards.

8. Policies related to demand for SETI (*commitments*):

a. The government will promote the active participation of the private sector in the national innovation system by providing an environment conducive to such participation. This is expected to contribute to economic growth through employment creation, poverty reduction and enhancement of successful and effective technology commercialization and industrialization.

b. This policy will also reinforce private-sector capacity and capability by addressing competition and credit issues, and promoting interactions and partnerships among stakeholders (such as academia, innovators, researchers, public and fund managers) for knowledge and information exchange. Partnerships will be set up in the form of private-sector advisory boards for review of curricula, fundraising for research activities, infrastructure development and support of student internships to ensure availability of competent human resources with relevant skills for industrial growth.

c. While the government will continue to invest in R&D in the foreseeable future, the private sector is expected to increasingly invest in scientific and technological development as a social responsibility and opportunity to strengthen business competitiveness through tailor-made technologies according to market challenges. In a knowledge-based economy that Botswana aspires for, the private sector alone will contribute more than 70% of gross expenditure on research and development (GERD). The private sector has potential to build up its contribution over time if its dependency on government expenditure as is currently the case is minimized and instead adopt an innovative and entrepreneurial culture. This applies to the small, medium and micro-sized enterprises (SMMEs) that have shown potential to become the backbone of the economy and can eventually support high-quality national R&D and subsequent commercialization of its products and services.

d. Botswana's innovative capability will be measured by its ability to produce outputs that contribute to economic diversification and economic growth for the benefit of the citizenry by supporting efforts towards poverty alleviation, employment creation and environmental sustainability. The end-users of home-grown and adapted technologies are the public at large in their quest for information and new knowledge in the form of products and services to improve lives. The government will use research findings to inform policy decisions on support programmes to improve livelihoods through use of appropriate technologies.

e. Botswana is faced with challenges that present opportunities for focused R&D such as a limited power supply; diminishing and scarce water resources to support large industries and the agricultural sector; high prevalence of HIV/AIDS and tuberculosis; restricted connectivity, mostly confined to towns and cities, resulting in general inefficient and costly services. These present opportunities for R&D in different fields, particularly as concerns the use of natural resources of untapped potential found in Botswana such as animal and plant species, minerals, solar energy, etc. Botswana's geographical location at the centre of Southern Africa also presents a comparative advantage of becoming a hub for several activities such as transport, cargo logistics, education, science and technology.

f. The government will regularly prioritize the national and sector-specific research agenda with the involvement of key stakeholders on the basis of their potential to grow the economy. Stakeholders will be expected to align their respective research programmes with the set priorities to ensure concerted efforts towards exploiting opportunities at global level.

g. The government, in consultation with stakeholders, will facilitate the selection of key research areas of utmost importance to the economy, including scientific validation of indigenous technologies, for funding through the national funding mechanism with private-sector involvement. It shall be mandatory for all public-funded programmes and projects to be aligned on the identified priorities.

h. The commercialization of research products is a critical stage in R&D that can nullify research efforts if not properly managed. The public- and private-sector players will be encouraged to participate in technology incubation and commercialization of any research outputs that have potential to compete at a commercial and industrial level. Uptake of technology by industry will be stimulated through the strengthening of linkages among national research institutions, non-governmental organizations, the private sector and extension organizations.

i. The authority and capacity of the institutional structures for implementation of this policy will be strengthened for efficient discharge of these functions, and targeting of public funding for R&D that can yield outputs with potential to impact positively on livelihoods and knowledge development.

BOX 7 – ANCHORING INDIGENOUS KNOWLEDGE SYSTEMS IN BOTSWANA'S POLICY

Botswana's *National Policy on Research, Science, Technology and Innovation* acknowledges that 'indigenous knowledge remains largely disregarded' (see also page 105). At the same time, it recognizes that indigenous knowledge will be an essential ingredient, if the country is to succeed in its efforts to become a knowledge-driven society. For this reason, one of the six major triggers identified by the policy to improve Botswana's landscape is 'expanding the knowledge base – both indigenous and scientific knowledge' (Republic of Botswana, 2012, p. 13)'.

The *Implementation Plan* outlines 12 key areas for intervention, including indigenous knowledge systems. One of the early steps identified In the programme accompanying this area of intervention is the future elaboration of a policy on indigenous knowledge systems. The development and implementation of such a policy will be critical for the success of Botswana's efforts to become a knowledge-driven society. The policy development process will offer an opportunity to broaden understanding of indigenous knowledge systems and the holders of indigenous knowledge, as well as their present and future contributions to society.

Although the *National Policy on Research, Science, Technology and Innovation* has paved the way to recognition of indigenous knowledge systems, its vision remains somewhat restricted and one-dimensional for the time-being.

International recognition of the importance of indigenous and local knowledge was triggered by the 1992 Convention on Biological Diversity and its well-known article 8(j):

> *respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge innovations and practices.*

Over the past few decades, governments have addressed the issues of access to knowledge and benefit-sharing, including through the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization*, adopted by the United Nations in 2010. Negotiations relating specifically to intellectual property are handled by WIPO's Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore.

Increasing attention is also being paid to the wider application of indigenous knowledge and its multiple dimensions. Beyond its contribution to identifying valuable genetic resources with applications in health, agriculture or industry, indigenous knowledge has gained growing recognition in such diverse fields as the management of renewable resources, wildlife and fisheries, natural disaster preparedness and response, environmental impact assessment and climate change assessment and adaptation. Most recently, the Intergovernmental Panel of Experts on Climate Change has encouraged authors of the Fifth Assessment Report to consider indigenous knowledge alongside scientific knowledge when assessing the impact of climate change and opportunities for adaptation in the report of Working Group II, due for release in March 2014. Similarly, the newly established Intergovernmental Platform on Biodiversity and Ecosystems Services (IPBES) has adopted as one of its founding principles, the need to 'recognize and respect the contribution of indigenous and local knowledge to the conservation and sustainable use of biodiversity and ecosystems.' These developments might also be relevant for Botswana's policy on indigenous knowledge systems.

This policy might also provide an opportunity to consider the multiple dimensions of indigenous knowledge systems. For example, indigenous knowledge has gained specific recognition for its role in protecting heritage through UNESCO's 2003 Convention for the

Safeguarding of Intangible Cultural Heritage. Recognition of the value of indigenous knowledge systems should be accompanied not only by a long-term vision of what indigenous knowledge systems can contribute to Botswana's sustainable development but also by a reflection on what measures may be required to ensure the long-term vitality of indigenous knowledge systems themselves. This brings to the fore the issue of the continuing transmission of indigenous knowledge and its relationship to both non-formal and formal education systems. The UN Convention on the Rights of the Child underlines the importance of education respecting the language and culture of indigenous children. Ensuring the longevity and dynamism of indigenous knowledge systems, including through intercultural education and education conducted in the child's mother tongue, is also an investment in the long-term benefits that indigenous knowledge systems can bring to Botswana society.

Lastly, the importance of traditional knowledge is recognized by the UN Declaration on the Rights of Indigenous Peoples (2007). It has been adapted to the African context through the deliberations of the African Court of Human Rights, which provides a holistic framework for an enlarged and multidimensional vision of indigenous knowledge systems can that can bring long-term benefits to Botswana.

Source: Douglas Nakashima, UNESCO's Local and Indigenous Knowledge Systems programme

9. Policies to foster networking between the SETI supply and demand sides (*commitments*):

a. The government will induce private-sector participation in research, science and technology through funding of R&D, support for human resource and infrastructure development, intellectual property protection, technology transfer and business incubation, marketing, commercialization and industrialization.

b. Funding mechanisms based on research capability and relevance to the desired national outcomes will be put in place to promote participation by individuals, corporations, educational institutions, etc. These will include the existing *Innovation Fund* that caters for the Botswana Innovation Hub companies, *Tertiary Education Fund* for universities, and the proposed *National Research Fund* as was envisioned in the 1998 *Science and Technology Policy*, and subsequently in *Vision 2016*, to administer funds for scientific and technological research, development and innovation.

c. The Government of Botswana will support the development of a strong, cohesive and well-coordinated national innovation system to ensure that research focuses on national priorities and contributes to economic growth through the conversion of research results into products and services that support commercialization and industrialization as critical catalysts for economic growth.

d. The government's key role in the national innovation system will be to create an enabling environment for conducting scientific and technological R&D and to stimulate innovation. This will be achieved by strengthening the policy and legislative environment to promote, support and intensify competitive technological development and adaptation, research funding, quality assurance, intellectual property protection, safety, commercialization and industrialization, resource mobilization and human capability development.

e. The Government of Botswana will guide the development of research and innovation by ensuring there is a coordinating mechanism to eliminate duplication, fragmentation and contradiction of efforts at national level. In this regard, the government commits to the creation and support of strong primary institutional structures to foster innovation and delivery of specific mandates.

f. The key players in the civil, public and private sectors will be encouraged and facilitated to form effective partnerships, networks and interactions that contribute to the efforts of government in supporting and promoting scientific and technological research and innovation. They are also

expected to strengthen and create support structures and mechanisms for intellectual property rights awareness; technology incubation, transfer and diffusion; cluster networking and support systems; funding and business promotion to effect the provisions of the policies.

g. Technology end-users will be empowered to play a critical role in setting the pace for innovation and sustaining a competitive edge in R&D, by demanding goods and services according to their specific needs. This will be supported through the development and implementation of a coordinated demand-driven R&D agenda that responds to the end-user needs and stimulates the achievement of high-value, knowledge-intensive industrial growth.

h. Stakeholders are expected to establish and maintain internal and external cooperation, partnerships and linkages in S&T in order to keep the national innovation system aligned on both national and global trends. In this regard, the government will continue to promote and renew strategic bilateral, regional, international and multilateral cooperation to facilitate cooperation. This is expected to promote the exchange of information and knowledge, accelerate internal innovation and expand external markets for home-grown technologies, goods and services.

i. All relevant stakeholders in the national innovation system are expected to engage fully in the execution of all functions necessary for driving innovation for economic growth and ensuring that the national innovation system is effective. Since the national innovation system is dynamic, it will be continuously reviewed to incorporate latest entrants and any changes in the S&T landscape as necessary. All Batswana are expected to drive continuous technological development and innovation by demanding scientific and technological services and products that stimulate extraordinary research and innovation. This will be achieved by inculcating an investigative, inquisitive, innovative and productive culture and provoking a quest for an improved quality of life among Batswana. A communication strategy on research, science, technology and innovation will be developed and implemented with the involvement of all stakeholders to promote interaction and information-sharing on related issues of interest in the country.

10. Regional and international dimensions of SETI policies:

a. Stakeholders are expected to establish and maintain internal and external cooperation, partnerships and linkages in S&T, in order to keep the national innovation system aligned on both national and global trends. In this regard, the government will continue to promote and renew strategic bilateral, regional, international and multilateral cooperation to facilitate cooperation. This is expected to promote the exchange of information and knowledge, accelerate internal innovation and expand external markets for home-grown technologies, goods and services.

b. All research institutions and stakeholders are expected to leverage bilateral, regional, international and multilateral cooperation agreements to source funding for research and innovation development over and above government provisions and strive to develop centres of excellence in sectors with a comparative advantage in Botswana.

c. Research and productive institutions are to undertake accreditation systems for their laboratories and products to maintain high-quality services, raise the profile of their laboratories and products and enhance the cooperation of local institutions with regionally and internationally renowned ones.

11. Monitoring, assessment, technological forecasting and prospective scenarios:

a. The Government of Botswana will lead the coordination and implementation of this policy to ensure that national research programmes are linked, complementary and non-duplicative. Monitoring and evaluation mechanisms to ascertain effective and efficient implementation of the policy and achievement of its objectives will be developed. The monitoring will be achieved by creating and maintaining databanks from which critical indicators will be generated to inform decision-making on planned, on-going and completed research programmes. This process will form an integral part of policy implementation to ensure maintenance of its integrity and relevance to prevailing

circumstances and efficient use of meagre resources. Regular national surveys will be conducted to inform policy formulation, international reporting on Botswana's system of research, science, technology and innovation and assessment of the capability of institutions to carry out particular types of research. All research work will be evaluated for quality, relevance, uptake and impact, in order to measure Botswana's innovation capability.

b. Appropriate input-, output- and outcome-based performance indicators and measures will be developed based on the macro-level indicators from international models, to assess national impact and facilitate international comparisons and closer internal monitoring of national SETI performance. The policy implementers will be equipped with requisite skills to enable them to assess the effectiveness of their interventions as they roll out the implementation plan for the policy.

c. The Government of Botswana will lead stakeholders through regular, systematic and participatory general and sector-specific technology forecasting exercises for futuristic medium- to long-term research and innovation vision-building. This will be necessary for Botswana to position herself for advancement in the knowledge age. This vision-building process will entail joint evaluation and bringing into perspective the diverse developmental elements such as local and international technological development, market performance and trends and key sector indicators. Thus, forecasting will improve decision-making; guide research, science, technology and innovation policy choices; generate alternative routes for future development; improve preparedness for emergencies in the technology arena as it evolves and; motivate change in policy direction and implementation.

