

An important aspect of economic integration would be the transition from national innovation systems to a single regional innovation system.

Erika Kraemer-Mbula and Mario Scerri

A humanoid robot directs traffic at a busy intersection in Kinshasa, in the Democratic Republic of Congo.

This solar-powered prototype is equipped with four cameras that allow it to record traffic. The information is then transmitted to a centre which analyses traffic infractions. This robot and its twin were designed by a group of Congolese engineers based at the Kinshasa Higher Institute of Applied Techniques (ISTA).

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20 · Southern Africa

Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe

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INTRODUCTION

Lifting trade barriers to foster regional integration

The Southern Africa Development Community (SADC) is home to 33% of sub-Saharan Africa's population and contributes about 43% of its GDP (US\$ 684 billion in 2013). The region combines middle-income countries with some of the fastest-growing economies in Africa¹ and some of the poorest. Nothing underscores the region's diversity more than the fact that one country alone generates about 60% of GDP within the SADC and one-quarter of the continent's GDP: South Africa.

Despite this heterogeneity, there is considerable potential for regional integration, which is being increasingly driven by the Southern African Development Community (SADC). A *Protocol on Trade in Services* signed in 2012 seeks to negotiate progressively the removal of barriers to the free movement of services within the SADC.

Intra-SADC trade is relatively modest and has not grown to any significant degree in the past five years, owing partly to the similarity of the resource-based economies across the region, a cumbersome regulatory framework and inadequate border infrastructure (AfDB, 2013).² Nevertheless, compared to other African regional economic communities (see Box 18.2), the SADC bloc still displays the most dynamic intraregional trade of the continent, albeit mostly directed towards South Africa. The SADC trades very little with the rest of Africa, the region's trade being mostly oriented towards the rest of the world.

On 10 June 2015, the 26 countries which make up the three regional communities of SADC, the Common Market for Southern and Eastern Africa (COMESA) and the East African Community (EAC) formally launched a Free Trade Area. This should accelerate regional integration.³

Relative political stability

The SADC region enjoys relative political stability and democratic political processes, although internal fragmentation continues to characterize the ruling political parties in most countries. For the past six years, SADC membership has remained relatively stable,

with the exception of Madagascar, which was suspended in 2009 following a coup d'état then reintegrated in January 2014 after its return to constitutional government. If Madagascar is now emerging from five years of political turmoil and international sanctions, the Democratic Republic of Congo is still recovering from the violence inflicted by armed groups who were neutralized by a United Nations peacekeeping force in 2013. Political tensions remain in Lesotho, Swaziland and Zimbabwe.

The SADC is striving to maintain peace and security within its member states, including through the SADC tribunal, which was established in Gaborone (Botswana) in 2005 then dismantled in 2010 before being revived by a new protocol in 2014, albeit with a diminished mandate. The SADC Regional Early Warning Centre is also based in Gaborone. This centre was established in 2010 to prevent, manage and resolve conflict, in conjunction with national early warning centres.

In 2014, five SADC countries held presidential elections – Botswana, Malawi, Mozambique, Namibia and South Africa – Namibia being the first African country to cast presidential ballots electronically through an e-voting system. The SADC aims to attain equal representation of men and women in key decision-making positions by 2015, through the *SADC Protocol on Gender and Development*, which entered into force in early 2013 after being signed in 2008. However, only five SADC countries are anywhere near reaching parity in parliament, having gone above the 30% threshold set previously by regional leaders for the representation of women: Angola, Mozambique, Seychelles, South Africa and Tanzania. Of note is that President Joyce Banda of Malawi became the SADC's first woman president in 2012. Three years later, renowned biologist Ameenah Gurib-Fakim made history by becoming Mauritius' first woman president.

Widespread poverty in two-thirds of countries

The population is growing fast, at 2.5% per year on average between 2009 and 2013. By 2013, the region counted a combined population of over 294 million. Human development varies widely, from a high of 0.771 on the UNDP's index in Mauritius to a low of 0.337 in the Democratic Republic of Congo. A promising trend is that ten countries advanced in the overall world ranking from 2008 to 2013. Madagascar, Seychelles and Swaziland, on the other hand, have slipped a few places (Table 20.1).

The SADC's aggregate economy still displays features of a developing region, with worrying unemployment levels in some countries. Poverty and inequality persist, despite

1. The Democratic Republic of Congo, Mozambique, Tanzania, Zambia and Zimbabwe experienced annual average GDP growth of about 7% from 2009 to 2013 but these five countries, along with Angola, Lesotho and Malawi, are also currently listed by the United Nations as being least developed countries.

2. In 2008, intra-SADC imports constituted only 9.8% of the region's total imports and intra-SADC exports 9.9% of SADC's total exports. Being the most diversified economy, South Africa is also the dominant exporter (68.1% of all intra-SADC exports) but only accounted for 14.8% of intra-SADC imports in 2009.

3. For the composition of these regions, see Annex I.

Table 20.1: Social landscape of Southern Africa

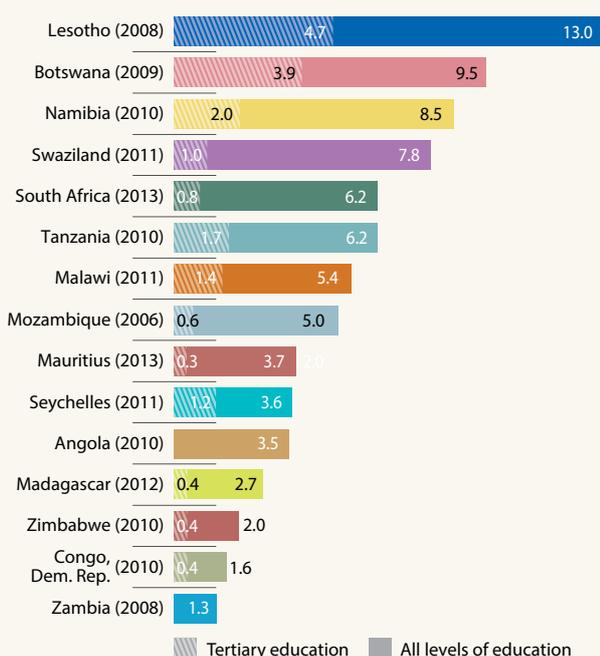
	Population (millions), 2013	Change since 2009 (%)	HDI ranking, 2013 (change since 2008)	Unemployment rate, 2013 (% of total labour force)	Poverty rate*, 2010 (change since 2000)	Gini, 2010 (change since 2000)
Angola	21.5	13	149 ⁽²⁾	6.8	67.42 ⁽⁻⁾	42.60 ⁽⁺⁾
Botswana	2.0	4	108 ⁽²⁾	18.4	27.83 ⁽⁻⁾	60.46 ⁽⁻⁾
Congo, Dem. Rep.	67.5	12	187 ⁽¹⁾	8.0	95.15	44.43
Lesotho	2.1	4	163 ⁽⁰⁾	24.7	73.39 ⁽⁻⁾	54.17 ⁽⁺⁾
Madagascar	22.9	12	155 ⁽⁻³⁾	3.6	95.1 ⁽⁺³⁾	40.63 ⁽⁺⁾
Malawi	16.4	12	174 ⁽⁰⁾	7.6	88.14 ⁽⁻⁾	46.18 ⁽⁺⁾
Mauritius	1.2	1	63 ⁽⁹⁾	8.3	1.85 ⁽⁺⁾	35.90 ⁽⁺⁾
Mozambique	25.8	11	179 ⁽¹⁾	8.3	82.49 ⁽⁻⁾	45.66 ⁽⁻⁾
Namibia	2.3	7	127 ⁽³⁾	16.9	43.15 ⁽⁻⁾	61.32 ⁽⁻⁾
Seychelles	0.1	2	70 ⁽⁻¹²⁾	–	1.84	65.77
South Africa	52.8	4	119 ⁽²⁾	24.9	26.19 ⁽⁻⁾	65.02 ⁽⁻⁾
Swaziland	1.2	6	148 ⁽⁻⁵⁾	22.5	59.11 ⁽⁻⁾	51.49 ⁽⁻⁾
Tanzania	49.3	13	160 ⁽⁵⁾	3.5	73.00 ⁽⁻⁾	37.82 ⁽⁺⁾
Zambia	14.5	13	143 ⁽⁷⁾	13.3	86.56 ⁽⁺⁾	57.49 ⁽⁺⁾
Zimbabwe	14.1	10	160 ⁽¹⁶⁾	5.4	–	–
TOTAL SADC	293.8	10	–	–	–	–

* calculated as the share of the population living on less than US \$2 per day.

Note: The reference year for the poverty rate and Gini index is 2010 or the closest year; see glossary, p.738.

Source: World Bank's World Development indicators, April 2015; for HDI: UNDP's Human Development Reports

Figure 20.1: Public expenditure on education in Southern Africa as a share of GDP, 2012 or closest year (%)



Source: UNESCO Institute for Statistics, May 2015

the fact that health and education remain top priorities for most countries, accumulating substantial portions of public expenditure (see Figure 20.1 and Table 19.2). The proportion of the population living on less than US\$ 2 a day remains extremely high in ten SADC countries for which data are available (Table 20.1). Moreover, even the Seychelles and South Africa, where a fraction of the population lives beneath the poverty line, report high levels of inequality, which even increased over the period 2000–2010.

Foreign investment has doubled since 2007

Foreign direct investment (FDI) in Southern Africa almost doubled from 2007 to 2013 to US\$ 13 billion. This was mainly due to record high inflows to South Africa and Mozambique, mostly for infrastructure development and the gas sector in Mozambique (Table 20.2). The proportion of national investment financed by donors is a good proxy indicator of the degree of economic self-sustainability. Once again, the region shows a high level of disparity in the degree of self-sustainability, with a clear distinction between countries that exhibit virtually no reliance on overseas development assistance (ODA) for national investment requirements and those where ODA is a significant contributor. Lesotho, Malawi and Swaziland show a growing reliance on ODA over the period under study. In other countries, such as Mozambique, Tanzania, Zambia and

Table 20.2: Economic landscape of Southern Africa

	GDP per capita in PPP\$ millions (2011 constant prices)			GDP growth		Overseas development assistance/GFCF*		FDI inflow, 2013 (% of GDP)	Patents, 2008–2013
	2009	2013	5-year change (%)	2009 (%)	2013 (%)	2009 (%)	2013 (%)		
Angola	7 039	7 488	6.4	2.4	6.8	2.1	1.6	-5.7	7
Botswana	12 404	15 247	22.9	-7.8	5.8	7.8	2.2	1.3	0
Congo, Dem. Rep.	657	783	19.1	2.9	8.5	87.2	38.3	5.2	0
Lesotho	2 101	2 494	18.7	3.4	5.5	26.5	33.0 ⁻¹	1.9	0
Madagascar	1 426	1 369	-4.0	-4.0	2.4	14.9	30.0	7.9	0
Malawi	713	755	5.9	9.0	5.0	64.3	153.9	3.2	0
Mauritius	15 018	17 146	14.2	3.0	3.2	6.7	5.9	2.2	0
Mozambique	893	1 070	19.7	6.5	7.4	130.8	85.0	42.8	0
Namibia	8 089	9 276	14.7	0.3	5.1	13.1	7.8	6.9	2
Seychelles	19 646	23 799	21.1	-1.1	5.3	9.8	5.2	12.3	2
South Africa	11 903	12 454	4.6	-1.5	2.2	1.7	1.8	2.2	663
Swaziland	6 498	6 471	-0.4	1.3	2.8	17.2	31.9	0.6	6
Tanzania	2 061	2 365	14.7	5.4	7.3	35.6	26.2	4.3	4
Zambia	3 224	3 800	17.8	9.2	6.7	–	17.4 ³	6.8	0
Zimbabwe	1 352	1 773	31.2	6.0	4.5	76.7	46.3	3.0	4

-n = data refer to n years before reference year

*Gross fixed capital formation, see the glossary, p. 738

Source: World Bank's World Development Indicators, April 2015; patent data from USPTO database

Zimbabwe, this reliance has dropped significantly in recent years, even if it remains high.

The SADC economy is highly dependent on natural resources, with mining and agriculture constituting substantial segments of economic activity. From Figure 20.2, we can see that the production structure of most SADC economies tends to be resource-based, with a relatively small manufacturing sector, except in Swaziland. The region is vulnerable to extreme weather events such as cyclical drought and flooding. Angola, Malawi and Namibia have all experienced below-normal rainfall in recent years, affecting food⁴ security. In 2014, Madagascar embarked on a nation-wide campaign to contain a locust outbreak which threatened staple crops. There has been a worrying drop in government funding for agricultural R&D by SADC countries and development agents, despite the continent's commitment, in the *Maputo Declaration* (2003), to devoting at least 10% of GDP to agriculture. By 2010, only a handful of SADC countries devoted more than 5% of GDP to agriculture, notably Madagascar, Malawi, Tanzania and Zambia (see Table 19.2).

4. The Regional Early Warning System, Famine Early Warning System and Climate Services Centre are all based at the SADC centre in Gaborone (Botswana). The SADC Plant Genetic Resource Centre is located in Lusaka (Zambia). All were established about two decades ago. See www.sadc.int

The region's strong dependence on natural resources has led to wild economic fluctuations and rendered it vulnerable to global economic crises, such as that which led to an economic slowdown in 2009. Since 2010, the region has enjoyed persistent growth, with prospects for a return to pre-2009 growth rates of 5–6% in 2015 (AfDB *et al.*, 2014).

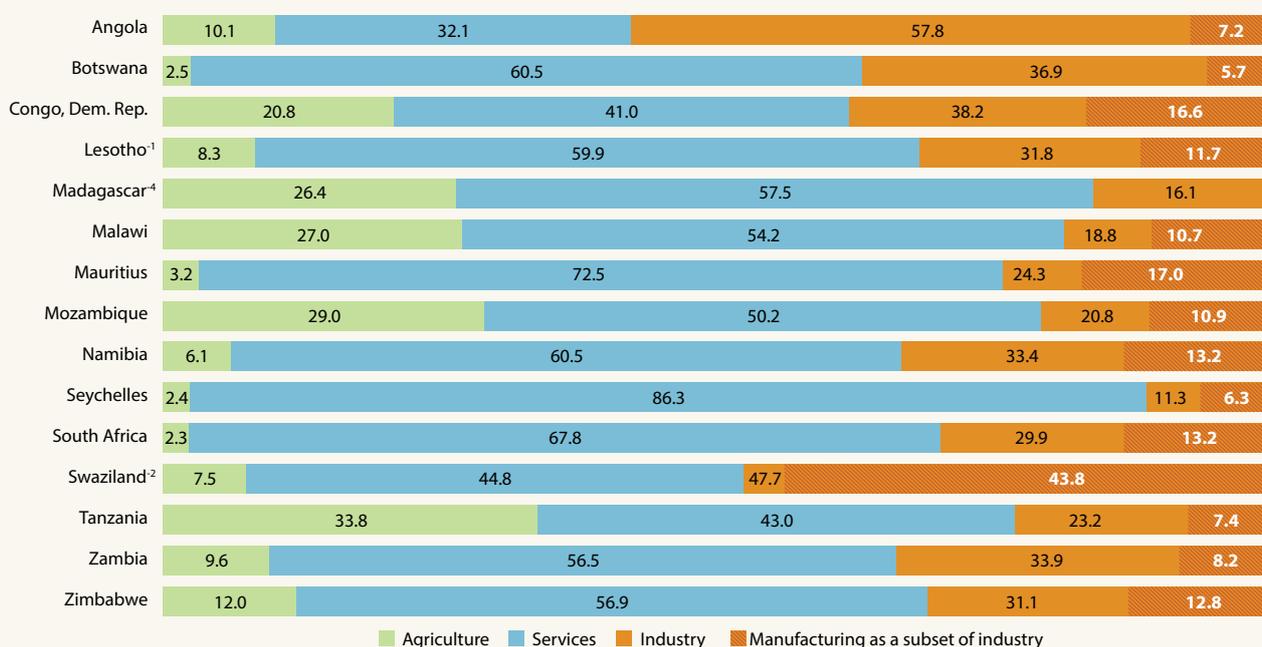
Four ratifications of SADC protocol on STI

The Southern African Development Community Treaty of 1992 provides the legal framework for co-operation among SADC member states. It has since been enriched by the adoption of 27 protocols in priority areas.⁵ In its *Protocol on Science, Technology and Innovation* (2008), the SADC stresses the importance of S&T for achieving 'sustainable and equitable socio-economic growth and poverty eradication'. It provides the basis for the development of institutional mechanisms for regional co-operation and co-ordination in the following areas:

- policy training;
- the role of women in science;
- strategic planning;

5. The SADC Treaty calls for the harmonization of political and socio-economic policies for the region to attain the objective of sustainable development, whereas the protocols promote legal and political co-operation.