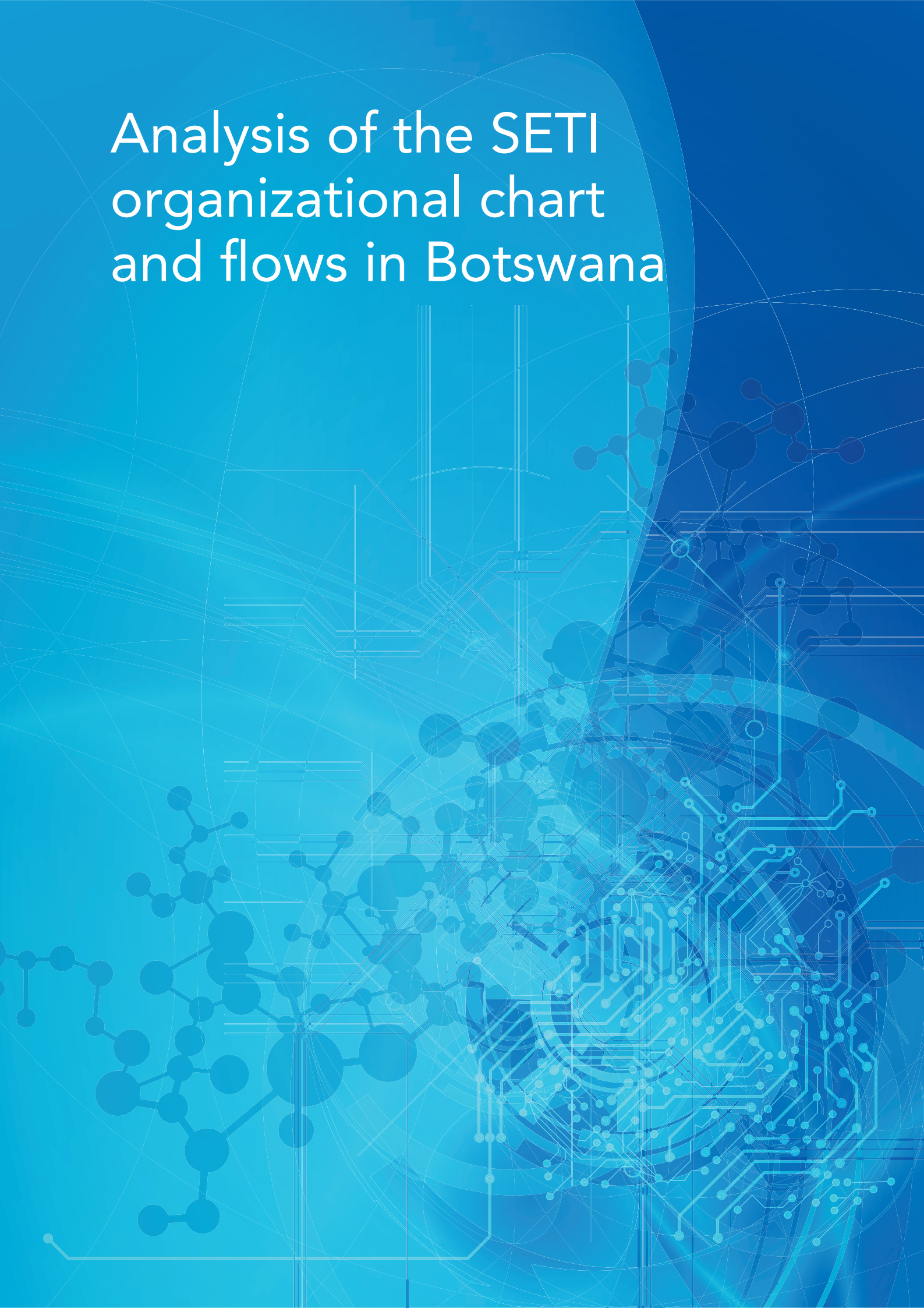
d. Technology forecasting will also guide long-term research prioritization and associated human resource and infrastructure developmental needs. Therefore, a regular forecasting process will be executed to inform and update policy and re-align government expenditure and incentives with key industrial sectors. New investments in completely new fields will be based on the forecasting results.

e. The institutional structures charged with the responsibilities of policy monitoring and implementation will be strengthened in mandate, capacity and capability.

12. SETI policy start date: 2011

13. Range of the SETI policy planning: 2011 onwards (open)

Analysis of the SETI organizational chart and flows in Botswana



The *National Policy on Research, Science, Technology and Innovation* adopted in 2011 envisions the creation of the following institutions. The *Implementation Plan* does not specify a planned date of creation in most cases, as this will be determined by the adoption of a relevant bill.

BOTSWANA NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION COORDINATING COUNCIL

In order to strengthen capacity for S&T and achieve sustainable economic development, the government will provide leadership and oversight of the entire R&D landscape, in accordance with international best practices, knowledge and guidance. A Botswana National Research, Development and Innovation Coordinating Council will consequently be established to advise the country's leadership and coordinate decision-making related to research, science, technology, and innovation. The council will be established by statute as an autonomous body chaired by the minister responsible for science and technology. Council membership will be drawn from renowned individuals in the scientific, economic and academic communities in both the public and private sectors.

The chairmanship of the council at the level of minister recognizes that S&T has the potential to stimulate the economy and cuts across all sectors. It will thus take the impetus of a higher office to give the council its requisite synoptic function and the authority to discharge its mandate. If it is treated just like any other committee embedded in the line ministry, the chance of the *statu quo* prevailing is high and likely to result in minimal implementation of this policy. The Council dealing with science and technology is thus to be considered at a similar level as other bodies instrumental in turning around the economic situation, such as the Botswana Economic Advisory Council and the High-level Consultative Committee. The National Research, Development and Innovation Coordinating Council is equally critical for catalysing socio-economic growth and comparatively complex.

The functions of the Botswana National Research, Development and Innovation Coordinating Council will be to:

- advise the country's leadership on issues related to research, science, technology and innovation;
- guide the national agenda on R&D and innovation and direct implementation of the *National Policy on Research, Science, Technology and Innovation* to ensure it makes an impact and achieves its goals;
- identify national priorities for R&D by providing broad guidance;
- decide on the funding strategies required to implement the research, development and innovation agenda adequately;
- determine levels and patterns of national investment in R&D based on the identified national priorities;
- monitor the implementation and performance of funded research projects in the country;
- foster results-oriented research and an alignment by players in the national innovation system with national priorities;
- provide oversight of activities by research and academic institutions;
- receive and review periodic reports from academic and research institutions on their research activities;
- guide smart partnerships between the government, business sector and scientific community.

The Botswana National Research, Development and Innovation Coordinating Council will establish sectorial research committees and boards as and when necessary, to cater for specific planning, implementation and coordination needs in key sectors. All the relevant committees that are already in place will automatically serve as sectorial committees once the Council is established. In order to avoid duplication and fragmentation of public resources, these committees will be aligned with the Sector Human Resource Development Committees (under the National Human Resource Development Council), as much as possible. The members will be drawn from both domestic and international R&D environment and represent major disciplines in natural sciences, engineering, human sciences, and social sciences.

DIRECTORATE ON RESEARCH, SCIENCE AND TECHNOLOGY

Responsible for coordination, the Department of Research, Science and Technology currently falls under the Ministry of Infrastructure, Science and Technology. The department will be transformed into an autonomous Directorate on Research, Science and Technology, established by statute. It will become the executing arm of the Botswana National Research Development and Innovation Coordinating Council and will be headed by a Coordinator of Research, Science, Technology and Innovation. The directorate will be primarily responsible for the creation of a policy and legislative environment that promotes participation by all in R&D. The directorate will also have administrative responsibility for the National Research Fund and Botswana research centres.

The directorate will coordinate the overall implementation of the *National Policy on Research, Science, Technology and Innovation* at the national level and ensure continuous interaction among stakeholders and government. It will lead implementation of the national strategy for advancing S&T and foster results-oriented research and an alignment of the efforts of players in the innovation system with national priorities. The Directorate will also monitor the implementation of funded research projects and development of appropriate performance indicators. This will require the establishment and maintenance of a comprehensive data and information repository and management system on research, science, technology and innovation to inform decision-making.

The functions of the directorate will also include managing the identification process for national research priorities, guiding and monitoring progress, the impact of the policy and its relevance to the development needs of Botswana. To this end, the directorate will develop and implement, with relevant stakeholders, strategies and mechanisms for technology diffusion, uptake and transfer and devise a communication plan to build public awareness of the importance of research, science, technology and innovation. Its mandate, capacity and capability will be strengthened to ensure effective implementation and coordination of the national agenda in related areas.

NATIONAL RESEARCH FUND

A National Research Fund will be established. The purpose of the fund will be to finance research of relevance to the national priorities on a competitive basis according to the requirements of the public and private sectors. This will promote objective, efficient funding of research, in line with the capability of institutions, individuals and consortia to undertake required research. The fund will be administered through a board managed by the Botswana National Research, Development and Innovation Coordinating Council.

The board will also be mandated to monitor and evaluate funded research programmes to determine value for money and the delivery of projects on time. Largely competitive, the funding will emphasize a multisectorial approach and collaboration, with a pooling of expertise for an optimum use of scarce resources. The board will also support small and medium-sized enterprises in incubating innovative products, systems and services. Funding of the long-term research agenda in sectors under the responsibility of line ministries will also be administered by the fund. The funds for such long-term research will be directly forwarded to the Botswana National Research, Development and Innovation Coordinating Council by the Ministry of Finance and Development Planning after the usual budgetary approvals. Line ministries will be required to provide the Botswana National Research Development and Innovation Coordinating Council with research procurement programmes for tender, based on the priority areas.

Other contributors to the fund will be the private sector and international partners. Both the public and private sectors are still expected to source funding from other funding bodies, within the guidelines of the policy implementation strategy to be synergized for optimum use of resources.

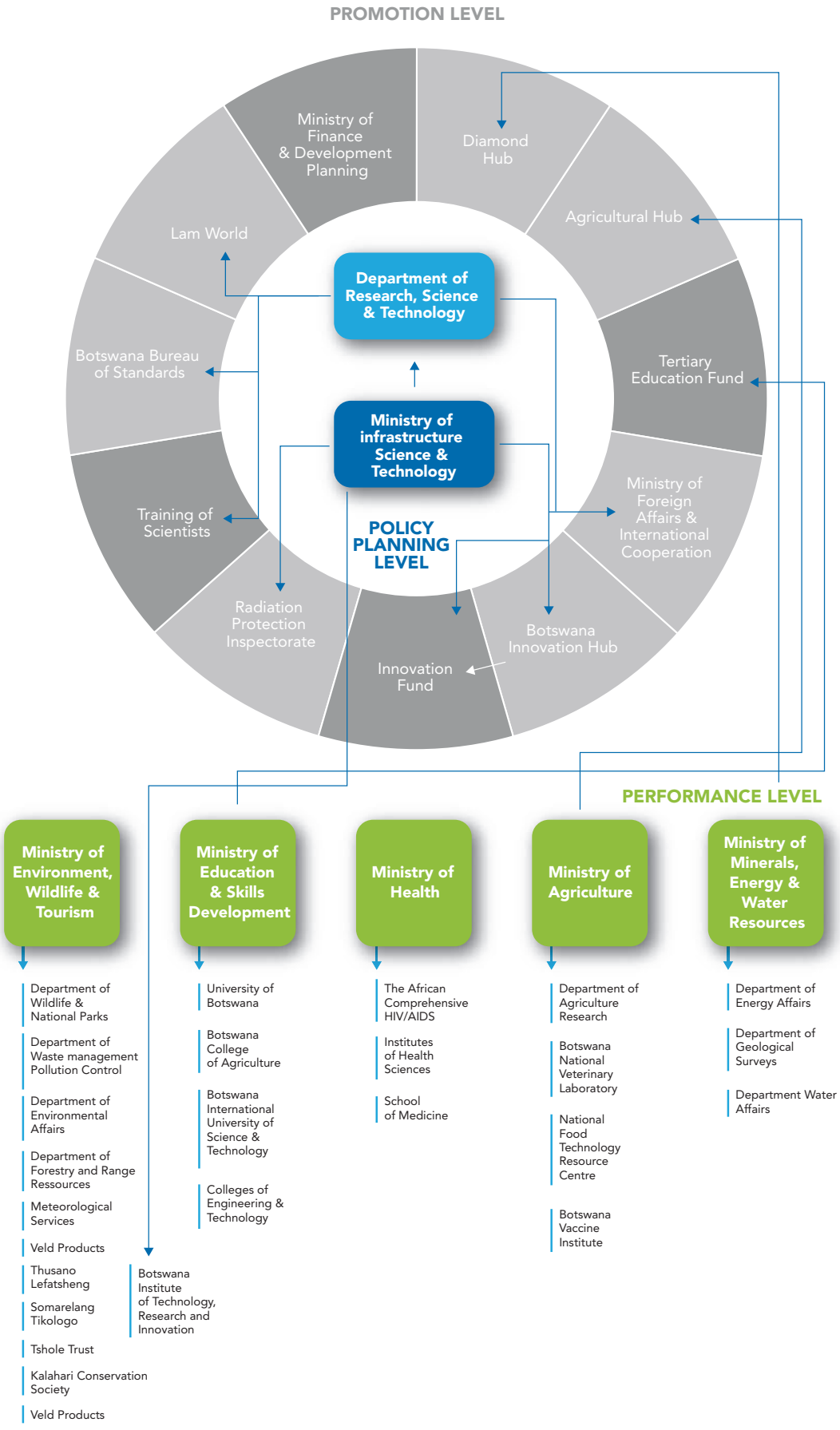


Figure 16: SETI organizational chart and flows in Botswana. Source: Government of Botswana

Inventory of SETI institutions in Botswana

Over the years, governments have built up structures to formulate, fund, implement and monitor national SETI policies. The purpose of the following section is to conduct a functional analysis of the responsibilities and tasks assigned to the various bodies which make up these structures.

The first body mentioned is the Department of Research, Science and Technology. It is followed by a description of the line ministries and government departments involved in research and innovation. Next come SETI non-governmental organizations, all the institutions of higher education in Botswana, SETI networking and support Institutions and, lastly, the new centres envisioned by the *National Policy on Research, Science, Technology and Innovation.*

DEPARTMENT OF RESEARCH, SCIENCE AND TECHNOLOGY

Address: Private Bag BR 279, Gaborone, Botswana

Telephone: +2673613100

Name of Executive head: Ms Lesego Motoma

Email: lmotoma@gov.bw

Established: 2004

Aims and responsibilities: the department is mandated to provide leadership in research, science, technology and innovation in Botswana through the provision of an enabling environment in terms of policy and legislation, combined with coordination and monitoring.

Priority level of the following functions:

1. Planning/programming/budgeting of SETI activities: *highest priority*
2. Promotion/financing/coordination of SETI activities: *highest priority*
3. Application/transfer/assessment of SETI activities: *highest priority*
4. Advocacy of SETI activities: *highest priority*
5. General Policy advice: *highest priority*

Name of information unit: *Science and Technology Information (STI) Unit.*

Preferred language: *English*

Frequency of professional contacts with the following organizations:

a. Organizations of the UN system: *Regular professional contacts*
b. Other intergovernmental organizations; *Regular professional contacts*
c. International non-governmental organizations; *Rare professional contacts*
d. National SETI policy bodies in foreign countries; *Irregular professional contacts*
e. Other institutions in foreign countries dealing with science, technology and innovation policy studies; *Rare professional contacts*

Policy-related publications of the department:

1. *National Policy on Research, Science, Technology and Innovation*, 2011 Available at: www.eis.gov.bw
2. *National Policy on Research, Science, Technology and Innovation, Implementation Plan*, 2012. Available at: www.eis.gov.bw

Number of professional staff = 10 (Males = 6; Females = 4)

MINISTRIES AND GOVERNMENT DEPARTMENTS WHICH PERFORM RESEARCH

Ministry of Minerals, Energy and Water Resources: undertakes research on energy efficiency, mineral exploration and groundwater resources. The following departments fall under the ministry: (1) Department of Energy Affairs; (2) Department of Geological Surveys and (3) Department of Water Affairs.

Ministry of Environment, Wildlife and Tourism: undertakes research in areas related to the environment, tourism and wildlife. The following departments are found under the ministry: (1) Department of Wildlife and National Parks; (2) Department of Waste Management & Pollution Control; (3) Department of Environmental Affairs; (4) Department of Forestry and Range Resources; and (5) Meteorological Services.

Ministry of Health: undertakes research in health-related areas.

Ministry of Agriculture: undertakes all agricultural research; the following departments are found under the ministry: (1) Department of Agricultural Research and (2) Botswana National Veterinary Laboratory (see below for details).

Name: Botswana National Veterinary Laboratory

Address: Private Bag 0035, Gaborone, Botswana

Telephone: +267 3928816

Name of Executive head: Dr C. Marobela-Raborokgwe

Email: cmarobela-raborokgwe@gov.bw

Aims and responsibilities: the core business of the National Veterinary Laboratory is to provide veterinary laboratory services (animal disease diagnosis, quality assurance testing of animal food products and quality assurance testing of animal feed) and to conduct applied research on public and animal health problems, in order to promote a diversified, sustainable and competitive livestock industry in Botswana.

Priority level of the following functions:

- Planning/programming/budgeting of SETI activities: *Highest priority*
- Promotion/financing/coordination of SETI activities: *Low priority*
- Application/transfer/assessment of SETI activities: *High priority*
- Advocacy of SETI activities: *High priority*
- General Policy advice: *Low priority*

Frequency of professional contacts with the following organizations;

- Organizations of the UN system: *Regular professional contacts*
- Other intergovernmental organizations: *irregular professional contacts*
- International non-governmental organizations: *irregular professional contacts*
- National SETI policy bodies in foreign countries: *rare professional contacts*
- Other institutions in foreign countries dealing with science, technology and innovation policy studies: *rare professional contacts*

Policy-related publications of the laboratory:

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2. Mushi, E.Z., Binta, M.G., Chabo, R.G., Hyera, J.M.K., Thibanyane, K.M. and Mkaria, J. (2001). Antibodies to Newcastle disease virus in the sera of indigenous chickens in Oodi, Kgatleng, Botswana. *Onderstepoort Journal of Veterinary Research*, 68: 69–70.

3. Sharma, S.P., Losho, T.C., Mangate, K.G., Linchwe, K.B., Amanfu, W. and Motsu, T.K. (2001). The resurgence of trypanosomosis in Botswana. *Journal of the South African Veterinary Association*, 72: 232–234.

4. Baipoledi, E.K., Nyange, J.F.C. and Hyera, J.M.K. (2002). A severe case of contagious ecthyma in Tswana goats. *Journal of the South African Veterinary Association*, 73: 86–87.

5. Marobela-Raborokgwe, C., Nicholas, R., Ayling, R. and Bashiruddin, J.B. (2003). Comparison of complement fixation test, immunoblotting, indirect ELISA and competition ELISA for detecting antibodies to Mycoplasma mycoides subspecies mycoides small colony (SC) in naturally infected cattle from the 1995 outbreak in Botswana. *Onderstepoort Journal of Veterinary Research*, 70: 21–27.

6. Sharma, S.P., Baipoledi, E.K., Nyange, J.F.C. and Tlagae, L. (2003). Isolation of Toxoplasma gondii from goats with a history of reproductive disorders and the prevalence of Toxoplasma and Chlamydia antibodies. *Onderstepoort Journal of Veterinary Research*, 70: 65-68.

7. Sharma, S.P., Losho, T.C., Baipoledi, E.K. and Nyange, J.F.C. (2003). The prevalence of heartwater in domestic ruminants in Botswana. *Bulletin of Animal Health and Production in Africa*, 51: 215–221.

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9. Johnson, N., Letshwenyo, M., Baipoledi, E.K., Thobokwe, G. and Fooks, A.R. (2004). Molecular epidemiology of rabies in Botswana: a comparison between antibody typing and nucleotide sequence phylogeny. *Veterinary Microbiology*, 101: 31–38.

10. Letshwenyo, M., Mapitse, N. and Hyera, J.M.K. (2006). Foot-and-mouth disease in a kudu (Tragelephus strepsciceros) in Botswana. *Veterinary Record*, 159: 252–253.

11. Hyera, J.M.K., Letshwenyo, M., Monyame, K.B., Thobokwe, G., Pilane, A.R., Mapitse, N. and Baipoledi, E.K. (2006). A serological survey for antibodies to foot-and-mouth disease virus in indigenous Tswana goats and sheep in Kasane, Maun and Shakawe districts in northwestern Botswana. *Onderstepoort Journal of Veterinary Research*, 73: 143–147.

12. Hyera, J.M.K and Baipoledi, E.K. (2008). A serological survey of African horse sickness in Botswana. *Journal of the South African Veterinary Association*, 79: 44–45.

13. Moagabo, K.T. and Baipoledi, E.K. (2008). Mortalities in goats and sheep in Botswana. *Bulletin of Animal Health and Production in Africa,* 56: 259-262.

14. Moagabo, K.T., Monyame, K.M., Baipoledi, E.K., Letshwenyo, M., Mapitse, N. and Hyera, J.M.K. (2009). A retrospective longitudinal study of animal and human rabies in Botswana 1989–2006. *Onderstepoort Journal of Veterinary Research,* 76: 399–407.

Number of professional staff: 71

Recurrent budget: BWP 7,449,000 ≈ US$ 9,310,125

INSTITUTIONS INVOLVED IN R&D

African Comprehensive HIV/AIDS Partnerships: advance research in HIV/AIDS prevention, care, treatment and support in Botswana.

Baylor Children's Hospital: education for health professionals and clinical research are an integral part of the centre's mission; collaborative education and training includes development of curricula on paediatric health and HIV/AIDS for health professionals, short-term USA–Africa exchange fellowships and long-term training for African health professionals at Baylor College of Medicine.

Botswana Harvard AIDS Partnership: undertakes research in matters related to HIV, such as prevention of mother to child transmission, analysis of the HIV virus and resistance to anti-retroviral drugs.

Botswana Technology Centre (BOTEC)[9]: engaged in R&D in renewable energy, electronic systems, sustainable architecture, energy efficiency and energy audits, wastewater management and ICTs. See also page 101.

Botswana Vaccine Institute: produces vaccines against livestock diseases.

Rural Industries Promotion Company Botswana (RIPCO)[9]**:** develops technologies in renewable energy, water treatment and pumping technologies, agricultural technologies and building technologies related to waste materials. See also page 101.

National Food Technology Research Centre: supports the food and agricultural industries to enhance national food security and safety, improve national nutritional well-being and promote economic diversification. See below for details.

Address: Private Bag 008, Kanye, Botswana

Telephone: +267 5445500

Name of executive head: Dr Charity Kerapeletswe-Kruger

Email: charike@naftec.org

Aims and responsibilities: this centre of excellence conducts research on food, nutrition and related areas; the centre has a mission to generate food technologies that enhance economic diversification, food security and quality through sustained R&D focused on the end user.

Key objectives: (a) To provide technical assistance to the agricultural industry and, in particular, the food processing sector, with the aim of expanding the industry to create jobs, facilitate import substitution and enhance food security; (b) To expand opportunities in the food sector by promoting the use of locally produced raw materials; (c) To ensure quality through the adoption of approved local and international standards;

Activities: (1) R&D on indigenous food products; (2) Commercialization of research outputs; (3) Assessment of food technologies for effective transfer in Botswana; (4) Promotion of good manufacturing practices; (5) Provision of general and specialized in-house and on-site training in food processing, nutrition and food safety; (6) Food analysis with respect to nutrition quality and food safety; (7) Provision of technical advice and extension services in food processing, nutrition and food safety; (8) Technical consultancies for clients; (9) Provision of information on all aspects of food processing; (10) Networking with similar institutions worldwide.

Priority level of the following functions:

- Planning/programming/budgeting of SETI activities: *highest priority*
- Promotion/financing/coordination of SETI activities: *highest priority*
- Application/transfer/assessment of SETI activities: *highest priority*
- Advocacy of SETI activities: *high priority*
- General policy advice: *high priority*

Frequency of professional contacts with the following organizations:

- Organizations of the UN system: *Regular professional contacts*
- Other intergovernmental organizations: *Regular professional contacts*
- International non-governmental organizations: *irregular professional contacts*
- National SETI policy bodies in foreign countries: *irregular professional contacts*

9 BOTEC and RIPCO merged while the current study was under preparation to form the Botswana Institute of Technology Research and Innovation (BITRI). The mandate and characteristics of the new institute are not yet available.

- Other institutions in foreign countries dealing with science, technology and innovation policy studies: *Regular professional contacts*

Number of professional staff: 35

Development budget: BWP5, 100,000 ≈ US$ 637,500

Recurrent budget: BWP 23,000,000 ≈ US$ 2,875,000

NON-GOVERNMENTAL ORGANIZATIONS

Somarelang Tikologo (Environment Watch Botswana) is a member-based environmental NGO located in Gaborone. It promotes sustainable environmental protection by educating, demonstrating and encouraging best practices in environmental planning, resource conservation and waste management in Botswana. It has a small staff and volunteer members who undertake numerous environmental awareness-raising activities throughout the community each year.

Thusano Lefatsheng Trust Is a rural development organization engaged in sustainable agriculture and natural resource management in rural Botswana.

Tshole Trust coordinates activities of stakeholders in used oil management in Botswana. The key delivery areas are: (1) Public education on used oil management; (2) Used oil management (provision of used oil collection tanks for public use) and (3) Coordination of stakeholders' relationships.

The Kalahari Conservation Society is the oldest environmental NGO in Botswana, specializing in protecting and managing wildlife and landscapes; it has lobbied effectively through advocacy and the provision of assistance to the government in policy-making; it collaborates on projects with other NGOs, the private sector and government departments to contribute to the conservation of Botswana's environment and wildlife. Services provided by the society include the coordination of research projects, community liaison and environmental education in schools and with community members.

Veld Products Research & Development: is a Botswana-based NGO involved in the sustainable utilization and management of veld products and natural resources for environmental and economic development. It was established in 1981 to conduct research and develop a wide range of veld products and to investigate suitable management systems for natural resources. In 1988, it began a long-term research programme on the domestication of indigenous fruit trees of economic importance from semi-arid areas. Later, a fruit tree nursery was established. In 1994, it formulated a community-based natural resources management programme in the central Kalahari, starting with three villages/settlements in the western Kwaneng District. The goal of this NGO is to conduct R&D projects in partnership with rural communities and households, to improve their quality of life through the sustainable utilization and management of natural resources. In order to achieve this, it: (1) engages in innovative research; (2) promotes human resource development on the basis of equal opportunity; (3) promotes systems enabling communities to develop their own strategies for utilizing their natural resources on a sustainable basis and (4) sets out to become an international centre of excellence in the utilization and management of veld products. Its objectives are: (a) to research all aspects of veld products, including identification, processing, production and marketing and the sustainable management of resources; (b) To improve the quality of life of rural people through the creation of income-generating activities and activities which ensure household food security based on natural resources; (c) to domesticate and genetically improve indigenous fruit trees and other plants of socio-economic importance.

INSTITUTIONS OF HIGHER EDUCATION

BOTHO UNIVERSITY

In 2013, Botho University celebrated its sixteenth anniversary. Originally created in 1997 as a computer training institute, in response to the government's call for capacity-building in ICTs, the institution became Botho College on 29 June 2009, a multidisciplinary education provider offering more than just computing programmes. In March 2013, Botho College obtained university status from the Tertiary Education Council, making it Botswana's first home-grown private university.

Botho aspires to become a centre of excellence in higher learning and a driver for positive social and economic change.

It operates according to a strong financial and viable business model, with the aim of providing a quality educational experience. Its academic programmes are continually benchmarked on national and international academic standards, in order to produce well-rounded employable graduates for the global market.

Table 10: University programmes at Botho University

Faculty	Programmes
Faculty of Computing	Diploma in Computing Professional Diploma in Computing BSc Computing BSc (Hons) in Mobile Computing BSc (Hons) in Network Security MSc in Computing
Faculty of Accounting and Finance	Association of Accounting Technicians Association of Chartered Certified Accountants Chartered Institute of management Accountants Botswana Institute of Chartered Accountants
Faculty of Business	BSc (Hons) in Business Management BSc (Hons) in Health Information Management
Faculty of Education and Continuing Studies	New venture creation course on starting and running a company Postgraduate Certificate in Higher Education

Source: Botho University

BOTSWANA COLLEGE OF AGRICULTURE

The Botswana College of Agriculture was established on 31 May 1991 through Act no. 9 of Parliament. The Act abolished the then Botswana Agricultural College which had existed since 1967. The college is a parastatal under the Ministry of Agriculture and an associate institution of the University of Botswana. As an associate institution, the college offers higher diploma and degree programmes in agricultural sciences and is responsible for its own short courses, offered by its Centre for In-service and Continuing Education.

Currently, the college is going through an exciting period of transformation, with the vision of becoming a university of international repute and the institution of choice in the region for training in agriculture. The college emphasizes innovation in teaching methods and research. Recently, it expanded its teaching facilities, ICT infrastructure, student accommodation and acquired state-of-the-art research equipment, in order to ensure quality programmes and broaden access to education.

Research is one of the main components of the college's vision and mission statements, in addition to teaching and service. The college endeavours to carry out relevant research in order to generate suitable technologies and provide relevant advisory services to the agricultural and related sectors in Botswana and beyond. The college has adequate human and physical resources for research distributed in the Departments of (a) Agricultural Economics, (b) Educations and Extension, (c) Agricultural Engineering and Land Planning, (d) Animal Science and Production, (e) Basic Sciences and (f) Crop Science and Production. The College Farm also has facilities for staff research, including the centre pivot irrigation system, various farm implements and animals.

Each department has developed research thrusts or themes under which research project proposals are developed. Research is funded through the college's Research and Publications Committee and international research funding organizations. Members of staff are encouraged to conduct collaborative research within and among departments, as well as with national and international institutions. The Research and Publications Committee funds the *Botswana Journal of Agricultural and Allied Sciences*.

Table 11: SETI-related programmes at the Botswana College of Agriculture

Programmes
Diploma courses
Higher Diploma in Agriculture
Higher Diploma in Animal Health and Production
Higher Diploma in Forestry and Range Ecology
Bachelor degree programmes
Bachelor of Science (Agricultural Education)
Bachelor of Science (Animal Science)
Bachelor of Science (Agriculture)
Bachelor of Science (Crop Science)
Bachelor of Science (Agricultural Mechanisation)
Bachelor of Science (Agricultural Economics)
Bachelor of Science (Soil and Water Conservation Engineering)
Master Degree Programs
Master of Science (Agricultural Education)
Master of Science (Agricultural Engineering)
Master of Science (Animal Science)
Master of Science (Crop Science)

Source: Botswana College of Agriculture

BOTSWANA INTERNATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

The Botswana International University of Science and Technology is situated north of Gaborone. It opened its doors to the first 267 students in September 2012, after being approved by Parliament in 2006.

The young university is committed to offering broad opportunities at the national, regional and international levels for higher education in science, engineering and technology, as well as for applied research. The university's standing as an international centre of higher learning and innovation is growing, thanks to its network of partner universities across the world. Academics known for excellence in their core disciplines, for the breadth of their experience and for wider skills such as creativity, critical thinking, communication, innovation and leadership, are responsible for creating new knowledge and for the transfer of knowledge in a diverse community of scholars, teachers and researchers.