Figure 20.2: GDP in SADC countries by economic sector, 2013 or closest year



-n = data refer to n years before reference year

Source: World Bank's World Development Indicators, April 2015

- intellectual property rights;
- indigenous knowledge systems;
- climate change; and
- high-performance computing, as exemplified by the Blue Gene project launched by IBM in 1999, which spent the next decade developing supercomputers with low power consumption.

The protocol is based on a broad definition that extends considerably beyond science and technology.⁶ A portfolio committee briefing by the South African Department of Science and Technology (RSA, 2011) notes that the protocol is an essential first step towards regional integration, with steady growth in self-financed bilateral co-operation. It considers that the SADC has become Africa's leading regional economic community. However, the briefing also points out that the regional STI desk remains under-resourced and mostly ineffectual. As a result, member states are still reluctant to support it. To date, the protocol has only been ratified by four countries: Botswana, Mauritius, Mozambique and South Africa. For the protocol to enter into force, it must be ratified by two-thirds of member states (10 countries).

6. The term 'national innovation system' refers to 'a set of functioning institutions, organisations and policies which intervene constructively in pursuit of a common set of social and economic objectives', as defined by the SADC Secretariat in 2008.

Two primary policy documents operationalize the SADC Treaty, the *Regional Indicative Strategic Development Plan* for 2005–2020 (RISDP, 2003) and the *Strategic Indicative Plan for the Organ* (SIPO, 2004). The RISDP identifies the region's 12 priority areas for both sectorial and cross-cutting intervention, mapping out goals and setting up concrete targets for each. The four sectorial areas are: trade and economic liberalization, infrastructure, sustainable food security and human and social development. The eight cross-cutting areas are:

- poverty;
- combating the HIV/AIDS pandemic;
- gender equality;
- science and technology;
- information and communication technologies (ICTs);
- environment and sustainable development;
- private sector development; and
- statistics.

Targets include:

- ensuring that 50% of decision-making positions in the public sector are held by women by 2015;
- raising gross domestic expenditure on research and development (GERD) to at least 1% of GDP by 2015;

- increasing intra-regional trade to at least 35% of total SADC trade by 2008 (10% in 2008);
- increasing the share of manufacturing to 25% of GDP by 2015 (Figure 20.2); and
- achieving 100% connectivity to the regional power grid for all member states by 2012 (see Table 19.1).

A 2013 mid-term review of RISDP noted that limited progress had been made towards STI targets, owing to the lack of human and financial resources at the SADC Secretariat to co-ordinate STI programmes. In Maputo in June 2014, SADC ministers of STI, education and training adopted the SADC *Regional Strategic Plan on Science, Technology and Innovation for 2015–2020* to guide implementation of regional programmes.

A vulnerable environment despite legal frameworks

The region's commitment to sustainable development is reflected in the SADC Treaty and countries' active participation in major multilateral environmental⁷ agreements. Although there has been some progress in environmental management in recent years, Southern Africa remains very vulnerable to climate change; it also suffers from high levels of pollution, biodiversity loss, inadequate access to clean water and sanitation services (see Table 19.1), land degradation and deforestation. It has been estimated that over 75% of land is partially degraded and 14% severely degraded. Soil erosion has been identified as the primary cause of declining agricultural production. For the past 16 years, the SADC has had a protocol governing wildlife, forestry, shared water courses and the environment, including climate change, the *SADC Protocol on Wildlife Conservation and Law Enforcement* (1999).

More recently, SADC has initiated a number of regional and national initiatives to mitigate the impact of climate change. In 2013, ministers responsible for the environment and natural resources approved the development of the SADC Regional Climate Change programme. In addition, COMESA, EAC and SADC have been implementing a joint five-year initiative since 2010 known as the Tripartite Programme on Climate Change Adaptation and Mitigation, or The African Solution to Address Climate Change. Five SADC countries have also signed the *Gaborone Declaration for Sustainability in Africa* (Box 20.1).

Regional policy frameworks, a continental strategy

In 2014, the *Science, Technology and Innovation Strategy for Africa* (STISA–2024) replaced Africa's previous decadal framework, *Africa's Science and Technology Consolidated Plan of Action* (CPA, 2005–2014). The CPA had been the continent's first consolidated attempt to accelerate Africa's transition to an innovation-led knowledge economy. As part of the *Plan of*

Action, several networks of centres of excellence have been set up. Within the African Biosciences Initiative, four subregional hubs have been established, including the Southern African Network for Biosciences (SANbio), based at the Council for Scientific and Industrial Research in Pretoria since 2005 (see Box 19.1). SADC countries also participate in the African Biosafety Network of Expertise (see Box 19.1).

However, the CPA implementation raised a number of concerns related to:

- its narrow focus on generating R&D, with less concern for the use of scientific output;
- insufficient funding to allow full implementation of programmes;
- excessive reliance on external financial support targeting short-term activities and solutions; and
- the failure to link it with other pan-African policies such as continent-wide agriculture and environmental protection projects.

STISA emerged in 2014, following a high-level review of the CPA (see p. 505). This strategic framework is the next decadal stepping stone towards the goals of the African Union's *Agenda 2063*, also known as 'the Africa we want.' In *Agenda 2063*, the African Union provides a broad vision and action plan for building a more prosperous and united Africa over the next 50 years. STISA displays a stronger focus on innovation and science for development than its predecessor. It foresees the establishment of an African Science, Technology and Innovation Fund (ASTIF) but the financial sources needed to operate the fund remain undetermined. The lack of committed funds from member states and the broadness of STISA's objectives have raised multiple questions as to the feasibility of its implementation. It will take more than a commitment from member states to devoting 1% of GDP to R&D – the target enshrined in the African Union's *Khartoum Declaration* of 2007 – to make ASTIF operational.

In adopting STISA in 2014, the heads of state and government called upon member states, regional economic communities and development partners to align, connect and use STISA as a reference framework in designing and co-ordinating their own development agendas for STI.

Concerning intellectual property, the proposal to create a Pan-African Intellectual Property Organization (PAIPO) has regained momentum since the idea was first put forward in 2007 at the African Union Summit in Khartoum. However, the development and publication in 2012 of the draft statutes creating PAIPO have been the object of substantial criticism, from questioning the impact of stronger intellectual property protection in Africa to concerns about how PAIPO would

7. such as the UN Framework Convention on Climate Change, UN Convention to Combat Desertification, the UN Convention on Biological Diversity and the Ramsar Convention on Wetlands

Box 20.1 The Gaborone Declaration for Sustainability in Africa

In May 2012, the heads of state of Botswana, Gabon, Ghana, Kenya, Liberia, Mozambique, Namibia, Rwanda, South Africa and Tanzania gathered in Gaborone for a two-day summit, in the company of several public and private partners.

By adopting the *Gaborone Declaration for Sustainability in Africa*, the ten countries engaged themselves in a multi-year process. They recommitted to implementing all conventions and declarations promoting sustainable development and undertook to:

- integrate the value of natural capital into national accounting and corporate planning and reporting processes, policies and programmes;
- build social capital and reduce poverty by transitioning agriculture, extractive industries, fisheries and other natural capital uses to

practices that promote sustainable employment, food security, sustainable energy and the protection of natural capital through protected areas and other mechanisms;

- build knowledge, data, capacity and policy networks to promote leadership and a new model of sustainable development and to increase momentum for positive change.

The overall objective of the *Declaration* was 'to ensure that the contributions of natural capital to sustainable economic growth, maintenance and improvement of social capital and human well-being are quantified and integrated into development and business practice.' This statement was propelled by the signatories' realization that GDP has its limitations as a measure of well-being and sustainable growth.

The interim secretariat of this initiative is being hosted by the Department of

Environmental Affairs within the Botswanan Ministry of Environment Wildlife and Tourism, with technical support from Conservation International, a non-governmental organization. Conservation International has pledged funding for a situational analysis which will provide baseline information on where the ten countries stand with respect to the agreed actions outlined above and set priorities for moving forward.

Since the 2012 summit, an implementation framework has been drafted to track progress. In 2012, for instance, Gabon adopted a strategic plan to 2025 which foresees integrating natural capital into the national accounting system and the adoption of a national climate plan, among other moves to foster sustainable development (see p. 521).

Source: www.gaboronedeclaration.com

align its mandate with those of the two existing regional organizations, the African Regional Intellectual Property Organisation (ARIPO)⁸ and the African Intellectual Property Organisation for French-speaking Africa, which already operate under separate regimes themselves.

The *Swakopmund Protocol on the Protection of Traditional Knowledge and Expressions of Folklore* was adopted in Namibia in April 2010 by nine ARIPO member States: Botswana, Ghana, Kenya, Lesotho, Liberia, Mozambique, Namibia, Zambia and Zimbabwe. The protocol will only enter into force once six ARIPO member states have deposited instruments of ratification (for signatories) or accession (for non-signatories), which was not the case in 2014. Any state that is a member of the African Union or the United Nations Economic Commission for Africa (UNECA) may also sign up to it.

The *AU–NEPAD African Action Plan for 2010–2015* expressly underscores the important role that harmonized regional policies could play in adapting to climate change. Africa's commitment to protecting its unique natural resources

is guided at pan-African level by the African Model Law for the Protection of the Rights of Local Communities, Farmers and Breeders and for the Regulation of Access to Biological Resources (2001). The prioritization of biodiversity conservation in pan-African programmes and policies was again manifest in 2011 when the African Union encouraged all member states to adhere to international agreements on biodiversity, including the *Nagoya Protocol on Access to Genetic Resources and Sharing of Benefits Arising from their Utilization* and the *Convention on Biological Diversity* (2010).

TRENDS IN STI GOVERNANCE

Two-thirds of SADC countries have STI policies

Despite the different stages of development in terms of STI governance in Southern Africa, there is a shared and common interest in achieving sustainable development through the promotion of STI. This has engendered a plethora of institutional arrangements and bodies mandated with co-ordinating and supporting STI, as well as widespread formulation of related policies and strategies. Innovation, however, remains a secondary objective of policy formulation and, although policies are intended to support the STI ecosystem,

8. The current members of ARIPO are Botswana, Gambia, Ghana, Kenya, Lesotho, Malawi, Mozambique, Namibia, Sierra Leone, Liberia, Rwanda, São Tomé & Príncipe, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

they remain firmly linked to the state apparatus for S&T, with little participation by the private sector in policy design. In 2014, 11 out of the 15 SADC countries had STI policies in place (Table 20.3). However, STI policy documents are rarely accompanied by implementation plans and allocated budgets for implementation. Some SADC countries without dedicated policies for STI nevertheless appear to be relatively active in developing programmes to promote university–industry collaboration and innovation. Mauritius is one such example (see p. 551).

A study conducted by UNESCO within its Global Observatory of STI Policy Instruments (GO→SPIN) found a high correlation between scientific productivity and effective governance. Only seven African countries shared positive values for both government effectiveness and political stability: Botswana, Cabo Verde, Ghana, Mauritius, Namibia, the Seychelles and South Africa. The great majority of African countries had negative values for both indicators, including Angola, the Democratic Republic of Congo, Swaziland and Zimbabwe (UNESCO, 2013).

Disparities in research and development (R&D) are evident across the region. This phenomenon is illustrated by the GERD/GDP ratio, which ranges from a low of 0.01% in Lesotho to a high of 1.06% in Malawi (Figure 20.3). South Africa's own ratio (0.73%) is down from 0.89% in 2008. South Africa filed 96% of SADC patents between 2008 and 2013 and, together with Botswana, counts by far the greatest density of researchers (Figure 20.4). South Africa also stands out for the fairly equal division between the government (45%) and business enterprise (38%) sectors in terms of R&D funding and thus the maturity of industrial R&D in this country (see Table 19.5).

SADC economies have receded in the KEI

Only four SADC countries have conducted national innovation surveys under the African Science, Technology and Innovation Indicators (ASTII) programme, making comparisons subject to caution. What does emerge from the ASTII report published in 2014 is that the percentage of firms describing themselves as being innovation active is quite high, with 58.5% in Lesotho, 65.4% in South Africa, 61.3% in Tanzania and 51% in Zambia.

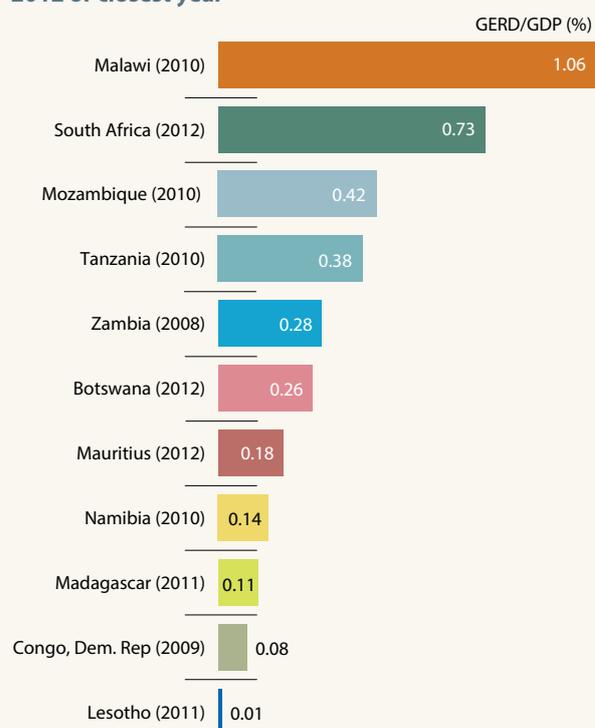
Table 20.4 presents SADC rankings in the World Bank's Knowledge Economy Index (KEI) and Knowledge Index (KI). Although these indices are largely based on the perceptions of the business sector and offer an inevitably biased view of the national innovation system, they do offer a basis for comparison. It is evident from this table that most SADC economies have receded in these international rankings since 2000, with Botswana, South Africa and Lesotho sliding the most. The four countries showing the highest KEI values are Mauritius, South Africa, Botswana and Namibia. South Africa is seen as having the most developed innovation system, whereas Mauritius offers the strongest incentive regime.