The university's mission it to provide globally competitive and high-quality academic programmes in science, engineering and technology, in order to produce employment-ready graduates through excellence in teaching and learning, research, collaborative partnerships, industry linkages and community engagement.

The university's strategic goals are (a) capacity-building: to increase the number of local citizens with degrees in science, engineering and technology; (b) economic development; (c) to engage in applied research that can be used to solve problems in Botswana and the wider SADC region; and (d) to earn a reputation as a centre of excellence in science, engineering and technology in the region.

Table 12: SETI-related programmes at the Botswana International University of Science and Technology

College	Departments	Undergraduate programmes
Engineering and Technology	The Department of Computer, Information and Computer Engineering (CITE)	BSc Information Technology
		BEng Computer Engineering
		BEng Telecommunications Engineering
	Department of Mining, Energy and Geological Engineering	BEng Mining Engineering
		BEng Energy Engineering
		BEng Geological Engineering
Science	Department of Earth & Environmental	BSc Geology
		BSc Earth & Environmental
	Department of Applied Science	BSc Applied Math
		BSc Applied Science

Source: Botswana International University of Science and Technology

LIMKOKWING UNIVERSITY

Limkokwing University is an international university with a global presence across three continents. Over 30,000 students from more than 150 countries study on the 12 campuses in Botswana, Cambodia, China, Indonesia, Lesotho, Malaysia, Swaziland and the United Kingdom. The university is known for its innovative brand of creative education merging the best of education from east and west.

The university's vision is to create a partnership of young people to make the world a better place. The aim is to stimuate creative and innovative abilities to develop new streams for wealth creation and new initiatives for societal advancement.

The university's vision is that it takes a special kind of skill to rise above the rest and excel in today's fast-moving world. It requires left-brain, right-brain thinking that enables a person to concentrate, conceptualize and connect. It is all about synthesizing information and arriving at innovation.

Half of the world's population comprises of youth under the age of 25. Few, if any, are involved in making decisions that affect their way of life, their desires, their interests and their future. The university envisions a time when youth from all parts of the world will be engaged in all the socio-economic sectors where issues affecting young people are debated and decisions made. The aim is to promote a global network of youth empowered with the skills and knowledge to contribute to world economics.

Table 13: SETI-related programmes at Limkokwing University

Faculties	Undergraduate programmes
Faculty of Design Innovation	Associate Degree in Packaging Design and Technology Bachelor of Design (Hons) in Professional Design (Visual Communication) Bachelor of Arts (Hons) in Industrial Design
Faculty of Information & Communication Technology	Associate Degree in Business Information Technology Associate Degree in Software Engineering Associate Degree in Business Information Systems Associate Degree in Information Technology Associate Degree in Mobile Computing Associate Degree in Multimedia and Software Engineering Bachelor of Science (Hons) in Electronic Commerce Bachelor of Science (Hons) in Information Technology Bachelor of Science (Hons) in Software Engineering with Multimedia

Source: Limkokwing University

UNIVERSITY OF BOTSWANA

The University of Basutoland, Bechuanaland and Swaziland opened on 1 January 1964, the outcome of an agreement reached in mid-1962 between the High Commission Territories and the Oblate of Mary Immaculate of the Pius XII Catholic University in Roma, Lesotho. On 13 June 1963, a deed of cession and indemnity was signed by the Oblates and the High Commissioner of Basutoland, Bechuanaland and Swaziland. The new university used funds from the Ford Foundation and British government to purchase the assets of the Roma Campus for an indemnity of half of its value, in exchange for guarantees of a continuing Catholic presence on the campus.

From a roll of 188 students in 1964, the university had swelled to 402 students by 1970, some 145 of whom came from Lesotho, with lesser numbers from Swaziland, Botswana, Rhodesia (former Zimbabwe), South Africa and elsewhere. The university conferred its first degrees in April 1967 after a transitional period during which the former Pius XII College students continued to take University of South Africa degrees.

In those days, the university offered its own four-year undergraduate degrees and diplomas in Arts (including economics and administration), Science and Education, with Law students following a five-year degree, including a two-year tuition period at the University of Edinburgh.

Students seeking specialized degrees in Medicine, Engineering, etc., proceeded to other universities after completing the first segment of their studies (years 1 and 2) in Science. The number of academic

staff doubled from 31 in 1964 to 78 in 1970. The personnel were recruited from many countries but the university pursued an active localization policy from 1971 onwards.

In the first phase of its existence during 1964–1970, the university changed its name to the University of Botswana, Lesotho and Swaziland. The university received funding from the governments of all three countries but had a comparatively modest physical presence in Botswana and Swaziland. The only substantial devolution of the university from its Roma Campus came towards the end of this phase. The Swaziland Agricultural College of Luyengo was associated with the University of Botswana, Lesotho and Swaziland, as the Swaziland Agricultural College and University Centre. Built for the Swazi government with Oxfam and 'Freedom from Hunger' funds, the Swaziland Agricultural College had opened in 1966.

In 1970, the Swazi government agreed to hand over the Swaziland Agricultural College to the University of Botswana, Lesotho and Swaziland, together with the Research Division of the Ministry of Agriculture and its experimental station at Malkerns near Luyengo. From 1972 onwards, these together constituted a new Faculty of Agriculture. In Botswana, the presence of the University of Botswana, Lesotho and Swaziland was limited to the energies of the Division of Extra- Mural Services and the School of Education, together with a small Short-Course Centre built during 1969. With independence, the three countries began to take a closer look at the colonial inheritance of education, including their joint university, and to identify the role the University of Botswana, Lesotho and Swaziland could play in higher and middle-level training.

Following the creation of the National University of Lesotho and the appropriation of all property in Lesotho belonging to the University of Botswana, Lesotho and Swaziland, students from Botswana and Swaziland were immediately withdrawn from the Roma campus. Teaching resumed within a few months in Botswana (Economics and Social Studies and Science) and in Swaziland (Law). Following the acceptance of the *Hunter Report* and further negotiations between the University and the Governments of Botswana and Swaziland, the University of Botswana, Lesotho and Swaziland was transformed into the University of Botswana and Swaziland, with two constituent colleges, the University College of Botswana and the University College of Swaziland.

The new university structure was dedicated to serving the ideals previously laid-out for the University of Botswana, Lesotho and Swaziland by the Botswana and Swazi governments. These ideals were summed up in the Second National Development Plan of Swaziland, which saw as playing an increasingly important role 'in national development, not only through the provision of the educated manpower needed, but also through the university's great potential as a focus for the academic and cultural activities of the nation.'

The years 1976 and 1982 saw both constituent colleges of the university develop their physical resources and academic programmes in close concertation, with the eventual establishment of separate national universities on 1 July 1982. The University of Botswana was formally inaugurated on 23 October 1982 by His Excellency Sir Ketumile Masire, President of the Republic of Botswana.

The Universities of Botswana and Swaziland pursued their collaboration until 31 December 1982 for the purpose of examining and awarding degrees, diplomas and certificates. Even today, the national universities in Botswana and Swaziland continue to exchange students and cooperate in certain areas. To that end, a consultative machinery has been put in place to proffer advice on how best to cooperate for mutual benefit.

The university aims to be a leading academic centre of excellence in Africa and the world. It has set itself the goal of becoming a research-intensive university by 2021. This entails two commitments: first, a commitment to undertaking pioneering research relevant to local needs and; second, a commitment to ensuring that this research is conducted in conformity with the highest ethical standards.

The university's mission is to improve socio-economic conditions while advancing as a distinctly African university with a regional and international outlook. Specifically, the university strives to: (a) provide excellence in the delivery of learning to ensure society is provided with talented, creative and confident

graduates; (b) advance knowledge and understanding through excellence in research and its applications; and (c) improve socio-economic development through a high-impact engagement with business, the various professions, government and civil society.

Table 14: Distribution of students and staff at the University of Botswana, 2013

Students (2013)	Staff (2013)
Overall total: 17,678 Full-time: 14,488 Part-time: 2,587 Distance Learning: 603 Male: 7,953 Female: 9,725 Under graduate: 16,308 Post graduate: 1,370	Total Staff: 2,793 Executive Management: 4 Support Staff: 1,500 Academic Staff: 877 Industrial Staff: 412 Academic: 31% Support: 54% Industrial: 15%

Source: University of Botswana

Table 15: SETI undergraduate and graduate studies at the University of Botswana, 2013

Faculties and schools	SETI*-related undergraduate studies and degrees	SETI*-related graduate studies and degrees
Centre for Continuing Education	Bachelor of Science in Radiation and Health Physics	MPhil/PhD in Natural Resources Management
Faculty of Business	Bachelor of Science in Physics with Meteorology	MPhil and PhD in Statistics
Faculty of Education	Bachelor of Science in Applied Geophysics	Master of Arts Degree in Statistics
Faculty of Engineering and Technology	Bachelor of Science (Information Technology)	Master of Arts Degree in Development Studies
Faculty of Health Sciences	Bachelor of Science (Computing with Finance)	Master of Arts Degree in Population Studies
Faculty of Humanities	Bachelor of Science (Computer Science)	MPhil/PhD in Economics
Faculty of Science	Bachelor of Science	Master of Arts Degree in Economics / Applied Economics
Faculty of Social Sciences	Bachelor of Information Systems (Computer Information Systems)	MPhil and PhD Degrees in Physics
School of Graduate Studies	Bachelor of Library and Information Studies	Master of Science Degree in Physics
Research and Development	Bachelor of Information Systems (Information Management)	MPhil and PhD Degrees in Mathematics
	Bachelor of Science (Medical Laboratory Sciences) (completion/upgrade programme)	Master of Science Degree in Mathematics
	Bachelor of Medicine Bachelor of Surgery	Master of Science Degree Programme in Hydrogeology
	Bachelor of Science (Medical Laboratory Sciences)	MPhil and PhD Degrees in Environmental Science
	Bachelor of Science (Environmental Health or BSc- EH degree)	Master of Science Degree in Environmental Science
	Bachelor of Engineering (Electrical and Electronic Engineering)	Master of Science Degree with specializations in Computer Science and Computer Information Systems

Faculties and schools	SETI*-related undergraduate studies and degrees	SETI*-related graduate studies and degrees
	Bachelor of Engineering (Construction Engineering & Management)	MPhil and PhD Degrees in Chemistry
	Bachelor of Science/Master of Arts Professional Degree in Urban and Regional Planning	Master of Science Degree in Chemistry
	Bachelor of Science (Real Estate)	MPhil and PhD Degrees in Biological Sciences
	Bachelor of Science (Mining Engineering)	Master of Science Degree in Applied Microbiology
	Bachelor of Industrial Engineering	Master in Medicine
	Bachelor of Engineering (Mineral Engineering)	Master of Science Degree in Mechanical Engineering
	Bachelor of Engineering (Mechanical Engineering)	Master of Science Degree in Electrical/ Electronic Engineering
	Bachelor of Engineering (Civil Engineering)	Master of Science Degree in Civil Engineering
	Bachelor of Science (Urban and Regional Planning)	Master of Education Degree in Mathematics Education and Science Education
	Bachelor of Education (Science)	Master of Education Degree in Research and Evaluation
	Bachelor of Business Administration (Entrepreneurship and Enterprise Development)	Modular Master in Science, Research and Educational Management
	Bachelor of Information Systems (Business Information Systems)	

*Includes basic and engineering sciences, social sciences and education in science degrees.

Source: University of Botswana

Research centres of the University of Botswana

Okavango Research Institute: The Okavango Research Institute (ORI) studies and conserves one of the largest and most intact inland wetland ecosystems, the Okavango Delta, as well as other southern African wetlands, river basins, watersheds and surrounding dry lands. The research institute was founded in response to plans to use the Okavango for a large-scale water supply programme.

Centre for Scientific Research, Indigenous Knowledge and Innovation: From the outset, the main aim has been to bring researchers from various disciplines together from different university departments to carry out research on indigenous knowledge. Previously, scientists from a range of disciplines had been working independently, defeating the goal of understanding issues from different angles.

Centre for the Study of HIV and AIDS: The primary purpose is to support and encourage an interdisciplinary approach to understanding and addressing the challenges that HIV and AIDS have presented to the nation.

Centre of Specialisation in Public Administrator Management: Its mandate is to educate leaders in the SADC public sector in best practices with regard to public administration and management, to empower them to lead and manage their respective organizations efficiently and effectively.

San Research Centre: This multidisciplinary research centre welcomes participation from researchers who have demonstrated an interest in San research within the University of Botswana, SADC region and beyond.

NETWORKING AND SUPPORT INSTITUTIONS

BOTSWANA AGRICULTURE HUB

The hub operates in conjunction with the Ministry of Agriculture and is in a position to interact fully with other hubs, ministries, parastatals, the private sector and others (see also page 14). The following projects and initiatives are part of the hub, which may make recommendations, undertake negotiations and otherwise intervene to enable their timely implementation: (1) National Agricultural Master Plan for Arable Agriculture and Dairy Development; (2) Proposed Zambezi Integrated Agro-Commercial Development Project; (3) Agricultural Infrastructural Development Initiative; (4) Establishment of Agricultural Service Centres within the Master Plan; (5) Facilitation of the establishment of the Contributory Agricultural Insurance Scheme in Botswana; (6) Facilitation of the establishment of State farms around dams and sewage ponds (arable and horticultural); (7) Restructuring of Botswana Meat Commission; (8) Restructuring of Banyana Ranch and other state-owned ranches (cattle sector).

BOTSWANA BUREAU OF STANDARDS

Following the adoption of the Standards Act by Parliament in 1995, the Botswana Bureau of Standards became a parastatal in April 1997, as envisaged in the Act. It is governed by a 12-member Standards Council, appointed by Minister of Trade and Industry. It is the official body responsible for all issues related to standardization and quality assurance at the national level. It offers technical services in the areas of standardization, goods testing, certification of products, industrial and trade metrology, quality management systems, environmental management systems, information and training. The bureau is a full member of the International Organization for Standardization and the national contact point for all SADC programmes related to standardization and quality assurance. It is also a member of the World Trade Organization.

BOTSWANA DIAMOND HUB

With 16 diamond factories in operation and five additional plants being established, Botswana's 'diamond hub" diversification programme is readying to move beyond the cutting and polishing stage. The diversification strategy hinges on four areas, namely: the promotion of cutting and polishing, establishing rough trading in the country, the development of a jewellery manufacturing industry and the establishment of support services for the diamond industry. Developing an attractive, efficient rough trading platform is a vital step in ensuring the long-term sustainability of Botswana's diamond industry. The additional volume of goods promoted by the Diamond Hub will benefit Botswana's economy (see also page 16).

BOTSWANA EDUCATION HUB

The objectives of this hub were approved by the Government Implementation Coordinating Office. They are to: (1) make Botswana a regional centre of excellence; (2) promote economic diversification and sustainable growth through the provision of quality education; (3) provide training, and research in key strategic areas such as science, technology and engineering, conservation, mining, hospitality and tourism, finance and business management, in order to create business and employment opportunities; (4) facilitate the alignment of skills development with national requirements by supporting the initiatives of other hubs and sectors through the provision of appropriate skills; (5) promote quality and access to education from the pre-primary to secondary levels, to ensure a sufficient pool of qualified students in key areas to feed into tertiary education; (6) encourage local participation in the provision of quality education and attract high-quality foreign players in terms of faculty, students and investors by creating an environment conducive to the provision of both local and foreign education; and (7) make Botswana a preferred and premiere destination for education in the region and beyond.

BOTSWANA HEALTH HUB

The hub functions under the Ministry of Health. Its objectives are to: (1) enhance service delivery through strategic public–private partnerships and outsourcing of selected services; (2) establish clinical centres and research centres of excellence that can serve both the region and international clients; (3) promote 'medical tourism' to cater for local, regional and international healthcare needs; (4) identify ways in which the delivery of high-quality health services can contribute to economic diversification and employment creation; (5) establish clinical and research centres of excellence in Botswana that can service SADC and international clients; and (6) stimulate focused initiatives that have a direct impact on the efficiency and quality of public healthcare in Botswana. The hub is responsible for: (a) driving strategic initiatives allocated to the hub; (b) intra-government liaison; (c) private-sector liaison and participation; (d) stakeholder communication and integration; and (e) funding. The hub's priority areas for Botswana are to: (i) become a centre of excellence for cancer treatment; (ii) provide a high-quality facility for orthopaedic services; (iii) provide modern treatment facilities, including cardio-vascular surgery; (iv) provide organ transplant services; (v) provide neurological treatment facilities; (vi) support the pharmaceutical industry; and (vii) develop high-quality diagnostic facilities (imaging and laboratory).

BOTSWANA INNOVATION HUB

This hub is a product of the Botswana Excellence Strategy of 2008, which proposed a three-pronged national strategic goal of economic diversification, job creation and a shift towards a knowledge-based economy. This hub is also aligned with *Vision 2016*'s pillar of achieving a prosperous, productive and innovative nation. The hub has been incorporated as a company to develop and operate Botswana's first science and technology park. The company is mandated to support new ventures and existing companies, as well as attract companies, universities, research and advanced training institutes to establish the science and technology park. This is intended to help transform Botswana into a technology-driven, knowledge-based economy, by promoting a culture of innovation and competitiveness among its associated companies and knowledge-based institutions (see also page 15 and page 99).

DEPARTMENT OF RADIATION PROTECTION

Established in April 2008, this department has a mandate is to ensure the safe use of atomic energy and nuclear technology. To achieve its mandate, the department is responsible for carrying out licensing and statutory inspections of all facilities that use nuclear sources and radiation-generating equipment, such as x-ray machines. As such, the department is responsible for enforcing the following: (1) medical exposure

control, which prevents possible overdoses during cancer treatment; (2) occupational exposure control to protect employees working with nuclear sources from the adverse effects of radiation that can lead to cancer, sterility and other associated illnesses; (3) public and environmental exposure control to protect the public, flora and fauna from short- and long-term effects of ionizing radiation; and (4) emergency preparedness and response to mitigate the effects of radiological emergencies that can result in injuries, contamination of the environment and damage to property.

LAMWORLD TECHNOLOGIES (PTY) LTD

This company is 100% owned by Botswana citizens. Since its inception in 2004, the company has become a reputable service provider in several fields. Lamworld has fully equipped ISO/IEC 17025 calibration laboratories and maintenance workshops and a contingent of experienced personnel of both a technical and managerial nature. This company provides technology, engineering and related industrial support services and solutions on the basis of a long-term partnership, in order to assist target industries in Botswana and the region in achieving global competitiveness.

NEW CENTRES ENVISIONED BY THE NATIONAL POLICY ON RESEARCH, SCIENCE, TECHNOLOGY AND INNOVATION

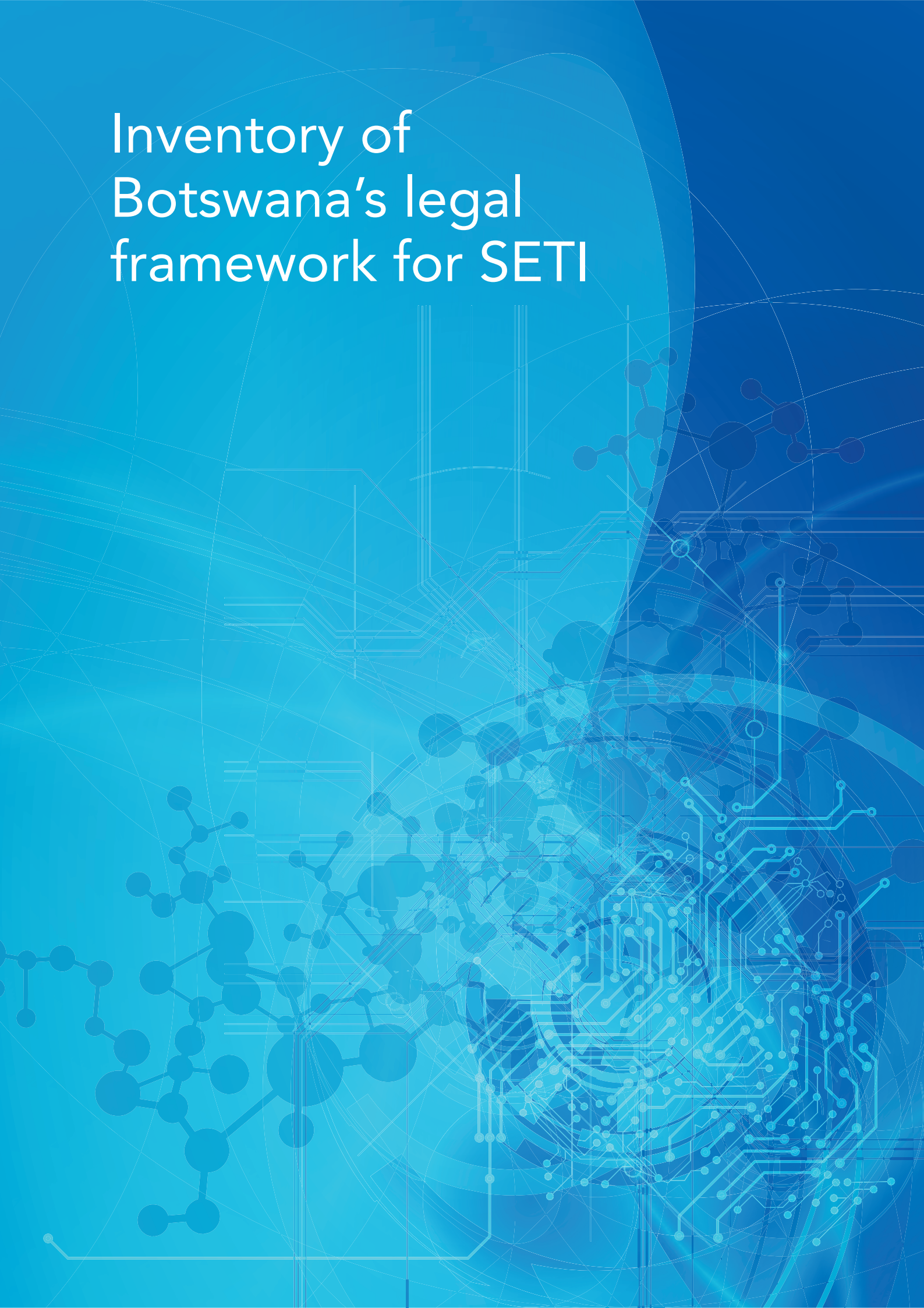
BOTSWANA RESEARCH CENTRES OF EXCELLENCE AND OTHER RESEARCH INSTITUTIONS

A good research institution is defined as offering a collection of complementary skills and competencies that can deliver a variety of quality research products, systems and services to the market place. Existing research and innovation institutions will continue to be rationalised to create Botswana research centres of excellence; these parastatal organizations will operate under different ministries, in line with the ongoing exercise to rationalize research organizations. The research centres will receive government subventions to cover basic needs and conduct short-term research for the public good. The centres will also compete for funding from the Botswana National Research, Development and Innovation Coordinating Council to develop technologies according to national priorities and goals and conduct world-class research that demonstrates intellectual merit, advances in knowledge and tangible benefits to society. Each centre will also generate its research budget from contract research with the private sector or foreign governments.

Institutions of higher learning, and private research and individual researchers wiall also compete for funding and participate in the development, diffusion and adoption of technologies. The form and size of institutions will evolve in response to the market for research over time. In this respect, the funding and commissioning bodies will award fully priced research contracts on a competitive basis to research providers that demonstrate required expertise and capability.

Research institutions will establish structures/organs for internal coordination of the research conducted by staff and any individuals affiliated to them (including students). They will achieve this by reviewing, approving and monitoring all research conducted by such individuals. Institutions will prepare and submit annual reports to the Botswana National Research, Development and Innovation Coordinating Council as a way of ensuring that the Council is kept apprised of all research conducted in the country.

Inventory of Botswana's legal framework for SETI



1. NATIONAL LAWS AND ACTS

NOXIOUS WEEDS

Enacted date: 1916, amended June, 1968 (Cap.35:04 of 1916)

Description: Allows for the control of arable and aquatic weeds by making land owners or occupiers responsible for destruction of weeds. 27 weeds listed, many of which occur in wetlands

Site: www.eis.gov.bw

FOREST ACT

Enacted date: 1968 (Cap.38:04 of 1968)

Description: The Act gazetted forest reserves, protected trees and the control of forest products. There is provision for the protection of trees on state land that occur within 10 m of a riverbank

Site: www.eis.gov.bw

ATMOSPHERIC POLLUTION (PREVENTION)

Enacted date: 1971 (Cap.65:03 of 1971)

Description: Provide for the prevention of pollution of the atmosphere by the carrying on of industrial processes and for matters incidental thereto

Site: www.eis.gov.bw

MINES, QUARRIES, WORKS AND MACHINERY

Enacted date: 1978 (Cap.44:02 of 1978)

Description: Generally aimed at working conditions but includes sections on slimes dams, fuel and oil spills and effluent water

Site: www.eis.gov.bw

PUBLIC HEALTH ACT

Enacted date: 1981, amended on 26 August, 1983 (Cap.63:01 of 1981)

Description: Protects the quality of water used by the public, by controlling the disposal of polluted water and control of mosquito larvae.

Site: www.eis.gov.bw

WASTE MANAGEMENT ACT

Enacted date: 1999 (Cap.40.02 of 1999)

Description: Management of controlled and hazardous waste. Provision of waste management plans; identification of waste management sites and control of groundwater pollution.

Site: www.eis.gov.bw

ENVIRONMENTAL ASSESSMENT ACT

Enacted date: 2005 (No. 6)

Description: Provides for the environmental impact assessments to be used to assess the potential effects of planned developmental activities; to determine and to provide mitigation measures for effects of such activities as may have a significant adverse impact on the environment; to put in place a monitoring process and evaluation of the environmental impacts of implemented activities; and to provide for matters incidental to the foregoing

Site: www.eis.gov.bw

VALUE ADDED TAX ACT

Enacted date: 2001, amended in 2006

Description: Copyright and related rights (neighbouring rights), enforcement of intellectual property and related laws, industrial designs, industrial property, other, patents (inventions), trademarks, undisclosed information (trade secrets). For provisions concerning the protection of intellectual property: see the First & Third Schedule for further details.

Site: http://www.wipo.int/wipolex/en/details.jsp?id=10503

AGRICULTURAL RESOURCES (CONSERVATION) ACT

Title: Agricultural Resources (Conservation) Act:

Enacted date: 1973, amended December 2006 (Cap.35:06 of 1973)

Description: Provides for the conservation of Botswana's agricultural resources. The Act defines agricultural resources as animals, birds, plants, waters, soils, vegetation and vegetation products, fish, insects, etc.

Site: www.eis.gov.bw

COPYRIGHT & NEIGHBOURING RIGHTS ACT

Enacted date: 2000, amended on December 2006

Description: Copyright and related rights (neighbouring rights), enforcement of intellectual property and related laws, intellectual property regulatory body, traditional cultural expressions.

Site: www.wipo.int/wipolex/en/details.jsp?id=9583

COMPANIES ACT

Enacted date: 2007

Description: Competition, enforcement of intellectual property and related laws, intellectual property regulatory body, trade names. For provisions concerning the protection of intellectual property: see Part IV for further details.

Site: www.wipo.int/wipolex/en/details.jsp?id=10492

COPYRIGHT & NEIGHBOURING RIGHTS REGULATIONS

Enacted date: 2008

Description: Copyright and related rights (neighbouring rights), intellectual property regulatory body

Site: www.wipo.int/wipolex/en/details.jsp?id=9601

COMPETITION ACT

Enacted date: 2009

Description: Competition, enforcement of intellectual property and related laws. For provisions concerning the protection of intellectual property, see Part I, paragraph 3 for further details.

Site: www.wipo.int/wipolex/en/details.jsp?id=9895

INDUSTRIAL PROPERTY ACT

Enacted date: 2010. Governing regulations passed in September 2012. Chapter 68:03 of the Laws of Botswana

Description: The Act provides for the protection of new, industrially applicable solutions to problems in any field of technology that involve inventive step. It also provides for the protection of utility models, industrial designs, layout circuits of integrated circuits, traditional knowledge and handicrafts. The Act recognizes the Patent Cooperation Treaty and the Harare Protocol which can be used for international protection of qualifying science and technology based research output.

Site: www.wipo.int/wipolex/en/details.jsp?id=9602

INDUSTRIAL PROPERTY ACT

Enacted date: 2012

Description: Implementing rules/regulations; geographical indications, industrial design, industrial property, layout design of integrated circuits, patents (Inventions), trademarks, traditional cultural expressions, traditional knowledge (see page 106, utility models. These regulations were published on 31 August 2012. This commenced the Industrial Property Act of 2010.

Site: www.wipo.int/wipolex/en/details.jsp?id=12792

2. NATIONAL REGULATIONS AND POLICIES

WILDLIFE CONSERVATION POLICY

Enacted date: 1986

Description: This policy paper not only recognizes but also emphasizes the need to obtain a better yield or economic return from land allocated for wildlife while at the same time ensuring the continuity of this resource

Site: www.eis.gov.bw

NATIONAL POLICY ON NATURAL RESOURCES CONSERVATION AND DEVELOPMENT

Enacted date: 1990

Description: The primary goals in formulating the strategy are to pursue policies and measure which increase the effectiveness with which natural resources are used and managed, so that beneficial interactions are optimised and harmful environmental side-effects are minimized

Site: www.eis.gov.bw

NATIONAL POLICY ON AGRICULTURAL DEVELOPMENT

Enacted date: 1991

Description: The policy acknowledges the need for technological development in agriculture and calls for the development of a technology development policy. The policy is currently under review. It was later complemented by the following policy instruments: Arable Land Development Programme; Accelerated Rainfed Arable Programme; National Master Plan for Arable Agriculture and Dairy Development; Integrated Support Programme for Arable Agriculture Development and; the Livestock Management and Infrastructure Development programme.