Table 20.3: STI planning in SADC countries

	STI policy document	Date of adoption/ period of validity
Angola	Yes	2011
Botswana	Yes	1998; 2011
Congo, Dem. Rep.	No	
Lesotho	Yes	2006–2011
Madagascar	Yes	2013
Malawi	Yes	2011–2015
Mauritius	No	
Mozambique	Yes	2003; 2006–2016
Namibia	Yes	1999
Seychelles	No	
South Africa	Yes	2010
Swaziland	(draft)	
Tanzania	Yes	1996; 2010
Zambia	Yes	1996
Zimbabwe	Yes	2002; 2012

Source: compiled by authors

Figure 20.3: GERD/GDP ratio in Southern Africa, 2012 or closest year



Source: UNESCO Institute for Statistics, August 2015; for Malawi: UNESCO (2014a)

Gender equity to be enshrined in national constitutions

Gender inequality is still a major social issue in Southern Africa. Women make up more than four out of ten researchers in just three countries: Mauritius, Namibia and South Africa (Figure 20.5). Only three countries report female participation in research across the public and private sectors: Botswana, South Africa and Zambia.

The *SADC Protocol on Gender and Development* (2008)⁹ set ambitious targets in this respect. One target stipulates that States Parties are to endeavour to ensure that 'by 2015, at least 50% of decision-making positions in the public and private sectors are held by women, including [through] the use of affirmative action.' Currently, South Africa (42%), Angola (37%), Mozambique (35%) and Namibia (31%) have achieved a participation rate of 30% and above for women in political representation but other countries lag far behind, including Botswana (11%). In Malawi, the proportion of parliamentary seats held by women increased from 14% to 22% between 2004 and 2009.

The protocol recommends that gender equity be enshrined in national constitutions by 2015. State Parties are also to enact laws by this date which promote equal access to, and retention at, all levels of education, including tertiary. By 2014, only seven countries had achieved parity in primary education,¹⁰ nine countries¹¹ had passed the threshold of a minimum of 50% female enrolment in secondary schools and seven counted more young women at university than young men¹² in 2014 (Morna *et al.*, 2014). It is clear that most Southern African countries will not achieve either the targets of the *SADC Protocol on Gender and Development* or the Millennium Development Goal on gender equality by 2015.

SADC students among world's most mobile

'SADC students are among the most mobile in the world, with six out of every 100 tertiary students studying abroad' (UIS, 2012). In 2009, 89 000 SADC students studied outside their home country, representing 5.8% of tertiary enrolment in the region. This ratio is higher than the regional average for sub-Saharan Africa (4.9%) and three times the world average (2.0%).

One explanation can be found in the *SADC Protocol on Education and Training* (1997), which sets out to facilitate mobility. Only three signatory countries (South Africa, Swaziland and Zimbabwe), however, have respected the

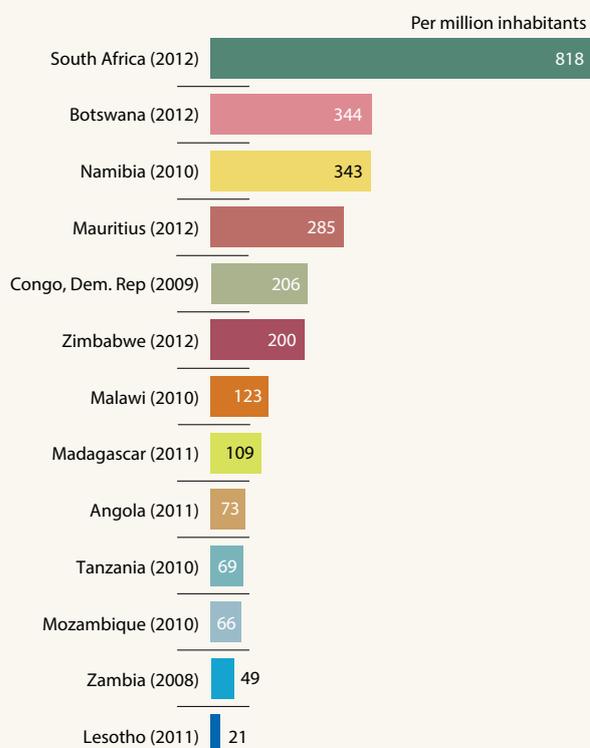
9. This protocol was signed by all but three SADC countries: Botswana, Malawi and Mauritius.

10. Botswana, Malawi, Seychelles, South Africa, Swaziland, Tanzania and Zimbabwe

11. Botswana, Lesotho, Madagascar, Mauritius, Namibia, Seychelles, South Africa, Swaziland and Zimbabwe

12. Botswana, Lesotho, Mauritius, Namibia, South Africa, Swaziland and Zambia

Figure 20.4: Researchers (HC) in Southern Africa per million inhabitants, 2013 or closest year



Source: UNESCO Institute for Statistics, April 2015

agreement in the protocol that countries cease charging higher fees for SADC students than for national students, a practice considered a potential barrier to student mobility (UIS, 2012).

Students who travel abroad from Botswana, Lesotho, Madagascar, Namibia, Swaziland and Zimbabwe tend to be concentrated in a single destination: South Africa.¹³ The latter hosted about 61 000 international students in 2009, two-thirds of whom came from other SADC nations. South Africa is not only the leading host country in Africa but also ranks 11th among host countries worldwide. Its higher education sector is well developed, with strong infrastructure and several respected research institutions that appeal to international students. Students from Angola, Malawi, Mozambique, the Seychelles, South Africa, Tanzania and Zambia tend to be dispersed across a wide range of host countries (UIS, 2012).

A growing number of publications

South Africa stands out for having the greatest number of researchers per million inhabitants (Figure 20.4) and by far the greatest output in terms of publications and patents (Figure 20.6 and Table 20.2). When population is taken into account, it comes second only to Seychelles for the number of articles.

13. with the exception of students from Madagascar, who prefer France

Table 20.4: KEI and KI rankings for 13 SADC countries, 2012

Rank	Change in rank since 2000	Country	Knowledge Economy Index	Knowledge Index	Economic Incentive Regime	Innovation	Education	ICTs
62	1	Mauritius	5.5	4.6	8.22	4.41	4.33	5.1
67	-15	South Africa	5.2	5.1	5.49	6.89	4.87	3.6
85	-18	Botswana	4.3	3.8	5.82	4.26	3.92	3.2
89	-9	Namibia	4.1	3.4	6.26	3.72	2.71	3.7
106	-9	Swaziland	3.1	3.0	3.55	4.36	2.27	2.3
115	-4	Zambia	2.6	2.0	4.15	2.09	2.08	1.9
119	-6	Zimbabwe	2.2	2.9	0.12	3.99	1.99	2.6
120	-12	Lesotho	2.0	1.7	2.72	1.82	1.71	1.5
122	-6	Malawi	1.9	1.5	3.33	2.65	0.54	1.2
127	-2	Tanzania	1.8	1.4	3.07	1.98	0.83	1.3
128	-2	Madagascar	1.8	1.4	2.79	2.37	0.84	1.1
129	5	Mozambique	1.8	1.0	4.05	1.76	0.17	1.1
142	-1	Angola	1.1	1.0	1.48	1.17	0.32	1.4

Note: Rankings are for a total of 145 countries.

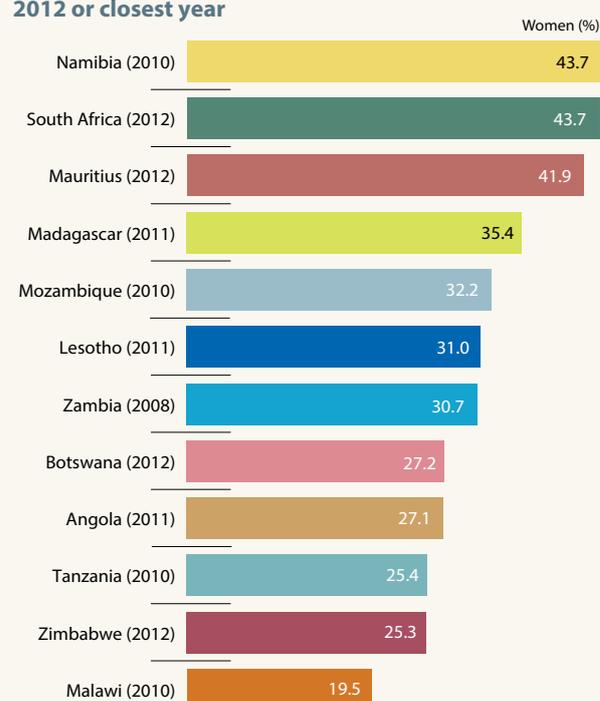
Source: World Bank

South Africa increased the number of its publications by 23% from 2009 to 2014 but the strongest growth rate was recorded by Angola and the Democratic Republic of Congo, albeit from a low base. The most prolific countries can boast of an average citation rate above the G20 average (Figure 20.6).

With nearly one-third of their publications concentrated in chemistry, engineering, mathematics and physics over the 2008–2014 period, Mauritius and South Africa are more akin to developed countries than other SADC countries where research tends to favour health-related sciences. Almost all countries share an inclination for geosciences, however (Figure 20.6).

When it comes to international collaboration, South African and Mauritian scientists stand out once more. Whereas just over half of South African articles (57%) and two-thirds of Mauritian articles (69%) had a foreign author over 2008–2014, the ratio among their SADC neighbours varied from 80% in Botswana to 96% in Mozambique and Zambia.

Figure 20.5: Women researchers (HC) in Southern Africa, 2012 or closest year



Note: Data are unavailable for some countries.

Source: UNESCO Institute for Statistics, April 2015

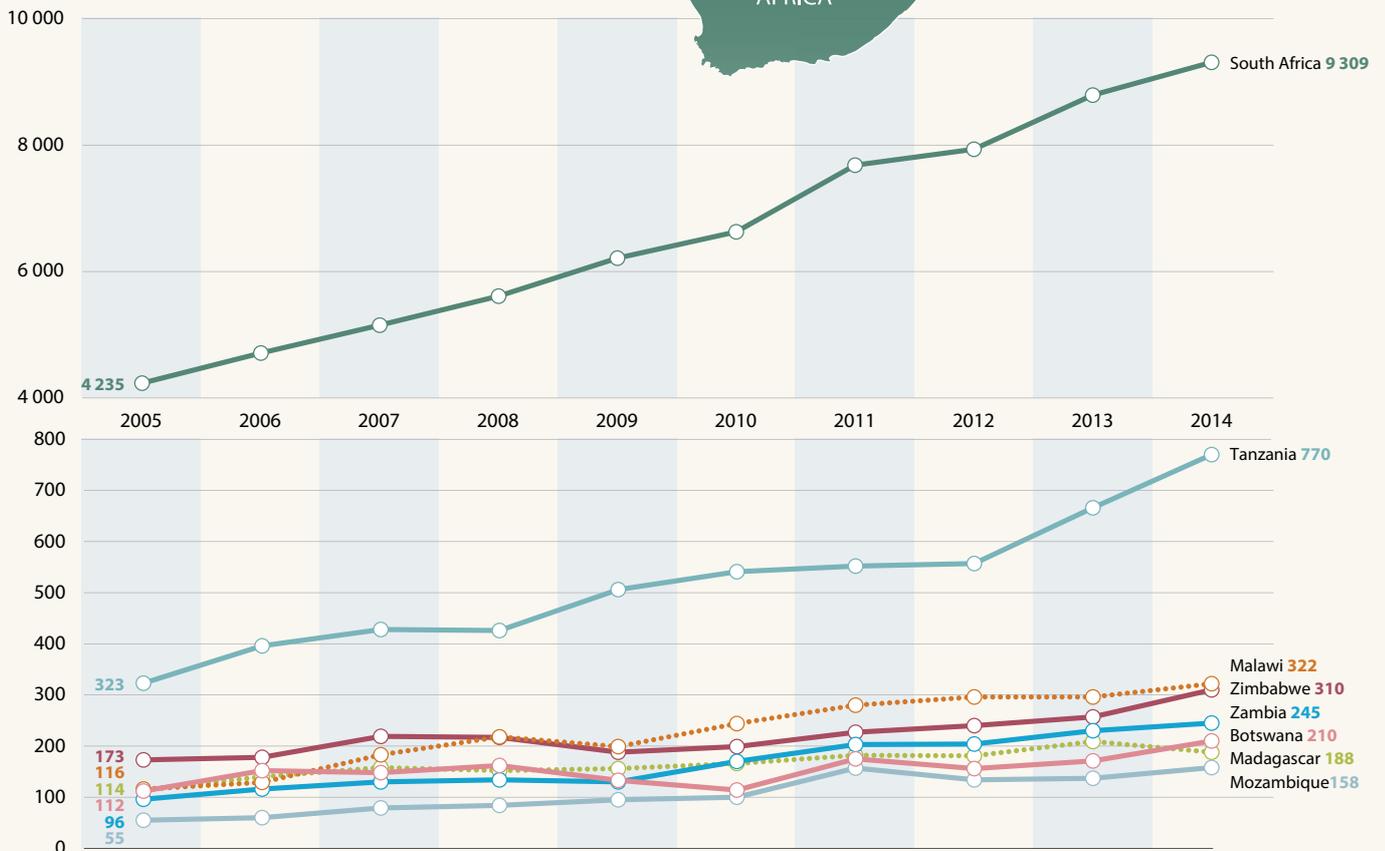
Figure 20.6: Scientific publication trends in SADC countries, 2005–2014

1.20

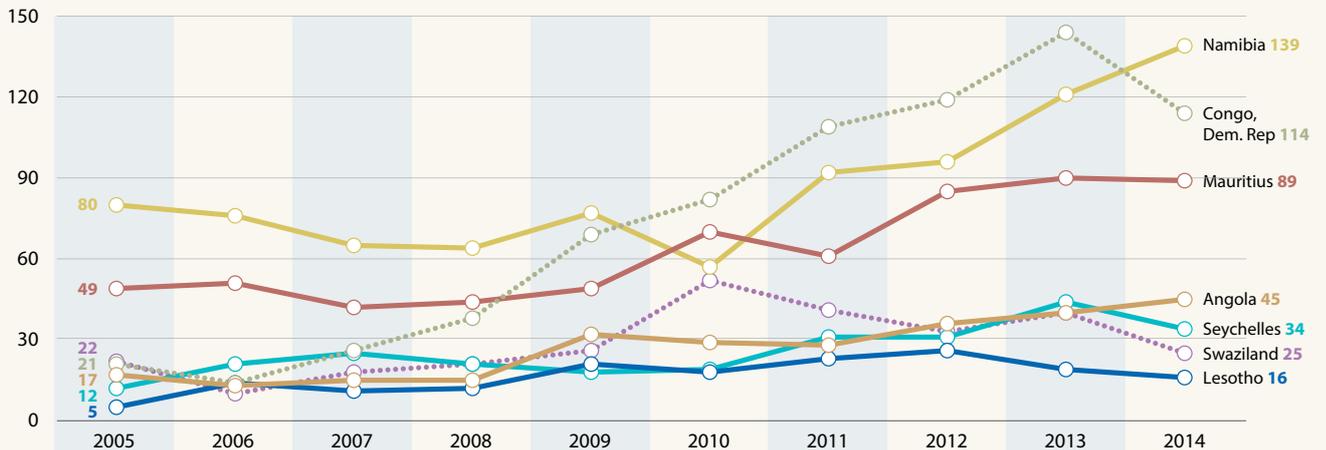
Average citation rate, 2008–2012, for the four countries with the most output: South Africa, Tanzania, Malawi and Zimbabwe; the G20 average is 1.02



Output from Malawi and Mozambique has almost tripled since 2005

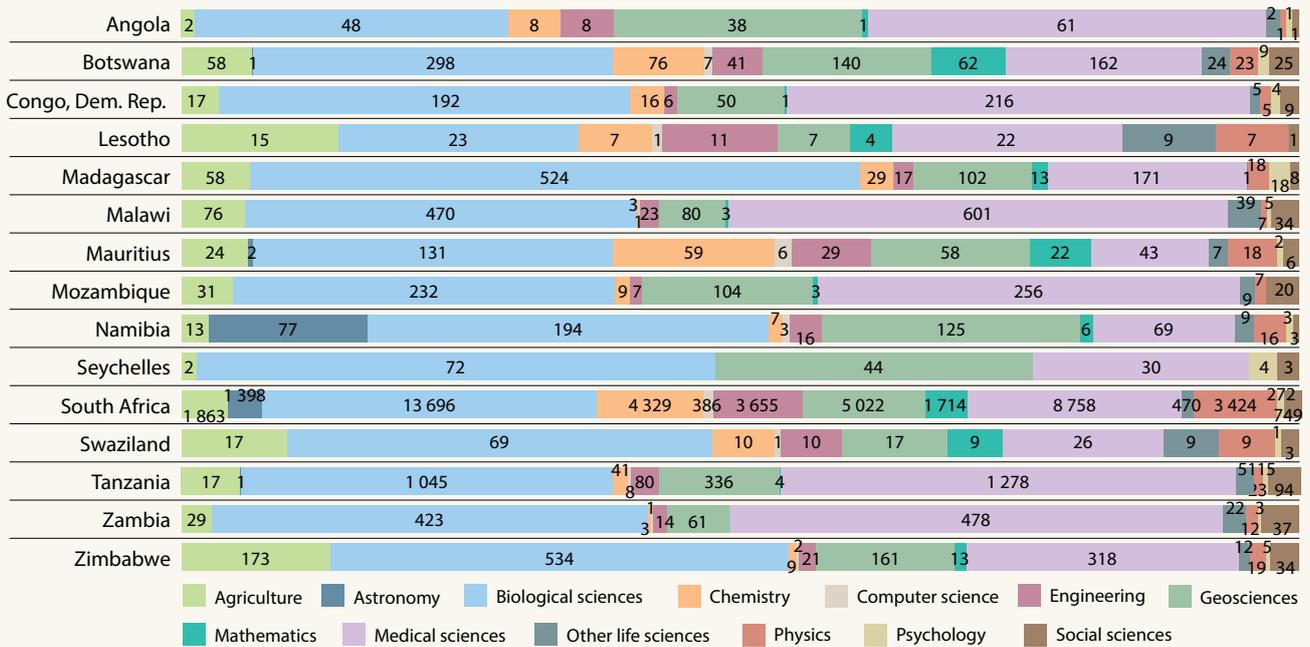


Strong growth in Angola and the Democratic Republic of Congo



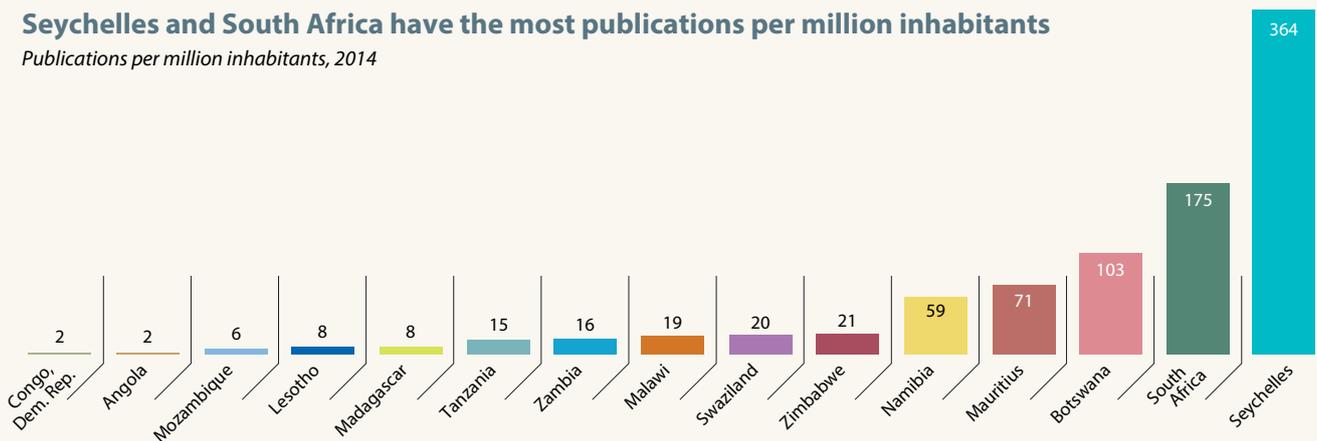
Life sciences and geosciences dominate

Cumulative totals by field, 2008–2014



Seychelles and South Africa have the most publications per million inhabitants

Publications per million inhabitants, 2014



South Africa is a key research partner for most SADC countries

Main foreign partners, 2008–2014 (number of papers)

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Angola	Portugal (73)	USA (34)	Brazil (32)	UK (31)	Spain/France (26)
Botswana	USA (367)	South Africa (241)	UK(139)	Canada (58)	Germany (51)
Congo, Dem. Rep.	Belgium (286)	USA (189)	France (125)	UK (77)	Switzerland (65)
Lesotho	South Africa (56)	USA (34)	UK (13)	Switzerland (10)	Australia (8)
Madagascar	France (530)	USA (401)	UK (180)	Germany (143)	South Africa (78)
Malawi	USA (739)	UK (731)	South Africa (314)	Kenya /N.lands (129)	
Mauritius	UK (101)	USA (80)	France (44)	India (43)	South Africa (40)
Mozambique	USA (239)	Spain (193)	South Africa (155)	UK (138)	Portugal (113)
Namibia	South Africa (304)	USA (184)	Germany (177)	UK (161)	Australia (115)
Seychelles	UK (69)	USA (64)	Switzerland (52)	France (41)	Australia (31)
South Africa	USA (9 920)	UK (7 160)	Germany (4 089)	Australia (3 448)	France (3 445)
Swaziland	South Africa (104)	USA (59)	UK (45)	Switz./ Tanzania (12)	
Tanzania	USA (1 212)	UK (1 129)	Kenya (398)	Switzerland (359)	South Africa (350)
Zambia	USA (673)	UK (326)	South Africa (243)	Switzerland (101)	Kenya (100)
Zimbabwe	South Africa (526)	USA (395)	UK (371)	Netherlands (132)	Uganda (124)

Source: Thomson Reuters' Web of Science, Science Citation Index Expanded; data treatment by Science-Metrix

COUNTRY PROFILES

The following section will be analysing the viability of national innovation systems, in terms of their potential to survive, grow and evolve. We shall be employing a broad 'national innovation systems' approach to examining the interconnectedness of STI and development (Table 20.5).

ANGOLA



Progress in higher education, despite governance issues

Angola is considered as having a viable national innovation system (Table 20.5). The biggest obstacle to the country's development prospects lies in governance. Angola ranks poorly on the Corruption Perceptions Index (161st out of 175) and Ibrahim Index of African Governance (44th out of 52, see Table 19.1). A recent UNESCO study has identified a correlation between low scientific productivity and ineffective governance (UNESCO, 2013).

Angola has the advantage of being minimally reliant on donor funding for its investment needs, being the second-largest oil producer in Africa after Nigeria and one of SADC's fastest-growing economies (see Figure 19.1). It ranks in the top half of SADC countries for GDP per capita and saw average annual growth of almost 3% over the period 2008–2013. Angola's income inequality is relatively low among SADC countries but it has a high poverty rate. It is deemed to have medium human development.

There have been concerns over the environmental impact of oil exploration and extraction, particularly the effect of offshore drilling on the fishing industry. Combined with the uncertain sustainability of global oil prices and domestic stocks, not to mention the fact that the oil industry does not generate significant local employment, this concern led the government to create a Sovereign Wealth Fund in 2012 to invest profits from oil sales in the development of a number of local industries, in an effort to diversify the country's economy and spread prosperity (AfDB, 2013).

Full data on R&D expenditure are unavailable but there are few institutions performing research and the number of researchers is low. The country's KEI and KI values are the lowest among SADC countries. In 2011, the Ministry of Science and Technology published the *National Policy for Science, Technology and Innovation*. The policy sets out to organize and develop the national STI system, identify funding mechanisms and to harness STI to sustainable development.

The prolonged civil war (1975–2002) not only left higher education in a time warp but also caused many academics to emigrate. Since the end of the war, the number of universities has mushroomed from two (1998) to over 60 today with a student roll of more than 200 000. In 2013, the government launched a *National Plan for Training Professionals*. Moreover, in a bid to anchor higher education in its development efforts, Angola is hosting the Centre of Excellence for Science Applied to Sustainability, which was established in 2011 and received its first intake of students in 2013. The centre plans to produce 100 PhDs within a decade. The first of its kind in Africa, it provides research and training on sustainable development that is open to all Africans. The centre is located within the University of Agostinho Neto in Luanda (SARUA, 2012).

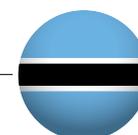
Table 20.5: Status of national innovation systems in the SADC region

Category	
Fragile	Democratic Republic of Congo, Lesotho, Madagascar, Swaziland, Zimbabwe
Viable	Angola, Malawi, Mozambique, Namibia, Seychelles, Tanzania, Zambia
Evolving	Botswana, Mauritius, South Africa

Note: National innovation systems can be analysed and categorized in terms of their potential to survive, grow and evolve. The assessment of viability thresholds is a complex exercise beyond the scope of the present chapter. The authors nevertheless propose the present set of three categories for a preliminary classification of national innovation systems in the SADC region. **Fragile systems** tend to be characterized by political instability, whether from external threats or internal political schisms. **Viable systems** encompass thriving systems but also faltering ones, albeit in a context of political stability. In **evolving systems**, countries are mutating through the effects of policy and their mutation may also affect the emerging regional system of innovation.

Source: elaborated by authors

BOTSWANA



Good governance

Along with Tanzania, Botswana has one of the longest post-independence histories of political stability in Africa. A multiparty democracy, it is deemed the continent's best-performing country by the Corruption Perceptions Index (31st out of 175) and ranks third in Africa in the Ibrahim Index of African Governance (see Table 19.1). Real GDP per capita is relatively high and growing but the country nevertheless ranks second in the SADC for inequality and there is widespread poverty (Table 20.1). Botswana's incidence of HIV (18.5% of the population) is also among the highest in the world, according to the *Botswana AIDS Impact Survey* of 2013.

Botswana is the world's top producer of diamonds, in terms of value. Despite being heavily reliant on the mining sector, Botswana has escaped the 'resource curse' to a large extent

by delinking public expenditure and revenue from the mining sector. This revenue is invested in a savings fund to enable an anti-cyclical fiscal policy. Revenue from diamonds has been invested in public goods and infrastructure and the government has long established universal scholarship schemes which fully subsidize education at all levels (AfDB, 2013).

Even before the slump in international demand during the global financial crisis of 2008–2009, diamond mining had been contributing less to economic growth with each plan period. This led the government to make diversifying the economy a priority of the *Tenth National Development Plan* for 2009–2016. The government considers private-sector participation as being ‘critical’ to the *Tenth Plan’s* success and enhancing the role of R&D as being the most effective way of fuelling entrepreneurship and private-sector growth (UNESCO, 2013).

In 2010, the government published its *Economic Diversification Drive*. A year later, it revised the Companies Act to allow applicants to register their company without the involvement of company secretaries, thereby reducing business start-up costs. The government has also introduced a points-based system to allow skilled expatriates to work in Botswana (UNESCO, 2013).

The centrepiece of the government’s strategy is the development of six innovative hubs. The first of these was established in 2008 to foster the commercialization and diversification of agriculture. The second to be set up was the Botswana Diamond Hub. Until recently, rough diamonds accounted for 70% of Botswana’s exports. After these exports contracted during the global financial crisis of 2008–2009, the government decided to derive greater benefits from its diamond industry by renegotiating agreements with multinational companies like De Beers in 2011 and setting up a Diamond Technology Park in Gaborone in 2009 as a hub for the local cutting and polishing of diamonds, as well as the manufacture of diamond jewellery. By 2012, the government had licensed 16 diamond polishing and cutting companies (UNESCO, 2013).

Hubs are also being put in place for innovation and the transport and health sectors. As of 2012, the Botswana Innovation Hub’s governing bodies had approved and registered 17 entities that will operate in the park. These include academic institutions like the University of Botswana and companies active in such diverse areas as custom design and the manufacture of drilling rigs, specialized mining exploration technologies, diamond jewellery design and manufacturing, as well as ICT applications and software. By 2013, basic services had been installed on the 57-acre plot in Gaborone, such as water mains and electricity, and the site was ready for intensive development (UNESCO, 2013).

In addition, an education hub has been approved by the Government Implementation Co-ordinating Office, with the objective of developing quality education and research training to make Botswana a regional centre of excellence and promote economic diversification and sustainable growth. High unemployment (18.4% in 2013, see Table 20.1) has been linked to the mismatch between skills development and market needs, together with slow private-sector growth. The Botswana Education Hub will be co-ordinating its activities with those of the other five hubs in agriculture, innovation, transport, diamonds and health (UNESCO, 2013).

Botswana has two public and seven private universities. The University of Botswana is primarily a teaching institution, whereas the newly established Botswana International University of Science and Technology, which welcomed its first 267 students in September 2012, is R&D-based and determined to raise the academic qualifications of staff. There has been considerable progress in education over the past decade (SARUA, 2012). Scientific publications also increased from 133 to 210 between 2009 and 2014 (Figure 20.6).

The *National Policy on Research, Science, Technology and Innovation* (2011) is accompanied by an implementation plan (2012). The policy sets the target of raising the GERD/GDP ratio from 0.26% in 2012 to over 2% by 2016 (Republic of Botswana, 2011, p. 6). This target can only be reached within the specified time frame by raising public spending on R&D. The policy has four main thrusts:

- Development of a co-ordinated and integrated approach to STI planning and implementation;
- Development of STI indicators, in accordance with the guidelines of the OECD’s *Frascati* and *Oslo Manuals*;
- The launch of regular participatory foresight exercises; and
- The strengthening of institutional structures responsible for policy monitoring and implementation.

The 2011 policy is a revision of the country’s first *Science and Technology Policy* (1998). The 2011 policy has been consolidated with the 2005 *Botswana Research, Science and Technology Plan* (2005), following the recommendations of a review conducted by UNESCO in 2009. The main reason for the review was to align Botswana’s policy with *Vision 2016* outlined in the *Tenth National Development Plan*. The review concluded that the same obstacles to R&D persisted in 2009, implying that the 1998 policy had made little impact on job and wealth creation (UNESCO, 2013).