Site: www.eis.gov.bw

NATIONAL POLICY ON EDUCATION

Enacted date: 1994

Description: The policy recognizes the need for increased emphasis on science and technology in the education system.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Education-MoE

NATIONAL YOUTH POLICY

Enacted date: 1996

Description: The policy encourages youth to get involved in research, science and technology.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Youth-Sport-and-Culture-MYSC

NATIONAL POLICY ON VOCATIONAL EDUCATION AND TRAINING

Enacted date: 1997

Description: Alignment is not clear, however, vocational training is critical in S&T and in research.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Education-MoE

BOTSWANA'S STRATEGY FOR WASTE MANAGEMENT

Enacted date: 1998

Description: It can be seen that the current situation in Botswana is far from perfect and that the solutions which need to be introduced are complex. Botswana needs a solution which is at the same time environmentally accepted and also affordable, within the constraints of limited financial and trained human resources. For these reasons, as many other countries have already decided, Botswana needs a national waste management strategy to achieve maximum impact at minimum cost.

Site: www.eis.gov.bw

INDUSTRIAL DEVELOPMENT POLICY

Enacted date: 1998

Description: There is alignment, however research, science, technology and innovation should be used for the beneficiation of local natural resources and job creation.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Trade-and-Industry-MTI

SMALL, MEDIUM AND MICRO-ENTERPRISES POLICY

Enacted date: 1999

Description: The policy refers to institutions whose research will be required to advance research, science and technology; it recommends funding for these institutions. Further, the policy expects these institutions to provide small, medium-sized and micro-enterprises with support through consultancies that promote technology acquisition, adaptation and transfer. It was followed by two instruments: Small Business Act (2004) and the Local Enterprise Authority (2005).

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Trade-and-Industry-MTI

PRIVATISATION POLICY

Enacted date: 2000

Description: The policy provides an opportunity for R&D institutions to privatize routine services which do not contribute to innovation and to promote the use of public–private partnerships for STI projects.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Trade-and-Industry-MTI

NATIONAL POLICY ON HOUSING IN BOTSWANA

Enacted date: 2000

Description: The policy notes the need for more effort by research institutions such as the Botswana Technology Centre (see page 101) and the Rural Industries Promotion Company Botswana to research and develop acceptable quality local building materials.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Lands-and-Housing

NATIONAL POLICY ON CULTURE

Enacted date: 2001

Description: The policy specifies the need for research to support the national effort to conserve and promote Botswana culture.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Youth-Sport-and-Culture-MYSC

NATIONAL ECOTOURISM STRATEGY

Enacted date: 2002

Description: The goal is to create an environment in which elements of tourism development planning and management facilitate, promote and reward adherence to the key 'principles' of ecotourism by all of those involved in the tourism industry

Site: www.eis.gov.bw

REVISED NATIONAL POLICY ON DESTITUTE PERSONS

Enacted date: 2002

Description: There is no alignment, however, the policy provides an opportunity to use research and S&T to reduce poverty.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Local-Government-MLG1

REVISED NATIONAL POLICY FOR RURAL DEVELOPMENT

Enacted date: 2002

Description: The policy creates an opportunity for research into the identification and exploitation of profitable alternatives to livestock and arable agriculture, exploitation of natural resources and increased agricultural activity.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Local-Government-MLG1

NATIONAL COMPETITION POLICY FOR BOTSWANA

Enacted date: 2005

Description: Competition, copyright and related rights (neighbouring rights), industrial property, patents (inventions), trademarks. Limited alignment. However, several issues of the policy provide an environment for fair research, STI for economic development. It was followed by three instruments: Competition Act (2009); Competition Authority (2011) and the Competition Commission (2012).

Site: www.wipo.int/wipolex/en/details.jsp?id=9896

COMMUNITY BASED NATURAL RESOURCES MANAGEMENT POLICY

Enacted date: 2007

Description: The overall goal is to create a foundation for conservation-based development, in which the need to protect biodiversity and ecosystems is balanced with the need to improve rural livelihoods and reduce poverty. This will be achieved by providing the community with diversified livelihoods and economic options, opportunities and incentives and by managing and using the country's natural resources in a sustainable manner

Site: www.eis.gov.bw

NATIONAL INFORMATION AND COMMUNICATIONS TECHNOLOGY POLICY

Enacted date: 2007

Description: The policy calls for a culture of lifelong learning that maximizes the potential within all citizens and accelerates innovation to develop knowledge-based systems and ICT infrastructure which will support research and STI.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Transport-and-Communications

TERTIARY EDUCATION POLICY

Enacted date: 2008

Description: The policy addresses research and innovation and requires the tertiary education system to play a leading role in transforming Botswana into a knowledge-driven innovative society. Further, the tertiary education system, and its constituent parts must sharpen their research focus significantly and ensure a proper integration of their efforts with the needs of the country.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Education-MoE

COPYRIGHT AND NEIGHBOURING RIGHTS REGULATIONS

Enacted date: 2008

Description: Implementing rules/regulations; copyright and related rights (neighbouring rights), intellectual property regulatory body.

Site: www.wipo.int/wipolex/en/details.jsp?id=9601

FIRST SCHEDULE RELATING TO INDUSTRIAL PROPERTY RIGHTS APPLICATION FORMS AND SECOND SCHEDULE RELATING TO FEES

Enacted date: 2010

Description: Copyright and related rights (neighbouring rights), geographical indications, industrial Design, iIndustrial iroperty, intellectual property regulatory body, layout design of integrated circuits, patents (inventions), trademarks, traditional knowledge. First Schedule includes Forms 1–23 for various kinds of industrial property rights. Second Schedule includes fees for patents, utility model certificates, marks, designs, geographical indications, layout designs and traditional knowledge.

Site: www.wipo.int/wipolex/en/details.jsp?id=13114

NATIONAL BIOSAFETY POLICY

Enacted date: 2010

Description: The policy regulates and monitors the application of biotechnology and promotes its development by ensuring the application of biosafety measure to regulate the protection of biological resources, in order to ensure sustainable use of biological resources, protection of human health and to minimize the adverse socio-economic impact of biotechnology.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/MinistryofHealth-MOH

REVISED NATIONAL YOUTH POLICY

Enacted date: 2010

Description: The policy encourages youth to get involved in research and S&T, in particular ICT. It was followed by two instruments: Young Farmers Fund and the Youth Development Fund.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Youth-Sport-and-Culture-MYSC

NATIONAL POLICY ON RESEARCH, SCIENCE, TECHNOLOGY AND INNOVATION

Enacted date: 1998, revised in 2011

Description: Government commits to implementing the policy to facilitate and promote the application of S&T to enable sustainable economic development, growth and diversification in the context of a highly competitive, globalized and rapidly changing nation

Site: www.eis.gov.bw

NATIONAL POLICY ON RESEARCH, SCIENCE, TECHNOLOGY AND INNOVATION IMPLEMENTATION PLAN

Enacted date: 2012

Description: Based on the *National Policy on Research, Science, Technology and Innovation* of 2011, a detailed implementation strategy is hereby presented, defining priorities and action plan. The policy represents Botswana's commitment to diversify her economy, attain global competitiveness, and enhance quality of life of the Batswana through development, adaptation and application of research, innovation, and technology.

Site: www.eis.gov.bw

FORESTRY POLICY

Enacted date: 2011

Description: The goal is to optimize the contribution of forest and range resources to the long term socio-economic development of Botswana by ensuring equitable and sustainable flow of benefits to the population.

Site: www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Environment--Wildlife-and-Tourism

NATIONAL HEALTH POLICY

Enacted date: 2011

Description: The goal is to develop and implement a research agenda in collaboration with relevant partners to support national policy development. The Health Research Agenda has been developed and has identified priority areas for health research.

Site: www.moh.gov.bw

NATIONAL INTEGRATED TRANSPORT POLICY

Enacted date: 2012

Description: The policy calls for the development of an R&D programme to increase the lifespan of roads, use of better materials and better workmanship. Under railway transport, the policy calls for the development and implementation of an R&D strategy to modernize railway transport.

Site: http://www.gov.bw/en/Ministries--Authorities/Ministries/Ministry-of-Transport-and-Communications

3. INTERNATIONAL AGREEMENTS

SOUTH AFRICA

Title: Agreement between the Government of the Republic of Botswana and the Government of the Republic of South Africa on Scientific and Technological Cooperation

Enacted date: 9 August 2005

Description: The objective is to promote and support the development of cooperation in S&T fields between the two countries through the exchange of scientists, information and joint formulation and implementation of R&Dprogrammes, seminars, conferences and workshops.

INDIA

Title: Agreement between the Government of the Republic of Botswana and the Government of the Republic of India in the fields of Science and Technology

Enacted date: 17 June 2010

Description: The objective is to promote and support the development of cooperation in S&T fields between the two countries through the exchange of scientists, information and joint formulation and implementation of R&D programmes, seminars and joint research projects

CHINA

Title: Memorandum of Understanding on Scientific and Technological Cooperation between the Ministry of Infrastructure, Science and Technology of the Republic of Botswana and the Ministry of Science and Technology of the People's Republic of China

Enacted date: 1 December 2011

Description: The purpose is to enhance cooperation between the two countries, to encourage cooperation between ministries, institutions, communities and other organizations. Priority areas include formulation and implementation of major S&T plans and programmes, design and plan of high-tech parks, ICTs, water technology, food technology, indigenous knowledge systems, environment technology.

KENYA

Title: Memorandum of Understanding between the Government of the Republic of Botswana and the Government of the Republic of Kenya on Cooperation in Education, Science and Technology

Enacted date: 4 November 2011

Description: The objective is to establish a legal framework for consultations and cooperation between the Parties to promote and support the developments in the fields of education and S&T. The areas of cooperation under the heading of Education include the establishment and development of direct relations between the universities and mid-level institutions of higher learning in both countries and the sharing of expertise in training mathematics and science teachers. Under Science and Technology, the focus is on the exchange of scientists, research workers and technical experts.

MOZAMBIQUE

Title: Agreement between the Government of the Republic of Botswana and the Government of the Republic of Mozambique in the Fields of Science and Technology

Enacted date: 21 July 2011

Description: The purpose is to facilitate cooperation in S&T between the Partiess in the areas of ICTs, scientific research and innovation, technological development, development of human resources, exchange of experts in S&T and technology transfer through joint seminars, workshops and research projects, cooperation between institutions and information exchange.

3.1 WIPO-administered treaties

Summary Table of Membership of the World Intellectual Property Organization (WIPO) and the Treaties administered by WIPO, plus UPOV

World Trade Organization (WTO) - Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) (Adopted on April 15, 1994. Entry into force on 1 January 1995).

Site: www.wipo.int/wipolex/en/other_treaties/details.jsp?group_id=22&treaty_id=231

Berne Convention for the Protection of Literary and Artistic Works (15 April 1998)

Site: www.wipo.int/wipolex/en/wipo_treaties/details.jsp?treaty_id=15

Convention Establishing the World Intellectual Property Organization (15 April 1998)

Site: www.wipo.int/wipolex/en/wipo_treaties/details.jsp?treaty_id=1

Paris Convention for the Protection of Industrial Property (15 April 1998)

Site: www.wipo.int/wipolex/en/wipo_treaties/details.jsp?treaty_id=2

Patent Cooperation Treaty (30 October 2003)

Site: www.wipo.int/wipolex/en/wipo_treaties/details.jsp?treaty_id=6

WIPO Copyright Treaty (27 January 2005)

Site: www.wipo.int/wipolex/en/wipo_treaties/details.jsp?treaty_id=16

WIPO Performances and Phonograms Treaty (27 January 2005)

Site: www.wipo.int/wipolex/en/wipo_treaties/details.jsp?treaty_id=20

Hague Agreement Concerning the International Deposit of Industrial Designs (5 December)

Site: www.wipo.int/wipolex/en/wipo_treaties/details.jsp?treaty_id=9

Protocol Relating to the Madrid Agreement Concerning the International Registration of Marks (5 December 2006)

Site: www.wipo.int/wipolex/en/wipo_treaties/details.jsp?treaty_id=8

3.2 Regional legal framework intellectual property

Lusaka Agreement on the Creation of the African Regional Intellectual Property Organization (ARIPO) (6 February 1985)

Site: http://www.wipo.int/wipolex/en/other_treaties/details.jsp?group_id=21&treaty_id=202

Harare Protocol on Patents and Industrial Designs within the Framework of the African Regional Industrial Property Organization (ARIPO) (6 May 1985)

Site: www.wipo.int/wipolex/en/other_treaties/details.jsp?group_id=21&treaty_id=204

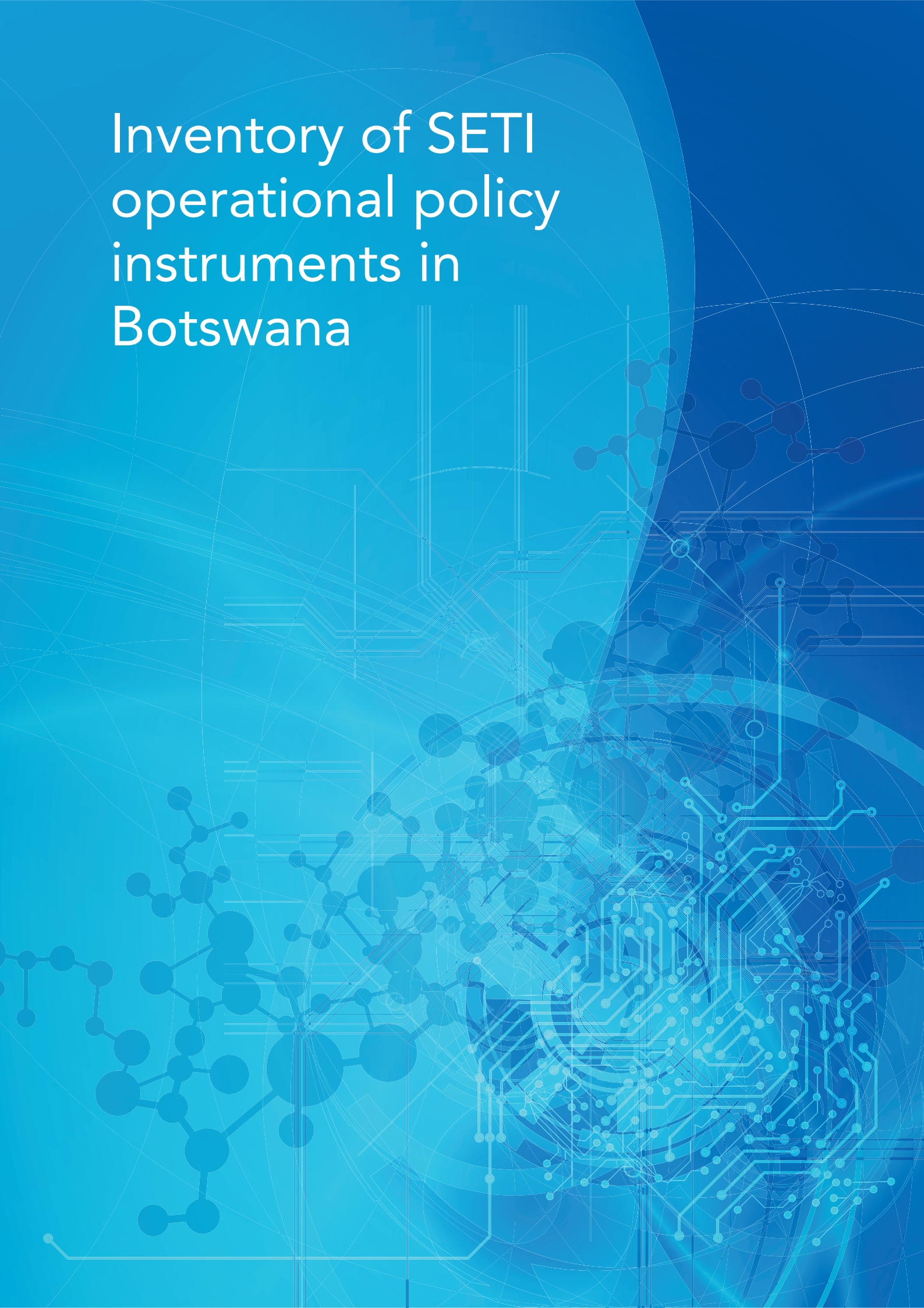
Banjul Protocol on Marks within the Framework of the African Regional Industrial Property Organization (ARIPO) (29 October 2003)