In 2013, Botswana initiated the development of a *National Climate Change Strategy and Action Plan*. A climate change policy will be developed first, followed by the strategy. The process will reportedly be highly consultative, with the participation of rural inhabitants.

DEMOCRATIC REPUBLIC OF CONGO



A new academy of science and technology

The ongoing armed conflict in the Democratic Republic of Congo remains a major obstacle to the development of a national innovation system. The country shows the lowest HDI and GDP per capita and the highest poverty rate of any SADC member. The country's dependence on donor funding is high and climbed steeply between 2007 and 2009. The country also scores poorly (40th) in the Ibrahim Index of African Governance (see Table 19.1).

The Democratic Republic of Congo does not have a national STI policy. Scientific research capacity exists mainly in public universities and government-owned research institutes. The Ministry of Scientific Research and Technology supports five research organizations active in the fields of agriculture, nuclear energy, geology and mining, biomedicine, environment and conservation, as well as a geographical institute.

In 2012, the Academy for the Advancement of Science and Technology for Innovation was established in Kinshasa, driven by the community of researchers and financed by members' contributions, donations and legacies, with support from the Ministry of Scientific Research and Technology. Another sign of the scientific community's dynamism is the near-tripling of its research output between 2008 and 2014 (Figure 20.6).

The Democratic Republic of Congo has a relatively large higher education sector, with a total of 36 publicly funded universities, 32 of which were established between 2009 and 2012 (SARUA, 2012). There seems to be little interaction between universities and industry and, to date, a single business incubator has been established in the country.

The Academic Instruction Act (2011) has replaced the former policy framework for higher education dating from 1982. Another influential document is *Vision 2020*, which aims to develop a university curriculum attuned to national development priorities through three key strategies: the promotion of entrepreneurship, the development of technical and vocational skills and the provision of the relevant human capital through improved teacher training. The *Poverty Reduction Strategic Paper* of 2005 had articulated the need for teacher training and better vocational and technical skills and identified higher education as being a central player in meeting national development needs (AfDB *et al.*, 2014).

LESOTHO



A compact to develop the private sector and social services

In mid-2014, this mountainous kingdom with a population of two million experienced a political crisis after parliament was suspended, prompting an attempted military coup. The SADC brokered a solution to the crisis which resulted in parliamentary elections being brought forward by two years to March 2015. The party of the outgoing prime minister was returned to power in what the SADC described as a 'free, fair and credible' election.

According to national figures, 62.3 % of the population lives below the national poverty line and unemployment is high, at 25.4%. With 23% of 15–49 year-olds infected with HIV,¹⁴ average life expectancy stands at less than 49 years. Human development is low, with Lesotho ranking 158th out of 187 countries in 2012, despite having registered some improvement since 2010 (Government of Lesotho and UNDP, 2014). GDP per capita grew by 18.7% over the period 2009–2013 (Table 20.2).

Three in four inhabitants live in rural areas and are dependent on subsistence agriculture. Since agricultural productivity is low and only 10% of the land is arable, Lesotho relies heavily on imports from South Africa. It also depends on its South African neighbour for employment and for the purchase of its main natural resource: water.

Within the country, the government remains the main employer and greatest consumer, accounting for 39% of GDP in 2013. Lesotho's largest private employer is the textile and garment industry; approximately 36 000 Basotho, mainly women, work in factories which produce garments for export to South Africa and the USA (see Figure 18.2). Diamond mining has grown in recent years and may contribute 8.5% to GDP by 2015, according to current forecasts. Lesotho remains extremely dependent on donor funding.

In 2007, Lesotho signed a six-year US\$ 362.5 million Millennium Challenge Account Compact to strengthen the health care system, develop the private sector and broaden access to improved water supplies and sanitation. Thanks to Lesotho's 'strong performance' and 'continued commitment to democratic principles and good governance', the country became eligible in December 2013 to apply for a second compact¹⁵ funded by the Millennium Challenge Account. The process of compact development takes two years, so, if the application is successful, the second compact will become effective in 2017.

14. See: www.unaids.org/en/regionscountries/countries/lesotho

15. See: www.lmda.org.ls

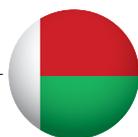
Major obstacles to economic growth, private sector-led entrepreneurship and poverty alleviation in Lesotho relate to the fact that the government has not managed to use its resources efficiently to provide public services that encourage high levels of private investment and entrepreneurship.

Much of STI policy still to be implemented

Lesotho's basic R&D indicators depict a poorly developed STI sub-sector with the lowest GERD/GDP ratio (0.01% in 2011) of any SADC country (Figure 20.3). The country has a single public university, the National University of Lesotho (est. 1945) and a number of other public and private tertiary-level institutions. The private establishments partly compensate for the limited capacity of the public sector to satisfy enrolment needs. Clearly, public resources need to be better utilized at all levels, if STI is to be harnessed to meeting the country's development needs.

The *National Science and Technology Policy for 2006–2011* envisioned raising government funding of R&D to 1% of the annual national budget and recommended establishing new institutions, including the Lesotho Advisory Commission on Science and Technology to manage S&T policy implementation and the Lesotho Innovation Trust Fund to mobilize funding for STI. The Department of Science and Technology – located in the Ministry of Communications, Science and Technology – is responsible for promoting and co-ordinating STI policy, according to the detailed implementation plan developed in 2010. The plan required that measures be taken to ensure that all segments of society benefit from STI, in keeping with the Basotho spirit of *letsema*. However, to date, the policy remains largely unimplemented and has not been revised.

MADAGASCAR



A research policy oriented towards development

In Madagascar, the coup d'état of 2009 resulted in international sanctions which have curtailed donor funding. Today, the economy is faltering: GDP per capita dropped by 10.5% over the period 2008–2013. Madagascar has the second-highest reported poverty rate within the SADC after the Democratic Republic of Congo, even though it has a median ranking within the community for human development.

In terms of governance, Madagascar actually dropped from 118th to 127th place out of 175 countries between 2013 and 2014 in the Corruption Perceptions Index. All governance indices identify political instability as an aggravating factor for corruption – and vice versa – and as being the main obstacle to creating an enabling and healthy business environment (IFC, 2013). Like many countries, Madagascar observes International

Anti-Corruption Day each year on 9 December. The theme in 2013 was 'Zero Corruption, 100% Development'.

Madagascar has a low GERD/GDP ratio (0.11% in 2011). R&D is spread across several research institutes which cover agriculture, pharmaceuticals, oceanography, environment, veterinary sciences, nuclear energy, botany and zoology, among other areas. The country counts six public universities and three technical universities, eight national centres of research and 55 privately funded universities and colleges. Enrolment has increased dramatically since 2005 and doctoral programmes are offered by 29 discipline-based schools or departments within both public and private universities.

The government has identified higher education as a major agent of national development. For example, Challenge 5 of the *Madagascar Action Plan 2007–2012* identifies the need to transform higher education. Its specific goals are to:

- ensure competitiveness, creativity and the employability of graduates;
- foster research and innovation;
- offer diversified courses to meet national socio-economic needs;
- improve the governance of public universities; and
- develop high-quality private universities and technical institutes.

Between 2000 and 2011, the number of students enrolled in Madagascar's public universities more than doubled from 22 166 to 49 395, according to the Ministry of Education and Scientific Research. Nearly half attended the University of Antananarivo. The great majority of PhD students were enrolled in science and engineering disciplines (SARUA, 2012). The student population at both public and private universities almost doubled between 2006 and 2012 to 90 235 but the number of PhD candidates actually shrank (Table 19.4).

Madagascar does not have a national STI policy but it did adopt a national research policy in December 2013 to promote innovation and the commercialization of research results for socio-economic development. This policy is accompanied by five *Master Plans of Research* related to renewable energies, health and biodiversity, agriculture and food security, environment and climate change. These plans have been identified as priorities for R&D; other plans are being elaborated in 2015–2016.

Moreover, a Competitive Fund for Research and Innovation is currently being set up. It is intended to strengthen the relationship between research and socio-economic benefits and to throw bridges between public researchers and the

private sector, as outlined by the national research policy. This fund is financed by the government, as well as by bilateral and multilateral partners.

In 2012, the Ministry of Higher Education and Scientific Research advocated a radical reform, emphasizing the importance of improving the interface between scientific research and the country's development goals.

MALAWI



wooing investors to diversify the economy

Malawi has been a multiparty parliamentary democracy since 1994. For the past 10 years, the economy has grown annually by 5.6% on average, making it the sixth-fastest growing economy in the SADC. It is projected that, between 2015 and 2019, annual growth in real GDP will range from 6% to 5% (IMF, 2014). Malawi's ratio of donor funding to capital formation rose considerably over the period 2007–2012. At the same time, its attempts to diversify the agriculture sector and move up the global value chain have been seriously constrained by poor infrastructure, an inadequately trained work force and a weak business climate (AfDB *et al.*, 2014).

Malawi has one of the lowest levels of human development in the SADC (see Tables 19.1 and 20.2) but it is also one of three African countries that 'are making especially impressive progress for several Millennium Development Goals,' along with Gambia and Rwanda, including with regard to primary school net enrolment (83% in 2009) and gender parity, which has been achieved at primary school level (UNESCO, 2014a).

The economy is heavily dependent on agriculture, which accounts for 27% of GDP (Figure 20.2) and 90% of export revenue. The three most important export crops are tobacco, tea and sugar – with the tobacco sector alone accounting for half of exports (see Figure 18.2). Malawi spends more on agriculture (as a share of GDP) than any other African country (see Table 19.2). Over 80% of the population is engaged in subsistence farming, with manufacturing earning just 10.7% of GDP (Figure 20.2). Moreover, most products are exported in a raw or semi-processed state.

Malawi is conscious of the need to attract more FDI to foster technology transfer, develop human capital and empower the private sector to drive economic growth. FDI has been growing since 2011, thanks to a government reform of the financial management system and the adoption of an *Economic Recovery Plan*. In 2012, the majority of investors came from China (46%) and the UK (46%), with most FDI inflows going to infrastructure (62%) and the energy sector (33%) [UNESCO, 2014a].

The government has introduced a series of fiscal incentives to attract foreign investors, including tax breaks. In 2013, the Malawi Investment and Trade Centre put together an investment portfolio spanning 20 companies in the country's six major economic growth sectors, namely agriculture, manufacturing, energy (bio-energy, mobile electricity), tourism (ecolodges) and infrastructure (wastewater services, fibre optic cables, etc.) and mining (UNESCO, 2014a).

In 2013, the government adopted a *National Export Strategy* to diversify the country's exports (Government of Malawi, 2013). Production facilities are to be established for a wide range of products¹⁶ within the three selected clusters: oil seed products, sugar cane products and manufacturing. The government estimates that these three clusters have the potential to represent more than 50% of Malawi's exports by 2027 (see Figure 18.2). In order to help companies adopt innovative practices and technologies, the strategy makes provision for greater access to the outcome of international research and better information about available technologies; it also helps companies to obtain grants to invest in such technologies from sources such as the country's Export Development Fund and the Malawian Innovation Challenge Fund (Box 20.2) [UNESCO, 2014a].

Productive scientists, few university places

Despite being one of the poorest countries in the world, Malawi devoted 1.06% of GDP to GERD in 2010, according to a survey by the Department of Science and Technology, one of the highest ratios in Africa. Also noteworthy is that Malawian scientists publish more in mainstream journals – relative to GDP – than any other country of a similar population size (UNESCO, 2014a).

Enrolment in higher education struggles to keep up with rapid population growth. Despite a slight improvement, only 0.81% of the age cohort was enrolled in university by 2011. Moreover, although the number of students choosing to study abroad increased by 56% between 1999 and 2012, their proportion decreased from 26% to 18% over the same period (UNESCO, 2014a).

Malawi's first science and technology policy from 1991 was revised in 2002. Despite being approved, the 2002 policy has not been fully implemented, largely due to the lack of an implementation plan and an unco-ordinated approach to STI. This policy has been under revision in recent years, with UNESCO assistance, to re-align its focus and approaches with the second *Malawi Growth and Development Strategy* (2013) and with international instruments to which Malawi is a party (UNESCO, 2014a).

¹⁶ including cooking oil, soaps, lubricants, paints, animal feed, fertilizers, snacks and cosmetics

The *National Science and Technology Policy* of 2002 envisaged the establishment of a National Commission for Science and Technology to advise the government and other stakeholders on science and technology-led development. Although the Science and Technology Act of 2003¹⁷ made provision for the creation of this commission, it only became operational in 2011, with a secretariat resulting from the merger of the Department of Science and Technology and the National Research Council. The Secretariat of the National Commission for Science and Technology reviewed the current *Strategic Plan for Science, Technology and Innovation (2011–2015)* but, as of early 2015, the revised STI policy had not yet met with Cabinet approval (UNESCO, 2014a).

Among the notable achievements stemming from the implementation of national STI policies in recent years are the:

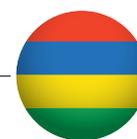
- establishment, in 2012, of the Malawi University of Science and Technology and the Lilongwe University of Agriculture and Natural Resources (LUANAR¹⁸) to build STI capacity. This brings the number of public universities to four, with the University of Malawi and Mzuzu University;
- improvement in biomedical research capacity through the five-year Health Research Capacity Strengthening Initiative (2008–2013) awarding research grants and competitive scholarships at PhD, master's and first degree levels, supported by the UK Wellcome Trust and DfID;
- strides made in conducting cotton confined field trials, with support from the US Program for Biosafety Systems, Monsanto and LUANAR (see Box 18.2).
- introduction of ethanol fuel as an alternative fuel to petrol and the adoption of ethanol technology;

17. A Science and Technology Fund was also established by the Science and Technology Act of 2003 to finance research and studies through government grants and loans; it was not yet operational by 2014 (UNESCO, 2014b).

18. LUANAR was delinked from the University of Malawi in 2012.

- launch of the *ICT Policy for Malawi* in December 2013, to drive the deployment of ICTs in all economic and productive sectors and improve ICT infrastructure in rural areas, especially via the establishment of telecentres; and
- a review of secondary school curricula in 2013.

MAURITIUS



Competing with South Africa as an investment hub

Mauritius is a small island nation with 1.3 million inhabitants. Unemployment is low and the country counts the second-highest GDP per capita in the SADC; it grew by more than 17% over the period 2008–2013. Mauritius also ranks second-highest in the SADC region for human development and has the third-best score in the Corruption Perceptions Index (47th out of 175), behind Botswana (31st) and Seychelles (43rd). In 2012, there were almost twice as many students enrolled in higher education as in 2006 (Table 19.4).

The economy is driven by tourism, textile manufacturing, sugar and financial services. There has been a rapid diversification of the economic base towards ICTs, seafood, hospitality, property development, health care, renewable energy, education and training, which have attracted both local and foreign investors. Mauritius' status as an investment hub for new businesses has also provided significant opportunities for offshore companies. This diversification is largely due to the government's determination to move the economy up the value chain towards an economy based on high skills and technology. The strategy has worked: in 2013, Mauritius overtook South Africa to become the most competitive economy in sub-Saharan Africa.

Box 20.2: The Malawi Innovation Challenge Fund

The Malawi Innovation Challenge Fund (MICF) is a new competitive facility, through which businesses in Malawi's agricultural and manufacturing sectors can apply for grant funding for innovative projects with potential for making a strong social impact and helping the country to diversify its narrow range of exports.

The fund is aligned on the three clusters selected within the country's

National Export Strategy: oil seed products, sugar cane products and manufacturing.

The MICF provides a matching grant of up to 50% to innovative business projects to help absorb some of the commercial risk in triggering innovation. This support should speed up the implementation of new business models and/or the adoption of technologies.

The first round of competitive bidding opened in April 2014.

The fund is endowed with US\$ 8 million from the United Nations Development Programme and the UK Department for International Development.

Source: AfDB press release and personal communication; authors

UNESCO SCIENCE REPORT

To a large extent, the radical transformation of the Mauritian economy has been informed by a policy document entitled *Maurice Ile Durable (Mauritius: Sustainable Island)*, adopted in 2011. This document anchors economic development firmly in sustainability and has five interlinking foci: energy, the environment, education, employment and equity. Mauritius passed an Energy Efficiency Act in 2011 and has adopted an *Energy Strategy for 2011–2025* which stresses sustainable building design and transportation, together with the development of renewable energy sources such as solar, geothermal and hydropower.

Mauritius has been a central player in the implementation of the *Programme of Action for the Sustainable Development of Small Island Developing States*, having hosted one of the three landmark meetings¹⁹ which are driving this programme, in 2005. Mauritius led a call, in 2014, for the establishment of a UNESCO centre of excellence on ocean science and innovation for capacity-building and research, as a contribution to the *2030 Agenda for Sustainable Development*. The call was endorsed by the *Mauritius Ministerial Declaration* adopted by Mauritius, Comoros, Madagascar and the Seychelles at the conclusion of a high-level meeting on strengthening STI policy and governance for the sustainable development of small island developing states and their resilience to climate change.

A series of moves to boost R&D

In 2012, Mauritius devoted 0.18% of GDP to GERD (Figure 20.3). About 85% of public R&D expenditure is invested in S&T-related fields. The sectors with the highest expenditure (together accounting for about 20% of total spending on S&T) are agriculture, environment and ocean/marine sciences, followed by health and ICTs, which account for about 4–7% of total spending. Mauritius has set itself the target of increasing public expenditure on R&D to 1% of GDP by 2025 and expects the private sector to contribute at least 50% of national expenditure on R&D by this date.

In 2009, the Mauritius Research Council held a series of consultations. In addition to its advisory role, this government agency co-ordinates and funds research to give industries the edge in innovation. The consultations produced the following proposals for:

- raising private spending on R&D;
- strengthening intellectual property laws;
- promoting market-driven research;
- consolidating the linkages between researchers in the public sector and industry; and

- instituting fiscal measures to attract private investment in R&D.

In response to these recommendations, the government took a series of measures to boost R&D, including the:

- provision, in 2014, of Rs 100 million (circa US \$3 million) to fund R&D, including through the Public Sector Collaborative Research Scheme and the Small Business Innovation Scheme, operated by the Mauritius Research Council; the main project areas are: biomedicine; biotechnology; energy and energy efficiency; ICTs; land and land use; manufacturing technology; science and technology education; social and economic research; and water resources;
- amendment, in 2014, to the Mauritius Research Council Act to provide for a National Research and Innovation Fund;
- establishment of the International Institute of Technology Research Academy, which moved to its main campus in 2015, through a memorandum of understanding between the Indian Institute of Technology in India and the Mauritius Research Council, in collaboration with the University of Mauritius; and, lastly,
- provision, in 2013, for the recruitment of 30 experienced international lecturers for the country's two universities – the University of Mauritius and the University of Technology²⁰ – to foster greater research and improve teaching standards.

The Mauritius Research Council is the main co-ordinating agency of the Ministry of Tertiary Education, Science, Research and Technology. The ministry is currently overseeing the formulation of the country's first *National Policy and Strategy on Science, Technology and Innovation* covering the period from 2014 to 2025. The main foci of the draft policy are:

- human competencies in the STI sector;
- the role of the public research sector;
- the link between science and society;
- technology absorption and innovation;
- investment in research and innovation;
- meeting challenges through enhanced research;
- promotion of African STI initiatives; and
- governance and sustainability.

Some challenges remain for policy formation; there is a need to bring coherence and a long-term vision to the forefront of STI governance and to bridge the gap between public research institutions and private businesses.

19. First adopted in Barbados in 1994, this programme was updated in Mauritius in 2005 then again in Samoa in 2014.

20. Three other institutions offer higher education: the Mauritius Institute of Education, the Mahatma Gandhi Institute and the Mauritius College of the Air.

MOZAMBIQUE



An opportunity to accelerate development

Mozambique's high growth rate over the past decade (6.0–8.8% per year) dates from the start of aluminium and natural gas production in the 2000s, which brought in substantial FDI. The country's reliance on donor funding, while still high, decreased dramatically between 2007 and 2012. However, economic growth has not yet translated into human development. Mozambique still ranks 185th out of 187 countries, there having been no change since 2007. Poverty is widespread. This situation is a major obstacle to economic diversification, especially when combined with high financial costs, poor infrastructure and an inhibitive regulatory framework (AfDB, 2013). Mozambique also scores poorly on the Corruption Perceptions Index (119th out of 175) and the Ibrahim Index of African Governance (see Table 19.1).

Neither the country's *Science and Technology Policy* (2003), nor the *Mozambique Science, Technology and Innovation Strategy*, approved in 2006 with a horizon of 10 years, has yet delivered on its promises. The *Strategy* establishes a set of priorities to eradicate extreme poverty, harness economic growth and improve the social well-being of all Mozambicans. It is being implemented in conjunction with international partners. The GERD/GDP ratio (0.42% in 2010) for Mozambique places it in the middle range of SADC countries but the density of researchers is low: just 66 per million inhabitants in 2010 (head count), excluding the business sector.

To foster implementation of the *Science and Technology Policy*, Mozambique created a National Research Fund in 2006 that is operated by the Ministry of Science and Technology. Funding goes to numerous projects for scientific research, innovation and technology transfer in the following areas: agriculture, education, energy, health, water, mineral resources, environmental sustainability, fisheries and marine sciences and botanical sciences.

The country has 16 research institutions, in addition to several national research councils active in the fields of water, energy, agriculture, medicine and ethno-botany, among others. The National Academy of Science dates from 2009.

Mozambique has 26 institutions of higher education, half of which are privately run. However, public institutions account for the majority of students, particularly Eduardo Mondlane University and Universidade Pedagógica. Demand for higher education is growing rapidly: there were four times more students enrolled in 2012 (124 000) than in 2005 (see Table 19.4).

Like several of its neighbours, Mozambique is currently mapping its science system, in partnership with UNESCO's Global Observatory of STI Policy Instruments (GO→SPIN).

The ultimate aim is to use this mapping exercise as the basis for drawing up a revised STI policy that could be applied to such critical areas as mitigating the consequences of climate change; exploring new energy sources; generating innovation to foster social inclusion; promoting the sustainable management and conservation of freshwater; terrestrial resources and biodiversity; and disaster resilience.

With its newfound political stability and income from aluminium, gas and coal, Mozambique has an unprecedented opportunity to accelerate development and improve social welfare. To generate income in a sustainable way, however, wealth must be managed and transformed into assets that can continue to serve the country's long-term interests.

NAMIBIA



A need to diversify the economy

While Namibia is classified as a middle-income country on the basis of its GDP per capita, its Gini coefficient (see the glossary, p. 738) reveals one of the world's highest levels of inequality, despite a modest improvement since 2004. Namibia also suffers from an unemployment rate of 16.9% (Table 20.1) and widespread poverty, with the majority of the population surviving on subsistence agriculture. To this must be added the impact of long periods of severe drought and a high prevalence of HIV and AIDS. Namibia also ranks 128th out of 186 countries for human development. These indicators point to the formidable obstacles that Namibia must overcome, if it is to shake off its over-reliance on mining (see Figure 18.2), which only employs about 3% of the population.

Namibia's long-term development strategy is guided by *Vision 2030*, a planning document adopted in 2004 to 'reduce inequalities and move the nation significantly up the scale of human development, to be ranked high among the developed countries²¹ in the world.' Five 'driving forces' were identified to realize the objectives of *Vision 2030*: education, science and technology; health and development; sustainable agriculture; peace and social justice; and gender equality.

In 2010, Namibia still had a low GERD/GDP ratio (0.14%) but it did count 343 researchers (head count) per million inhabitants, one of the region's better ratios. The country's KEI and KI values are also quite high, even though Namibia dropped nine places between 2000 and 2012. Two factors no doubt explain this relatively good performance: Namibia's market-friendly environment, which benefits from its proximity to South Africa; and its two reputable universities which have produced a critical mass of skilled workers over the past two decades, as well as a small, well-trained professional and managerial class.

21. See: www.gov.na/vision-2030

UNESCO SCIENCE REPORT

Two reputable universities

Taken together, the Namibia University of Science and Technology (formerly the Polytechnic of Namibia) and the University of Namibia account for 93% of student enrolment, the remainder being assured by two private institutions.

The University of Namibia boasts a student population of about 19 000 and a network of 12 satellite campuses and 9 regional centres nationwide. It has Faculties of: Agriculture and Natural Resources; Economics and Management Science; Education; Engineering; Health Sciences; Humanities and Social Sciences; Law; and Natural Sciences. The university offers 12 PhD programmes and has so far awarded 122 PhDs. It has put incentives in place to encourage researchers to publish their findings.

The Namibia University of Science and Technology strives to 'enhance innovation, entrepreneurship and competitiveness in Namibia and the SADC region.' It counts seven schools/faculties and 10 centres of excellence, which served a student body of over 12 000 in 2014. A Cooperative Education Unit (CEU) was established in 2010, in order to give graduates the skills required by industry. The CEU collaborates with industry in the design of its curricula and co-ordinates a programme through which students compete for an internship or industrial placement to put what they have learned into practice.

A three-year programme to boast STI

Within the Ministry of Education, it is the Directorate for Research, Science and Technology under the Department of Tertiary Education, Science and Technology which ensures co-ordination of science. In 2013, Namibia established a National Commission on Research, Science and Technology, pursuant to the Research, Science and Technology Act (2004). The commission is mandated to implement the Biosafety Act of 2006. It has also been entrusted with developing a three-year National Research, Science, Technology and Innovation Programme, with UNESCO's²² assistance. The programme stems from the directives of the *National Policy on Research, Science and Technology*, adopted in 1999.

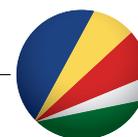
A national consultative workshop was held in March 2014 to pave the way towards an implementation strategy for the National Research, Science, Technology and Innovation Programme. Participating researchers, innovators and entrepreneurs assisted in identifying national priority fields, taking into consideration *Namibia's Industrial Policy* (2013), its current economic blueprint, the *Fourth National Development Plan* (2012–2017) and *Vision 2030*. The programme will seek to create an environment more conducive to research and innovation in the essential areas

of policy, human resource development and the related institutional framework.

In 2013, UNESCO helped Namibia to develop a manual for operationalizing the National Research, Science and Technology Fund. The first disbursement from the fund was made jointly with South Africa in March 2014 (30 projects for a value of N\$ 3 million, *circa* US\$ 253 000). This was followed by a first national disbursement in May 2014 (27 projects for N\$ 4 million). The funds from the second and third national calls for research proposals are due to be disbursed in May 2015. The grant recipients thus far are the University of Namibia, Polytechnic of Namibia, Ministry of Fisheries and Marine Resources, Ministry of Education and an NGO, the Desert Research Foundation of Namibia.

Namibia is also participating in UNESCO's GO→SPIN programme, in order to put a reliable information system in place to monitor STI policy implementation.

SEYCHELLES



A first university and national STI institute

Having recovered from virtual economic collapse in 2007–2008, Seychelles is now a rising star (AfDB *et al.*, 2014). It comes out on top in the SADC region for GDP per capita, human development and unemployment and poverty levels. It is also one of the top-scorers for good governance, low corruption and general security. Despite these achievements, not everyone in this small island state is seeing the benefits. The economy is primarily based on tourism, agriculture and fisheries but economic growth has been led almost exclusively by the tourism sector. As a result, Seychelles has the greatest level of inequality of any SADC country.

There are no recent R&D data for Seychelles. In 2005, the country had a low GERD/GDP ratio (0.30%) and, given its population of 93 000, only a handful of researchers: 14. The main research institute is the Seychelles Centre for Marine Research and Technology (est. 1996).

Seychelles' first university dates only from 2009; it welcomed its first 100 students in 2012 (see Table 19.4). Though still in its infancy, the University of Seychelles is developing rapidly. It has already established strong collaboration with other universities in the SADC region (SARUA, 2012).

Parliament passed a bill creating the country's first National Institute of Science, Technology and Innovation in 2014. In January 2015, the government upgraded the Department of Entrepreneurship Development and Business Innovation to ministry status, adding the portfolio of investment.

22. See: <http://tinyurl.com/unesco-org-policy-namibia>

SOUTH AFRICA

**Outward FDI flows have doubled**

South Africa is currently Africa's second-largest economy after Nigeria. Despite having a population of only 53 million, it generates about one-quarter of African GDP. It is classified as a middle-income country and has a relatively solid national innovation system. With its regional political influence and growing economic presence in Africa, the country has the potential to drive economic growth across the continent. For the moment, its weight is felt most by its immediate SADC neighbours, through the development of trading partnerships, political agreements, business linkages and movements of people.

South Africa is the main destination for FDI inflows to the SADC region, attracting about 45% of the region's FDI in 2013, a slight decrease from 48% in 2008. South Africa is also establishing itself as a main investor in the region: over the same six-year period, its outward flows of FDI almost doubled to US\$ 5.6 billion, powered by investment in telecommunications, mining and retail in mostly neighbouring countries. In 2012, South Africa invested in more new FDI projects in Africa than any other country in the world. Moreover, among emerging economies, it is the second-biggest investor in least developed countries after India, according to the United Nations Conference on Trade and Development.

Through the Department of Science and Technology, South Africa has entered into 21 formal bilateral agreements with other African countries in science and technology since 1997, most recently with Ethiopia and Sudan in 2014 (Table 20.6). Within three-year joint implementation plans which define spheres of common interest, co-operation tends to take the form of joint research calls and capacity-building through information- and infrastructure-sharing, workshops, student exchanges, development assistance and so on.

A negative trade balance in high-tech

South Africa trades mainly with Botswana (21%), Swaziland, Zambia and Zimbabwe (12% each) and Angola (10%). This contrasts with the main destinations for South African FDI, which are Mauritius (44%), Tanzania (12%) and Mozambique (7%). Table 20.7 shows that South Africa has a consistently high negative trade balance in high-tech products, along with the rest of the SADC economies, making it a peripheral national innovation system in the global arena.

STI to help diversify the economy by 2030

The vision of the *National Development Plan* (2012) is for South Africa to become a diversified economy firmly grounded in STI by 2030. This transition is guided by the *Ten-Year Innovation Plan* (2008–2018) and its five 'grand challenges': biotechnology and the bio-economy

(formerly pharmaceuticals); space; energy security; global change; and understanding of social dynamics. Among the achievements so far, we could cite:

- the decision in 2012 to host the € 1.5 billion project to build the world's largest radio telescope in South Africa and Australasia; this is bringing significant opportunities for research collaboration (see Box 20.3), attracting leading astronomers and researchers at all stages of their careers to work in Africa; it is worth noting that South African astronomers co-authored 89% of their publications with foreign collaborators during 2008–2014;
- the *National Bio-economy Strategy*, approved in 2013, which positions bio-innovation as an essential tool for reaching the country's industrial and social development goals;
- within the DST, a reorganization of some programmes in the past five years to give greater emphasis to innovation that addresses social challenges; the Socio-Economic Innovation Partnerships programme within DST is responsible for the downstream innovation chain, through sub-programmes on innovation for inclusive development and the green economy, among others;
- the launch of the DST Technology Top 100 internship programme in 2012, which places unemployed science, technology and engineering graduates in high-tech companies; in 2013 and 2014, one in four of the 105 interns were offered permanent employment with their host companies at the end of the one-year programme; in 2015, a further 65 candidates were placed with companies in the Gauteng and Western Cape Provinces; it is planned to expand the network of private firms involved in the programme.