Site: www.wipo.int/wipolex/en/other_treaties/details.jsp?group_id=21&treaty_id=203

Swakopmund Protocol on the Protection of Traditional Knowledge and Expressions of Folklore within the Framework of the African Regional Intellectual Property Organization (ARIPO) (9 August 2010)

Site: www.wipo.int/wipolex/en/other_treaties/details.jsp?group_id=21&treaty_id=294

Inventory of SETI operational policy instruments in Botswana



There is currently a single operational policy instrument in Botswana. It concerns an ongoing Training of Scientists and Technologists Project. See below for details.

TRAINING OF SCIENTISTS AND TECHNOLOGISTS PROJECT

Keywords: Training, scientists, technologists, project

Overview: This is a pilot project which is aimed at training Botswana citizens in the area of research, science and technology. Through this pilot project, Botswana sent candidates outside the country to reputable universities to undertake studies at PhD level in areas related to S&T.

Objectives of the plan (or the SETI policy) to which the instrument relates: Human capital development and human capacity-building

Specific objectives: Human resources for research, innovation and strategic planning. Capacity-building, education and training of specialized human capital for (1) the production of new scientific knowledge; (2) development of new technologies; (3) promotion of innovation within the productive and services systems and (4) management of the knowledge society.

Sectoral and horizontal approach of the instrument: Horizontal: the benefits go to all the disciplines, areas and sectors

Mode of support/Type of Mechanism: Scholarships

Conditions to apply for the instrument: (a) Be a citizen of Botswana; (b) Hold a masters' degree in an S&T field

Target groups/Beneficiaries: Professionals/Masters holders/PhDs

Eligibility/Selection Criteria: Be a citizen of Botswana

Eligible costs: Tuition fees, living allowances, travelling allowances, conferencing and publishing allowances

Source of funding: The Government of Botswana

Mode of disbursement of financial resources: The Government of Botswana disburses the funds through foreign missions where candidates are based for training.

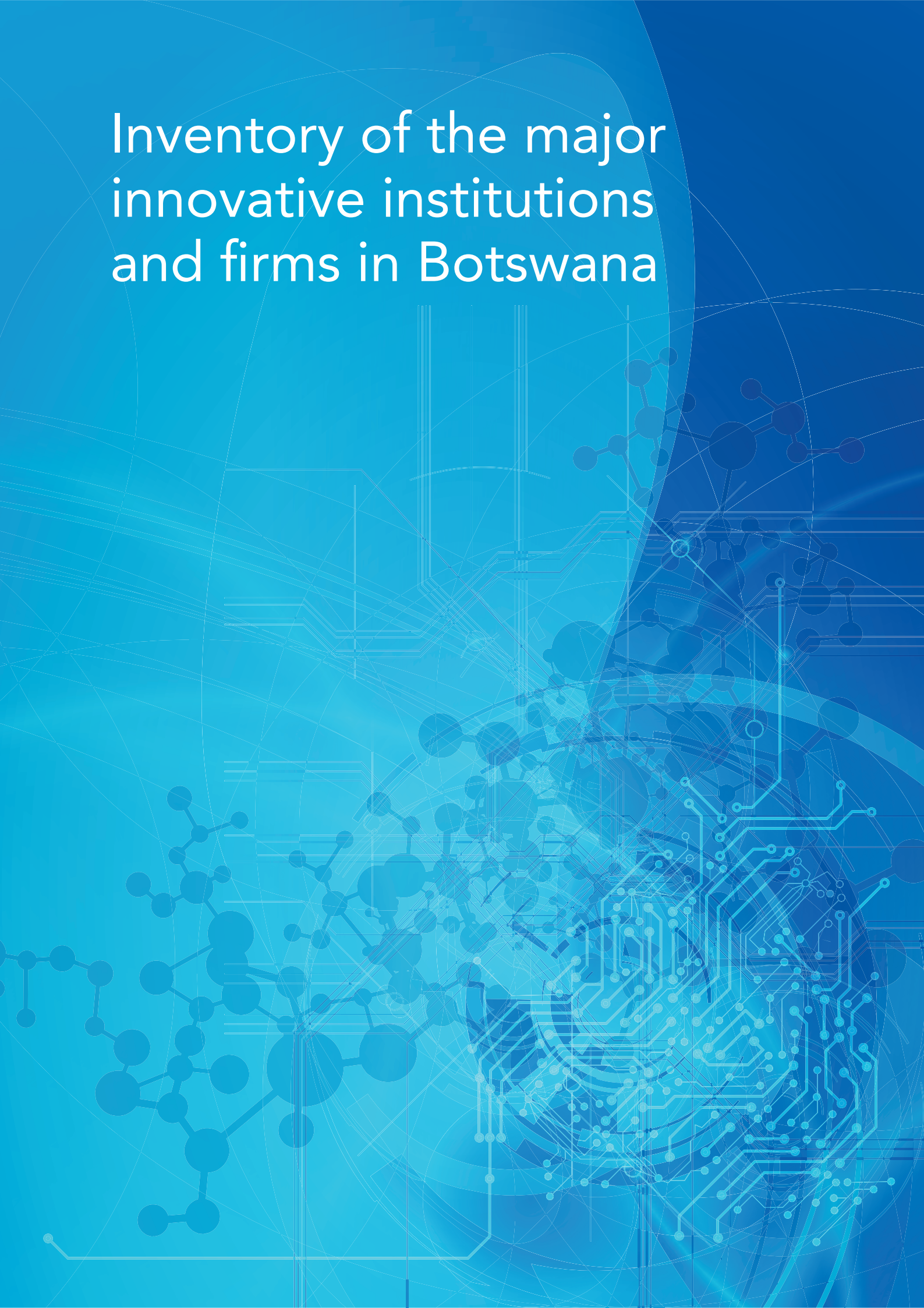
Annual budget: US$187,500

Continuity of the instrument in time: Start date: 2007, End date: 2012. There is an ongoing study to scope and map out a strategy for upscaling the project for a meaningful impact

Geographical coverage: National

Results, outcomes and evidence of success of a given measure: All the candidates but one have successfully completed their studies and are back in the country with their respective employers.

Inventory of the major innovative institutions and firms in Botswana



There are currently six major innovative institutes and firms in Botswana. These are described hereafter.

BOTSWANA VACCINE INSTITUTE LTD

Core business: Manufacture and Distribution of Livestock Vaccines

Mandate: A public company wholly owned by the Government of Botswana, the institute was originally established as a project to conduct research in 1979 on foot-and-mouth disease (FMD) viruses circulating in Botswana and the region. It was later registered a company in 1979 under the Companies Act, the mandate of which was to safeguard Botswana beef exports to the European Union before discovery of minerals by manufacturing relevant livestock vaccines. Over the years this mandate has now become regional and international as BVI products and services are offered throughout Africa and the Middle East.

Services offered: In addition to production and sales of vaccines, in 1985 BVI was appointed as the Regional Reference Laboratory for Foot and Mouth Disease in Sub Saharan Africa by the OIE (World Organisation for Animal Health). Through this mandate BVI is able to provide expertise and laboratory confirmation and related training on FMD to countries largely in Sub Saharan Africa region, for free. The laboratory is also tasked with providing reagents to National Veterinary Laboratories in African countries for serological surveillance of FMD.

Funding: Self-funding from the sales of vaccines

NATIONAL FOOD TECHNOLOGY RESEARCH CENTRE

Core business: This centre of excellence deals with S&T research in food, nutrition and related areas. The centre has a mission to generate food technologies that enhance economic diversification, food security and quality through sustained end-user focused R&D. Its objectives are to: (a) provide technical assistance to the agricultural industry, in particular, the food processing sector, with the aim of expanding the industry, leading to job creation, import substitution and enhanced food security; (b) expand opportunities in the food sector by promoting the use of locally produced raw materials; (c) ensure quality through the adoption of approved local and international standards.

The centre is involved in (i) R&D of indigenous food products; (ii) commercialization of research outputs; (iii) Assessment of food technologies for effective transfer in Botswana; (iv) promotion of good manufacturing practices; (v) provision of general and specialized in-house and on-site training in food processing, nutrition and food safety; (vi) food analysis with respect to nutrition quality and food safety; (vii) provision of technical advice and extension services in food processing, nutrition and food safety; (viii) technical consultancies to clients; (ix) provision of information on all aspects of food processing; and (x) networking with similar institutions worldwide.

Services offered: (1) Product and process development; (2) Laboratory analysis for nutritional and food safety assessment; (3) Training in food processing and food safety management; (4) Client requested consultancies in food-related matters.

Funding: Government (through the Ministry of Agriculture); project-specific sponsorship from donors, namely: International Atomic Energy Agency, European Union; some other funds are generated through services. Annual Budget (awarded). Recurrent: BWP 23,000,000 and R&D: BWP 5,100,000

BOTSWANA TECHNOLOGY CENTRE (BOTEC)

Core business: BOTEC is wholly owned by the Government of Botswana and operates within the Department of Research, Science and Technology under the Ministry of Infrastructure Science and Technology (see footnote on page 71). Its mandate is to conduct research in the following fields: (1) renewable energy; (2) civil engineering; (3) electronics engineering; (4) architecture and the built environment, and (6) ICTs. The specific research topics are guided by the ideals and contents of the government's official documents, such as the *Tenth National Development* Plan, *Vision 2016* and the 1998 *Science and Technology Policy*. The research–development–innovation value chain covers both original or empirical work, as well as the implementation of adopted technologies that have been adapted to local conditions. As a research and technology organization, BOTEC transfers the technologies it has developed to industry for economic development. In most cases, this is done through a license of patent or via the product itself.

Mandate: To provide solutions for industrial business development through innovative research and the application S&T.

Services offered: (a) S&T research in the fields described above; (b) surveys for needs assessments within the scope of its mandate; (c) limited consultancies as demanded, usually by government; (d) stakeholder assistance with enquiries and requests for technology interests and concerns; (e) incubates small, medium-sized and micro-enterprise technologies for stakeholders; and (f) advises the government on matters related to research.

Funding: Source: Government of Botswana. Annual Budget: BWP 26,000,000 for Recurrent; BWP 6,000,000 for Development

RURAL INDUSTRIES PROMOTIONS COMPANY (RIPCO)

Core business: Rural Industries Promotions Company (Botswana) is a company limited by guarantee incorporated in Botswana (see footnote on page 71). It is funded through, and operates under, the Ministry of Infrastructure, Science and Technology. It is engaged in R&D of commercially feasible agricultural equipment.

Services offered: incubation, installation, after-sales service, energy audit.

Incubation: The objective is to empower Batswana to undertake commercially viable projects. Following a successful period of incubation, prospective entrepreneurs are identified to undertake these projects on a commercial basis. Entrepreneurs are also incubated in the business and technical aspects of the projects to be able to operate them profitably. The company also runs the Centre for Entrepreneurial Training, previously the Village Skills Training Programme; it provides training for self-empowerment in baking, sewing and patchwork, fabric printing and dyeing, blacksmith, carpentry, leatherwork and business management.

Installation: The **i**nstallation unit installs all technologies purchased by clients which require this intervention.

After-sales service: RIPCO (B) technologies come with a one-year warranty. When the product is under warranty, RIPCO (B) repairs any mechanical fault free of charge and maintains equipment. This service is provided by the extension officers in Kanye, Palapye, Maun and Francistown. After the warranty expires, repair and maintenance services are provided at a cost.

Energy audit: An energy management programme has been carried out and was aimed at monitoring energy consumption rates. Once monitoring is completed, RIPCO (B) will conduct consultancies and extend the benefits to industry.

Funding: Government of Botswana.

BOTSWANA NATIONAL VETERINARY LABORATORY

Core business: The core business is to provide veterinary laboratory services (animal disease diagnosis, quality assurance testing of animal food products and quality assurance testing of animal feed) and to conduct applied research related to public and animal health problems, in order to promote a diversified, sustainable and competitive livestock industry in Botswana (see also page 69).

Services offered: (a) Diagnosis of animal diseases; (b) Quality assurance of food of animal origin (meat and dairy products) and (c) Quality of animal feed.

Funding: The Government of Botswana is the main source of funding through the Ministry of Agriculture. Donors, particularly FAO and IAEA, have supported capacity-building at the Botswana National Veterinary Laboratory by providing laboratory equipment and training for core staff in the form of fellowships and attachments at specialized international laboratories and/or universities.

Annual budget: The recurrent budgets for the 2010/2011, 2011/12 and 2012/2013 financial years were respectively BWP 6,914,374; BWP 6,350,600 and; BWP 7,449,000.

KHOKHO B HOLDINGS T/A DOBI FOODS

Core business: Processing and packaging of indigenous and non-indigenous foods

Mandate: To promote healthy eating through the provision of high-quality indigenous and non-indigenous vegetables and legumes.

Services offered: (a) Peanut/groundnuts powder; (b) Roasted groundnuts/peanuts; (c) Roasted Groundnuts/Peanut Granules; (d) Spinach cooked with groundnut/peanut powder; (e) Bean leaf cooked with groundnut/peanut powder; (f) Cooked and dried corn; (g) Legumes; (h) Dobi bar from groundnuts/peanut granules and other ingredients (being worked on); (i) Others, such as soups, will follow.

Funding: Self-funding and still sourcing funding from CEDA and other funding agencies. *Annual budget*: BWP 1,300,000.

SWOT analysis of Botswana's national research and innovation system

The following analysis focuses on the strengths, weaknesses, opportunities and threats (SWOT) related to Botswana's research and innovation system. These characteristics are summarized in Table 16 on page 108.

Strengths

- **Political stability and good governance:** Botswana is well-known for political stability and good governance, with democratic principles that are deeply entrenched following decades of successful democratic transitions. Botswana operates a multi-party democracy with a parliamentary system of government. Botswana is one of the seven African countries with positive values on political stability/absence of violence and government effectiveness, a position it has held for more than two decades. Since independence, it has been democratic, holding regular and competitive elections; it has never experienced civil war or any military intervention. The government has set up economic institutions enforcing property rights, ensuring macroeconomic stability and encouraging the development of an inclusive market economy.
- **Good investment climate:** High diamond revenues have allowed large investments in infrastructure development and education, making Botswana an attractive destination for global investment. A combination of government and macroeconomic stability have attracted foreign investment in the economy – particularly in the mining industry –, bringing new technologies, new knowledge and new skills to the country.
- **Good communications infrastructure:** The country boasts good traditional infrastructure (water, electricity, transport, etc.) and this is improving in rural areas; for instance, rural access to electricity increased from 24% in 2004 to 43% in 2008. Modern telecommunications infrastructure is also on the increase (telephone, mobile and internet penetration). Botswana's ICT infrastructure provides an opportunity for technology leapfrogging and for increasing productivity in key productive sectors: mining, energy, agriculture, health, education, etc.
- **Sustainable GDP per capita growth: O**ver the past 47 years, GDP per capita, expressed in constant US$, has experienced a continuous quadratic growth.
- **High number of mainstream scientific publications per capita for Africa:** The number of scientific articles published in mainstream journals has evolved, with a continuous cubic growth for more than four decades. In 2012, Botswana was ranked 21st in Africa and 115th in the world, in terms of the total number of scientific publications listed at SCOPUS. In the past two decades Botswana has remained the third-most productive African country for scientific publications per million population, after Tunisia and South Africa (for countries with a population over 500,000) [see Figure 9].

Weaknesses

- **Low innovative capability:** The innovative capability of Botswana remains low on a global scale. According to the Knowledge Economy Index (World Bank database, 2009), Botswana ranks 95th out of 145 countries and its rank has deteriorated considerably in recent years. Botswana imports most of its capital goods (machinery and equipment) from neighbouring countries. In terms of technology, Botswana continues to depend on imported technologies, with very little adaptation and innovation.
- **Inadequate legislation to promote innovation and FDI:** No specific legislation offers tax incentives or proposes other schemes to promote innovation, FDI and the installation of high-tech firms.
- **Shortage of critical skills:** The deficit of skills in Botswana is nothing new and has been widely acknowledged. Despite heavy investments in education, the education system has been biased towards the needs of the public sector for many years. The needs of the private sector have consequently been neglected, not only in manufacturing but also in the mining sector, the main driver of the country's economic development. There is a recognized shortage of local skills in the

health and education sectors and widespread use of foreign expatriates in all sectors of the economy. Additionally, the chances of economic diversification are hampered by the severe shortage of professional skills in critical sectors such as human-capital-intensive service industries (e.g. banking), manufacturing, and sectors that could potentially exploit national advantages, such as solar energy and conservation.

- **Narrow economic spectrum:** Botswana's narrow economic base for the exploitation of mineral resources has been an impediment to expanding opportunities in other sectors through technological innovation. The primary aim of the 1998 *Science and Technology Policy* was to facilitate the diversification of Botswana's economy to reduce reliance on the mining of diamonds. Research, science, technology and innovation are critical for increasing productivity and the competitiveness of the different sectors, including mining, by encouraging the application of innovative and efficient technology that is suited to local conditions and minimizes environmental degradation. Downstream processing of minerals such as stone-cutting and jewellery manufacturing, as well as diamond-associated services, need cutting-edge technologies to stay competitive in the global market. The launch of the Diamond Hub in 2008 represents a significant step towards expanding opportunities for participation in the diamond value chain of manufacturing and services based on new technologies and innovative processes. These can eventually lead to business expansion, higher returns and economic diversification.
- **Research collaboration remains low:** Dissemination of knowledge and technology transfer across actors is the engine of a well-functioning innovation system. In Botswana, the landscape for research, science, technology and innovation has been described as highly fragmented, scattered over several institutions, without coordination, streamlining or proper targeting (Republic of Botswana, 2012). Achievements in R&D have not been disseminated, owing to poor linkages with end-users and little collaboration among local researchers. Interactions between industry, research institutions and learning institutions are sparse. Botswana's infant small and medium-sized enterprise sector is particularly vulnerable to the lack of access to research and technologies. This results in perpetually low productivity and limited possibilities to develop technological capabilities at the local level. The establishment of the Botswana Innovation Hub (see also pages page 15 and 81) and the Botswana International University of Science and Technology (see page 75) are intended to encourage the interaction between education, research and production.
- **Indigenous knowledge remains largely disregarded:** Knowledge is the key input to innovation. It can come from a formal process, such as R&D, but also in the form of indigenous knowledge developed over centuries of learning from the environment. Indigenous knowledge can play a central role in transforming and modifying technologies to suit local conditions and the local context, and in developing indigenous home-grown technologies. To play that role, indigenous knowledge needs to be documented, protected and efficiently managed. Botswana needs to incorporate indigenous knowledge into the formulation of research and technology development strategies. The work of the Centre for Scientific Research, Indigenous Knowledge and Innovation (see page 79) at the University of Botswana contributes to this goal.
- **Slow policy implementation:** The 1998 *Science and Technology Policy* has been implemented to some extent see page 40), although some of the proposed structures for coordination and funding of scientific research within the country have never been launched. Only the National Commission for Science and Technology was established in 2002 before being dissolved in 2006 following the establishment of the Department of Research, Science and Technology. There is a need to develop coordination structures that facilitate the process of setting priorities collectively across sectors and fund allocation. Operating these mechanisms entails building a new coordination and advisory structure at the highest level of policy.

Opportunities

- **Capacity-building in performance and governance of research, science, technology and innovation:** Botswana has been building up her governance capacity in this area for over a decade with the blessing of the 1998 *Science and Technology Policy,* and *Botswana National Research, Science and technology Plan* (see page 47). This plan identified research priorities and the required resources and funding instruments for the plan's implementation. In 2004, Botswana established the Department of Research, Science and Technology, initially under the Ministry of Communications, Science and Technology, before it was moved to the Ministry of Infrastructure, Science and Technology in 2009. The Department of Research, Science and Technology is responsible for coordinating R&D, by providing an enabling policy environment and also ensuring that research activities are aligned with national priorities. The Ministry of Infrastructure, Science and Technology also oversees the Botswana Technology Centre and the Rural Industries Promotions Company. Botswana has a number of institutions tasked with researching, developing and/or adapting technologies for application in Botswana. These include higher education institutions (University of Botswana and the recently established Botswana International University of Science and Technology) and public sector research and technology institutes (including the Botswana Technology Centre, the Rural Industries Promotions Company of Botswana, Botswana Vaccine Institute and the National Food Technology Research Centre (see page 99). Additionally, government departments also undertake research in their respective areas , such as the Department of Agricultural Research, the Department of Energy Affairs, the Department of Geological Survey and the Department of Water Affairs. Thusano Lefatsheng and Veld Products Research and Development are key NGOs working on the commercialization of natural resources. The Botswana Bureau of Standards is the official body responsible for all issues related to standardization and quality assurance at the national level (see page 80). Botswana's capacity has been pushed forward with the opening of the country's first science and technology park in 2012, the Botswana Innovation Hub (see page 15).
- **Prioritization of human capital development:** The development of Botswana's human resource capacity through education and training has become a first line priority. This is reflected in the approval of the *National Human Resource Development Strategy,* 2009–2022 and its current implementation.
- **Traditional knowledge law in place:** In 2010, the Industrial Property Act enacted a special legislative instrument to protect traditional knowledge and handicrafts (see page 86). Botswana is one of the few countries in the world with such a law, which is also the first of its kind in the SADC region. According to this legislation, traditional knowledge can be owned by a group of people or a community. This is not possible with the other forms of intellectual property or intellectual property rights. The terms of protection expire only when the traditional knowledge has lost its value as: (a) an element of cultural identification; (b) a result of wilful and expressed abandonment by its owner or owners; or (c) as a result of non-use or use in a distorted manner by third parties of which the owner or owners are aware.
- **Intellectual property law in place and compliant with international treaties:** Botswana has at least six different acts to protect intellectual property rights and has committed to a great variety of international treaties on intellectual property (see page 94).
- **Potential for international collaboration:** For a small country like Botswana, the process of innovation and technological development depends critically on its links with the rest of the world. Botswana's membership of international organizations could facilitate its access to globally available knowledge and technology. Additionally, sector-specific bilateral agreements have been signed between Botswana and other countries for mutual benefit in research, science, technology and innovation. Botswana has also signed the SADC Science, Technology and Innovation Protocol (see page 46); is a member of the African Union and supports Africa's Science and Technology Consolidated Plan of Action; it is also a member of the International Atomic Energy Agency (IAEA) and participates in the the African Regional Cooperative Agreement, established in 1990 by the IAEA and African Member States.

- **Good articulation among the Innovation Hub, Education Hub, Diamond hub, Agricultural Hub, Transport Hub and Health Hub:** in order to promote innovation to make society more inclusive and guarantee sustainable development, there is a great need to coordinate the strategies and operational policy instruments that will be put in place by each individual hub, in order to foster coherence and synergy to generate the desired societal effects.
- **Coherent and complementary SETI operational policy instruments for the promotion of research and innovation by the National Research Fund and Innovation Fund:** There is a need to coordinate the different operational policy instruments to be implemented by the Research and Innovation Funds, in order to design a complementary set of instruments, including those which promote coordination and networking between the supply side (academic sector and generation of knowledge) and demand side (productive sector and generation of innovation).

Threats

- **Excessive dependence on the state:** Currently the government is the largest employer and financier of R&D. There is a critical need to encourage private-sector involvement in economic development through research, science, technology and innovation, as it facilitates the creation of alternative growth engines and supports small and medium-sized enterprises which are vital for sustainable development.
- **Low participation of the private sector:** There are no specific policy instruments in place to promote research and innovation within the private sector. Only a very small group of enterprises from the agriculture and food sectors are integrating the results of research into innovation (see page 99) for an inventory of the six major innovative institutions and firms in Botswana). Other sectors of the economy should increase their participation in STI. New operational policy instruments should be in place to increase investment by the private sector in research and innovation.
- **Poor monitoring and evaluation:** The development and revision of evidence-based policy requires adequate indicators. Indicators allow adequate monitoring of activities and programmes, evaluation of performance over time and against other countries, as well as the conduct of foresight exercises, determination of specific areas of investment and fixing of targets. Botswana needs to deploy greater efforts to create a record of STI resources in the country, in order to inform policy decision-making.
- **Lack of sources for funding infrastructure:** In order to achieve her ambitious goals espoused in *Vision 2016*, the *Tenth National Development Plan* and other policies, Botswana needs to increase efforts in R&D and innovation significantly. To this end, the establishment of a body to coordinate funding is largely overdue. The scarcity of finances in the face of competing demands on the public purse requires exploring innovative funding regimes. Innovative funding infrastructures involves both ensuring that relevant areas for research and innovation are covered but also exploring means of recovering the costs of public support and encouraging greater cooperation between public and private enterprises.
- **Lack of explicit postgraduate degree policies and funding:** In order to transform the country into a knowledge society, there is a need to increase the number of FTE researchers to at least eight times the present values. No explicit policy or funding mechanisms are yet in place which target postgraduate studies, in order to promote a new generation of masters and PhD holders in the country and thereby expand the pool of new researchers.
- **Inadequate networking instruments to connect the academic and research system (supply side) with the productive system (demand side):** The emphasis is on creating and increasing the national stock of knowledge through research, while ensuring that benefits from this research accrue through technological development and innovation. It is therefore necessary to bring everybody on board, to re-brand the policy by modifying its name to reflect this new emphasis, which will be applied across all sectors of the economy. There is an absence of explicit policy instruments to promote networking

between the supply and demand sides of the national innovation system, Nor is there any policy instrument to promote the transference of technology, incubation or entrepreneurial partnerships between the public and private sectors.

Table 16: SWOT analysis of Botswana's research and innovation system

Strengths	Weaknesses
• Political stability and good governance • Good investment climate • Good communications infrastructure • Sustainable GDP per capita growth (parabolic growth over 47 years) • High number of mainstream scientific publications per capita for Africa	• Low innovative capability • Inadequate legislation to promote innovation and FDI • Shortage of critical skills • Narrow economic spectrum • Research collaboration remains low • Indigenous knowledge remains largely disregarded • Slow policy implementation

Opportunities	Threats
• Capacity-building in performance and governance of research, science, technology and innovation • Prioritization of human capital development • Traditional knowledge law in place • Intellectual property law in place and compliant to international treaties. • Potential for international collaboration • Good articulation among the innovation hub, educational hub; diamond hub, agricultural hub and health hub • Coherent and complementary SETI operational policy instruments for the promotion of research and innovation by the National Research Fund and the Innovation Fund	• Excessive dependence on the State • Low participation of the private sector in research, science, technology and innovation • Poor monitoring and evaluation • Lack of funding sources for infrastructure for research, science, technology and innovation • Lack of explicit postgraduate degree policies and funding • Inadequate networking instruments to connect the academic and research system (supply side) with the productive system (demand side)

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At the time of independence in 1966, Botswana was one of the poorest countries in the world. Today, it has one of the highest levels of income and scientific productivity per capita in sub-Saharan Africa. In 2011, the Department of Research, Science and Technology reviewed implementation of Botswana's *Science and Technology Policy* dating from 1998, as a prelude to updating it. The new policy aims to respond to the challenges of rapid technological evolution, globalization and the achievement of the national development goals formulated in high-level strategic documents that include Botswana's *Tenth National Development Plan* to 2016 and *Vision 2016*.

This first volume in UNESCO's new online series of GO→SPIN Country Profiles in Science, Technology and Innovation Policy is dedicated to a study of the research and innovation landscape of Botswana. It represents the first published inventory of the science, technology and innovation policy instruments of an African country.

Launched in 2012 via a series of UNESCO workshops, the Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN) is helping Member States to monitor and evaluate their performance in science, engineering, technology and innovation, via an analysis of a series of indicators and an inventory of the various components of their national innovation system. This monitoring tool has been designed to help countries reform and upgrade their national science systems and governance. GO→SPIN should also offer a solid foundation for foresight studies in relevant areas.

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