A fund to boost sagging private sector R&D

South Africa's GERD/GDP ratio (0.73% in 2012) has dropped from a high of 0.89% in 2008. This has been mostly due to a sharp drop in private sector R&D, in spite of rising public spending on R&D. However, South Africa's research output still comprises about 85% of Southern Africa's total output (Lan *et al.*, 2014).

To help reach the target of a GERD/GDP ratio of at least 1%, the Sector-Specific Innovation Fund was launched in 2013. This fund targets specific industrial sectors, which partner with the government through the DST to support the industry's specific research, development and innovation needs, through a co-funding arrangement. This funding instrument also addresses one of the recommendations from the 2012 *Ministerial Review Report*, which called for greater interaction between DST and the private sector.

The R&D tax incentive programme introduced in 2007 and amended in 2012 gives a 150% tax deduction for expenditure on eligible scientific or technological R&D undertaken by

Table 20.6: South Africa's bilateral scientific co-operation in Africa, 2015

Joint co-operation agreement (signed)	Human development	Intellectual property	STI policy	Biosciences	Biotechnology	Agriculture /Agro-processing	Space	Laser technology	Nuclear medical technology	Water management	Mining / Geology	Energy	ICTs	Mathematics	Environment and climatechange	Indigenous knowledge	Aeronautics	Material sciences and nanotechnology	Basic sciences	Human and social sciences
Algeria (1998)								●	●								●	●		
Angola (2008)	●																			
Botswana (2005)*					●	●	●			●	●	●	●			●				
Egypt (1997)							●	●										●		●
Ethiopia (2014)																				
Ghana (2012)**					●		●						●							
Kenya (2004)*						●	●						●							
Lesotho (2005)						●														
Malawi (2007)	●		●	●				●								●				
Mali (2006)																				
Mozambique (2006)**	●					●	●						●							
Namibia (2005)*						●	●				●		●			●				
Nigeria (2001)					●		●				●							●		
Rwanda (2009)				●			●					●			●					●
Senegal (2009)																				
Sudan (2014)																				
Tanzania (2011)		●	●		●								●					●		
Tunisia (2010)					●							●	●							
Uganda (2009)				●			●					●		●	●	●				
Zambia (2007)*							●				●		●			●				
Zimbabwe (2007)	●				●						●		●					●		

*partner of the African Very Long Baseline Interferometry Network and of the Square Kilometre Array

**partner of the African Very Long Baseline Interferometry Network

Source: compiled by authors via the DST

enterprises or individuals. The 2012 amendment requires companies to apply for pre-approval of their R&D projects in order to qualify. The programme has grown over the past eight years and has provided tax reductions to nearly 400 claimants, nearly half of which are small and medium-sized enterprises. The programme has managed to leverage more than ten times the value in R&D from a R 3.2 billion government contribution to this incentive.

The earlier DST Innovation Fund (1999) has been transformed into a range of funding instruments grouped under the Technology Innovation programme administered by the Technology Innovation Agency, which has been operative since 2010. Some of the most recently launched funds include the Youth Technology Innovation Fund (2012) targeting innovators between the ages of 18 and 30 who receive

vouchers enabling them to access services and/or resources that they could not otherwise afford, and a Seed Fund (2012) to assist universities in bridging financing requirements, in order for them to translate university research output into ideas that can be commercialized.

The Technology and Human Resources for Industry (THRIP) scheme matches investment by industry in projects where researchers from public institutions, including universities, serve as project leaders and students are trained through projects in industry. THRIP was established in 1994 and was the object of an external evaluation in 2013; this was followed by a review of some THRIP processes that has been dubbed the 're-invigoration of THRIP'. This review led to a series of new measures, including the provision of student bursaries for the first time and the introduction of a 'first-come-first-served' rule

to accelerate the uptake of awarded funds. From 2010 to 2014, THRIP supported an average of 1 594 students and 954 researchers per year, showing steady growth in the numbers of black and female researchers over the years.

An older scheme which has helped to increase the number of black and female researchers is the South African Research Chairs Initiative (SARChI) established in 2006. SARChI was externally reviewed in 2012 and, by 2014, had awarded a total of 157 chairs. The Centres of Excellence funding scheme launched in 2004 currently has a network of 15 research centres, five of which were established in 2014. One of the

most recent is the Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy, the work of which is expected to lead to better decision-making in STI policy and consolidate related national information systems.

The *National Development Plan* (2012) has fixed a target of producing 100 000 PhDs by 2030 to improve the country's capacity for research and innovation. The DST has significantly increased its funding for postgraduate students. By 2014, 34 PhDs were being produced per million inhabitants but this is still below the target of 100 PhDs per million inhabitants fixed by the *Plan*.

Table 20.7: International trade by the SADC in high-tech products, 2008–2013, in US\$ millions

	TOTAL											
	Import						Export					
	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
Botswana	251.7	352.9	248.0	274.1	303.7	–	21.1	24.4	15.1	44.6	62.7	–
Lesotho	16.6	28.4	–	–	–	–	0.4	1.6	–	–	–	–
Madagascar	254.1	151.8	177.0	141.6	140.2	–	7.4	10.7	5.5	52.6	2.0	...
Malawi	112.5	148.9	208.3	285.4	–	152.4	1.7	3.4	2.0	22.7	–	11.0
Mauritius	284.3	327.8	256.6	255.2	344.8	343.5	101.1	21.9	6.2	9.8	10.6	6.3
Mozambique	167.3	148.6	125.4	134.1	189.2	1 409.2	6.1	23.8	0.5	71.2	104.7	82.1
Namibia	199.5	403.8	334.9	401.9	354.6	378.9	22.0	42.8	49.3	46.6	108.0	71.7
Seychelles	32.1	–	–	–	–	–	0.2	–	–	–	–	–
South Africa	10 480.4	7 890.5	10 190.3	11 898.9	10 602.2	11 170.9	2 056.3	1 453.3	1 515.6	2 027.3	2 089.1	2 568.6
Tanzania	509.1	532.2	517.4	901.7	698.4	741.6	11.8	18.1	27.4	43.0	98.9	50.0
Zambia	209.7	181.9	236.4	354.9	426.7	371.2	8.8	5.9	4.6	222.0	55.2	40.0
Zimbabwe	116.8	201.1	393.3	343.1	354.2	447.3	80.0	7.3	9.2	9.7	20.4	18.5

Note: Rankings are for a total of 145 countries.

Source: World Bank

Box 20.3: South Africa wins bid to host radio telescope

In 2012, South Africa and Australia won a bid to build the world's largest radio telescope, the Square Kilometre Array (SKA), at a cost of € 1.5 billion. As a result, South Africa will work with eight African partners, six of them from within the SADC: Botswana, Madagascar, Mauritius, Mozambique, Namibia and Zambia. The other two are Ghana and Kenya.

South Africa is also co-operating with other SADC countries in skills training, through the African SKA Human Capital Development Programme, which has been operating since 2005. In 2012, the programme awarded

about 400 grants for studies in astronomy and engineering from undergraduate to postdoctoral level, while also investing in training programmes for technicians. Astronomy courses are being taught as a result of the SKA Africa project in Kenya, Madagascar, Mauritius and Mozambique.

This work is complemented by an agreement signed in 2009 between Algeria, Kenya, Nigeria and South Africa for the construction of three low-Earth-orbiting satellites within the African Resource Management Constellation (ARMC). South Africa will build at least one out of the three, construction of which (ZA-ARMC1) began in 2013.

The development of qualified personnel and researchers is a critical prerequisite for the successful implementation of the SKA project in South Africa and the construction of new satellites under the ARMC agreement. These initiatives will develop Africa's technological and human capacities in Earth observation, for use in urban planning, land cover mapping, disaster prediction and monitoring, water management, oil and gas pipeline monitoring and so on.

Source: compiled by the authors

A popular destination for scientists and students

Within the SADC, South Africa hosts the largest number of leading scientists, consistent with its leading role in African science. Southern Africa is known for its unhindered circulation of scientific personnel and research mobility, with South Africa playing an important role as a hub for higher education and research in the region. Nearly half of the researchers in South Africa (49%) are transitory, spending fewer than two years in the country's research centres (Lan *et al.*, 2014).

South African universities attracted 61 000 foreign African students in 2009, providing potential human capital for South Africa and facilitating a greater integration with the rest of the continent (UIS, 2012). Students from SADC countries pay the same fees as local students. This is in accordance with the *SADC Protocol on Education and Training* and effectively means that the South African taxpayer subsidizes their studies. Other initiatives, such as the African Institute for Mathematical Sciences (AIMS), further encourage the circulation of students, scientists and researchers in the region and beyond (Box 20.4).

SWAZILAND



STI development undermined by social problems

The Kingdom of Swaziland is the second-smallest country in Southern Africa after the Seychelles, with a population of less than 1.3 million. In spite of being classified as a lower middle-income country, Swaziland shares characteristics with Africa's low-income countries. About 78% of the population derives its livelihood from subsistence agriculture and 63% lives in poverty that is exacerbated by regular food shortages. Unemployment has remained high over the past decade, at about 23% (Figure 20.1). There is also a high prevalence of HIV and AIDS: 26% among the adult population.

The ratio of donor funding to capital formation is high but fell considerably over 2007–2009. Economic growth has been sluggish for over a decade, hovering between 1.3% and a high of 3.5% in 2007. In 2011, the country even slipped into recession (-0.7%). GDP per capita is nevertheless situated at the higher end of the SADC scale (Table 20.1). The economy is closely tied to that of neighbouring South

Box 20.4: A network of African Institutes for Mathematical Sciences

The African Institute for Mathematical Sciences (AIMS) is a pan-African network of centres of excellence for postgraduate education, research and outreach in mathematical sciences. The first AIMS institute was founded in Cape Town (South Africa) in 2003.

Four other institutes have since been set up in Senegal (2011), Ghana (2012), Cameroon (2013) and Tanzania (2014). That in Senegal proposes courses in both French and English. So far, these five institutes have produced 731 graduates, one-third of whom are women.

The institutes teach both basic and applied mathematics, covering a large range of mathematical applications in physics (including astrophysics and cosmology), quantitative biology, bioinformatics, scientific computing, finance, agriculture modelling and so on.

The institute in Cape Town was set up with the support of six universities which continue to contribute to the academic programme: Cambridge and Oxford (UK), Paris Sud XI (France) and

Cape Town, Stellenbosch and Western Cape (South Africa).

In addition to its academic programmes, AIMS South Africa has a research centre in interdisciplinary areas like cosmology, computing and finance. The institute also directs the AIMS Schools Enrichment Centre for primary and secondary school teachers, which also organizes public lectures, workshops and master classes and supports maths clubs in schools across the country.

The other AIMS institutes also provide community services. AIMS Senegal has developed an innovative teaching module for secondary school maths teachers and has partnered with local businesses to raise funds for the creation of a national contest on computer applications and mathematical modelling, with a focus on finding development-oriented solutions. Scholars and lecturers from AIMS Ghana have equipped teachers at Biriwa Junior High School with an innovative teaching module. AIMS Cameroon is planning to launch its own research centre to host resident and visiting researchers from universities in Cameroon and beyond.

AIMS is the brainchild of South African cosmologist Neil Turok, whose family had been exiled for supporting Nelson Mandela during the Apartheid years. Knowing Mandela's passion for education, Turok had no difficulty persuading him to endorse the project.

After AIMS South Africa won the TED Prize in 2008, Turok and his partners developed the AIMS Next Einstein Initiative, the goal of which is to build 15 centres of excellence across Africa by 2023. The Government of Canada made a US\$ 20 million investment in 2010, through its International Development Research Centre, and numerous governments in Africa and Europe have followed suit.

The plan for a vast network is gathering momentum. In October 2015, a forum is taking place in Dakar under the auspices of UNESCO's International Basic Sciences Programme to take the project to the next stage.

Source: www.nexteinstein.org; Juste Jean-Paul Ngome Abiaga, UNESCO

Africa for trade and its currency is pegged on the South African rand.

Nine out of ten adults are literate, one of the continent's highest ratios. By 2010, the Orphaned and Vulnerable Children's Initiative launched in 2002 and the State Funded Primary Education Programme (2009–2013) had together contributed to a 10% increase in primary school enrolment, which stood at 86%.

Swaziland has four universities and five colleges. However, only the University of Swaziland can claim to have research centres and institutes, such as the Swaziland Institute for Research in Traditional Medicine, Medicinal and Indigenous Food Plants.

In 2012, public expenditure on education accounted for 7.8% of GDP. Although only 13% of this went to higher education, this still represents a healthy investment of 1% of GDP (see Table 19.2). Although education remains the top priority, government spending on education has since become a casualty of the poor economic situation.

Enrolment in higher education remains low but is progressing: there were 8 057 tertiary students in 2013, up from 5 692 seven years earlier (see Table 19.4). One key development has been the introduction of PhD programmes in recent years, including one in agriculture at the University of Swaziland since 2012. Some 234 students were enrolled in PhD programmes in 2013.

A survey conducted by the UNESCO Windhoek Office in 2008 found that the University of Swaziland had the highest concentration of researchers, followed by the Energy Department of the Ministry of Natural Resources and Energy and the Agricultural Research Division of the Ministry of Agriculture. Some industries and public enterprises also engage in sporadic research (SARUA, 2009). Swaziland scores highly on the KEI and KI index, despite having dropped nine places between 2000 and 2012.

STI is acknowledged as being a top national priority in the *National Science, Technology and Innovation Policy*, which was drawn up in 2011 but has yet to be approved by parliament. UNESCO has been accompanying this process since 2008, when it prepared a status report of STI in Swaziland at the Ministry of Education's behest. The process has spawned the development of a *National Science, Mathematics and Technology Education Policy*, implemented by the Ministry of Education and Training. A Royal Science and Technology Park is also currently under construction, funded jointly by the Government of Swaziland and Taiwan, China.

In November 2014, a Directorate for Science, Technology and Innovation was established within the Ministry of Information, Communication and Technology. The directorate

is responsible for finalizing the *National Science, Technology and Innovation Policy*. A National Commission for Research, Science and Technology is also being established to replace the existing National Research Council.

Funding instruments such as venture capital and tax relief for R&D are non-existent in Swaziland, as donors have tended to focus on providing aid. The draft STI policy acknowledges the need to develop a diverse range of financial instruments and funding bodies to stimulate innovation.

UNITED REPUBLIC OF TANZANIA



Consistently high economic growth

Tanzania has been a multiparty parliamentary democracy since the early 1990s. In common with much of Africa, growing indebtedness and falling commodity prices forced the country to adopt a series of IMF structural adjustment programmes from 1986 until the early 2000s. The country's poor economic performance over this period prompted a progressive abandonment of neoliberalism. Economic indicators have since picked up, with growth averaging 6.0–7.8% per year since 2001. Though still high, donor funding dropped substantially between 2007 and 2012. As the economy becomes less reliant on donor funding, it may gradually diversify.

So far, impressive growth has not significantly altered the country's economic structure, which is still based on agriculture. The latter accounted for 34% of GDP in 2013, compared to 7% for manufacturing. GDP per capita remains low by SADC standards but nevertheless progressed between 2009 and 2013 (Table 20.2). Tanzania is also a member of the East African Community (see Chapter 19), with which its trade more than doubled between 2008 and 2012 (AfDB *et al.*, 2014).

Tanzania's low level of human development has improved somewhat in recent years. The country has the lowest level of income inequality within the SADC and little unemployment (just 3.5%) but its poverty rate is the highest among SADC countries with viable national innovation systems.

Policies to harness STI to development

The *Vision 2025* document adopted in 1998 aspires to 'transform the economy into a strong, resilient and competitive one, buttressed by science and technology'. Tanzania's first *National Science and Technology Policy* (1996) was revised in 2010 and renamed the *National Research and Development Policy*. The policy recognizes the need to improve the process of prioritization of research capacities, international co-operation in strategic R&D areas and planning for human resources; it also makes provisions for the establishment of a National Research Fund. This policy was, in

UNESCO SCIENCE REPORT

turn, reviewed in 2012 and 2013. Tanzania also published a policy on biotechnology in December 2010. It is a member of the African Biosafety Network of Expertise (see Box 18.1).

The main body in charge of STI policy in Tanzania is the Ministry of Communication, Science and Technology and its main co-ordinating agency, the Commission for Science and Technology (COSTECH). COSTECH co-ordinates a number of research institutes engaged with industry, health care, agriculture, natural resources, energy and the environment.

Tanzania occupies the second-lowest rank for the KEI and KI among the viable national innovation systems in the SADC region. Basic R&D indicators send conflicting signals. Despite a GERD/GDP ratio of 0.38% of GDP, there were just 69 researchers (head count) per million population in 2010. One in four researchers is a woman (see Figure 19.3). The UNESCO Dar es Salaam office has been leading the reform of STI in Tanzania within the United Nations Development Assistance Programme for 2011–2015 (formerly the One

UN Programme) since 2008. As part of this programme, UNESCO commissioned a series of studies, including one on biotechnology and bio-entrepreneurship (Box 20.5) and another on the participation of women in industries based on science, engineering and technology, which spawned a project to improve Maasai homes (Box 20.6).

Even though Tanzania has eight public institutions of higher education and a plethora of private institutions, fewer than half of secondary school-leavers who qualify for entry obtain a place at university. The establishment of the Nelson Mandela African Institute of Science and Technology in Arusha in 2011 should augment Tanzania's academic capacity considerably. This university has been designed as a research-intensive institution with postgraduate programmes in science, engineering and technology. Life sciences and bio-engineering are some of the initial niche areas, taking advantage of the immense biodiversity in the region. Together with its sister institution set up in Abuja (Nigeria) in 2007, it forms the vanguard of a planned pan-African network of such institutes.

Box 20.5: Challenges facing Tanzania's bio-industry

A report commissioned by UNESCO has identified a number of challenges for *Biotechnology and Bio-entrepreneurship in Tanzania* (2011).

It observes, for instance, that, although the first academic degree courses in biotechnology and industrial microbiology were introduced at Sokoine University of Agriculture in 2004 and at the University of Dar es Salaam in 2005, Tanzania still lacks a critical mass of researchers with skills in biotech-related fields like bioinformatics. Even when scientists have been sent abroad for critical training, poor infrastructure prevents them from putting their newly gained knowledge into practice upon their return.

Problems encountered in diagnostics and vaccination stem from the reliance upon biologicals produced elsewhere. Biosafety regulations dating from 2005 prevent confined field trials with genetically modified organisms.

Incentives are lacking for academics to collaborate with the private sector. Obtaining a patent or developing a

product does not affect an academic's remuneration and researchers are evaluated solely on the basis of their academic credentials and publications.

The current lack of university–industry collaboration leaves academic research disconnected from market needs and private funding. The University of Dar es Salaam has made an effort to expose students to the business world by creating a Business Centre and setting up the Tanzania Gatsby Foundation's project to fund student research proposals of relevance to SMEs. However, both of these schemes are of limited geographical scope and uncertain sustainability.

Most research in Tanzania is largely donor-funded via bilateral agreements, with donor funds varying from 52% to 70 % of the total. Research has benefited greatly from these funds but it does mean that research topics are preselected by donors.

The conditions for export and business incubation have improved in recent years, thanks to the adoption of an export policy and a Programme for

Business Environment Strengthening for Tanzania in 2009. However, no specific fiscal incentives have been envisioned to promote business in the biotechnology sector, resource limitations being given as the principal cause. Private entrepreneurs have appealed for tax regimes to support ideas developed domestically and for the provision of loans and incubation structures to allow them to compete against foreign products.

The report also observes that communication and co-ordination between the relevant ministries may also need optimizing, in order to provide the necessary resources for policy implementation. For example, lack of co-ordination between COSTECH, the Ministry of Health and Social Welfare and the Ministry of Industry, Trade and Marketing appears to be hindering potential implementation and exploitation of patent exemptions related to the agreement on Trade-related Aspects of Intellectual Property Rights.

Source: Pahlavan (2011)

ZAMBIA

**Impediments to economic transformation**

Zambia's economic growth has been derived mainly from the commodities boom (especially copper), fuelled by demand from China. However, growth has not resulted in job creation and poverty reduction, as Zambia has not yet managed to diversify its resource-based economy by developing manufacturing and adding value to commodities. Copper exports constitute about 80% of foreign exchange earnings but only 6% of total revenue. Although agriculture employs about 85% of the labour force, it contributes only 10% of GDP (see Figure 19.2). Productivity is low, with agriculture representing only about 5% of exports, mostly due to its weak linkages with manufacturing. The combination of poor infrastructure, an inappropriate regulatory and tax regime, limited access to finance, a low level of skills and the generally high cost of doing business are all major impediments to economic transformation in Zambia (AfDB *et al.*, 2014).

The higher education sector consists of three public universities, the University of Zambia, Copperbelt University and, since 2008, Mulungushi University. There are also

32 private universities and colleges and 48 public technical institutes and colleges. Demand nevertheless far outstrips supply, as there are only enough places for one-third of qualifying school-leavers. The low remuneration of academic staff relative to other SADC countries has also resulted in an exodus of qualified academics (SARUA, 2012).

Zambia's GERD/GDP ratio is modest (0.28% in 2008) and it counts just 49 researchers per million inhabitants. When indicators for unemployment (13% in 2013), education and poverty (Table 20.1) are taken into account, Zambia's national innovation system is clearly struggling but viable.

A fund to spur research

Zambia's *National Science and Technology Policy* dates from 1996 and the Science and Technology Act from 1997. These milestones have given rise to three key science and technology institutions, the National Science and Technology Council (NSTC), National Technology Business Centre (est. 2002) and National Institute for Scientific and Industrial Research (a research body which replaced the National Council for Scientific Research dating from 1967). The NSTC provides grants through the Strategic Research Fund, Youth

Box 20.6: Simple technology brings Maasai better homes

The concept of innovation is often associated with high technology and thus perceived by many African communities as being beyond the reach of the poor. Affordable solutions exist, however, for making life more comfortable.

In 2012, the UNESCO Dar es Salaam office worked with the advocacy group Tanzanian Women in Science and the NGO Tanzanian Women Architects for Humanity to design a series of improvements to the adobe (mud) dwellings of Maasai women in the village of Olooskwan, at the request of a group of Maasai women.

Home-building tends to fall to the womenfolk in Maasai communities. The architects taught the women a number of techniques for improving the comfort, safety and durability of their homes (*bomas*). In order to raise the ceiling and strengthen the structure, existing poles were replaced with sturdier, longer ones. To protect the *bomas* from water leakage, the

architects designed roofs with eaves and overhangs. Sloping aprons were introduced at the foot of the walls to protect them from splashing rain. Troughs made of ferro-cement were fitted round the roof overhangs to catch rainwater and channel it into drums at the base of the structure.

To ensure the mud plaster would not erode over time, the Maasai women were shown how to add bitumen and kerosene oil to the adobe mixture of clay and sand. The adobe was then blended with cow dung to produce a hard cement. This lengthened the time before the structures would need any maintenance from two to 5–10 years.

The stove in the centre of the room was relocated to a corner and surrounded on two sides by a clay brick wall, in order to help direct smoke upward. A hood or chimney channelled the smoke outside.

The windows were enlarged to let in more light and improve ventilation.

Solar panels were introduced to provide lighting. The SunLite Solar Kit (*circa* US\$ 50) consists of a solar panel, control-box with charger and battery and a bright LED light; the kit comes with a long cable and wiring that can be connected to most mobile phones, enabling owners to charge their own mobile phones and earn extra income from providing the service to others.

The two Maasai showhomes were completed in August 2012. Nearby villages sent emissaries, many of whom were so impressed that they offered to pay the women to build model homes for them. The women are now contemplating setting up a small construction business.

This project was funded by the United Nations Development Assistance Plan for 2011–2015, within a wider drive to give women a bigger role in harnessing STI to national development.

Source: Anthony Maduekwe, UNESCO

Innovation Fund and Joint Research Fund. It also administers the Science and Technology Development Fund instituted by the Science and Technology Act (1997). This fund encourages research that contributes to the goals of the *Fifth* (2006–2010) and *Sixth National Development Plans and Vision 2030* (2006) for a prosperous middle-income nation by 2030, especially projects targeting a better standard of living, innovation, value addition to natural resources and the integration of locally produced technologies in the Zambian industrial sector, not to mention the purchase, maintenance or repair of equipment. For its part, the National Technology Business Centre (est. 2002) administers a Business Development Fund.

A strong commitment to agriculture

A Biosafety Act was adopted in 2007 (see map in Box 18.1). Zambia is surpassed only by Malawi within the SADC region for the level of public expenditure on agriculture: 10% of GDP in 2010. However, the country's main centre for agricultural research, the Zambian Agricultural Research Institute, 'is in a dire situation', having suffered a 30% decline in the staffing table, which counted 120 professional staff, 120 technicians and 340 support staff in 2010. The institute plays an essential role in maintaining laboratories for specialized research, while managing the country's seed bank. Very little donor funding has been forthcoming, leaving the government to shoulder 90–95% of the burden. The private non-profit Golden Valley Agricultural Research Trust²³ is trying to compensate for the staff cuts at its sister institute but it, too, is reliant on government and international donor funding – only 40% of its income comes from commercial farming and contract research (UNESCO, 2014b).

ZIMBABWE



A country emerging from a long crisis

Between 1998 and 2008, the Zimbabwean economy contracted by a cumulative 50.3%, sending GDP per capita plummeting to less than US \$400. In July 2008, inflation peaked at 231 000 000%. By this time, 90% of the population was unemployed and 80% were living in poverty. Infrastructure had deteriorated, the economy had become more informal and there were severe food and foreign currency shortages. The economic crisis was accompanied by a series of political crises, including a contested election in 2008 which resulted in the formation of a government of national unity in February 2009 (UNESCO, 2014b).

The economic crisis coincided with the implementation of the Fast-track Land Reform Programme from 2000 onwards which compounded the decline in agricultural production by reducing the cropping area of traditionally large commercial

crops such as wheat and maize. In parallel, FDI shrank after the imposition of Western sanctions and the suspension of IMF technical assistance due to the non-payment of arrears. Hyperinflation was only brought under control in 2009 after the adoption of a multicurrency payment system and economic recovery programme. Once stabilized, the economy grew by 6% in 2009 and FDI increased slightly; by 2012, it amounted to US\$ 392 million (UNESCO, 2014b).

Zimbabwe continues to score poorly for governance indicators. In 2014, it ranked 156th (out of 175) in the Corruption Perceptions Index and 46th (out of 52) in the Ibrahim Index of African Governance (see Table 19.1). The economy remains fragile, plagued by high external debt, degraded infrastructure and an uncertain policy environment (AfDB *et al.*, 2014). The lack of co-ordination and coherence among governance structures has led to poor implementation of existing policies and the multiplication of research priorities (UNESCO, 2014b).

An uncertain policy environment

The *Second Science and Technology Policy* was launched in June 2012, after being elaborated with UNESCO assistance. It replaces the earlier policy dating from 2002 and has six main objectives:

- Strengthen capacity development in STI;
- Learn and utilize emerging technologies to accelerate development;
- Accelerate commercialization of research results;
- Search for scientific solutions to global environmental challenges;
- Mobilize resources and popularize science and technology; and
- Foster international collaboration in STI.

The *Second Science and Technology Policy* cites sectorial policies with a focus on biotechnology, ICTs, space sciences, nanotechnology, indigenous knowledge systems, technologies yet to emerge and scientific solutions to emergent environmental challenges. The policy makes provisions for establishing a National Nanotechnology Programme. There is also a *National Biotechnology Policy* which dates from 2005. Despite poor infrastructure and a lack of both human and financial resources, biotechnology research is better established in Zimbabwe than in most sub-Saharan countries, even if it tends to use primarily traditional techniques.

The *Second Science and Technology Policy* asserts the government commitment to allocating at least 1% of GDP to GERD, focusing at least 60% of university education on developing skills in science and technology and ensuring that school pupils devote at least 30% of their time to studying science subjects (UNESCO, 2014b).

23. The Agricultural Research Trust has also been active in Zimbabwe since 1981.

Following the elections of 2013, the incoming government replaced the *Medium Term Plan 2011–2015* elaborated by its predecessor with a new development plan, the *Zimbabwe Agenda for Sustainable Economic Transformation* (ZimAsset, 2013–2018). One objective of ZimAsset is to rehabilitate and upgrade national infrastructure, including the national power grid, road and railway network, water storage and sanitation, buildings and ICT-related infrastructure (UNESCO, 2014b).

In 2013, the Ministry of Science and Technology Development (dating from 2005) was disbanded and its portfolio relegated to the newly established Department of Science and Technology within the Ministry of Higher and Tertiary Education, Science and Technology Development.

The same year, the government approved four national research priorities proposed by the Research Council of Zimbabwe:

- The social sciences and humanities;
- Sustainable environmental and resource management;
- Promoting and maintaining good health; and
- The national security of Zimbabwe.

A worrying exodus of skills

Zimbabwe has a long research tradition that dates back a century. However, the economic crisis has precipitated an exodus of university students and professionals in key areas of expertise (medicine, engineering, etc.) that is of growing concern. More than 22% of Zimbabwean tertiary students are completing their degrees abroad. In 2012, there were just 200 researchers (head count)²⁴ employed in the public sector, one-quarter of whom were women. The government has created the Zimbabwe Human Capital Website to provide information for the diaspora on job and investment opportunities in Zimbabwe. Of note is that ZimAsset contains no specific targets for increasing the number of scientists and engineers (UNESCO, 2014b).

Despite the turbulence of recent years, Zimbabwe's education sector remains sound. In 2012, 91% of youth aged 15–24 years were literate, 53% of the population aged 25 years or more had completed secondary education and 3% of adults held a tertiary qualification. The government is planning to establish two new universities with a focus on agricultural science and technology: Marondera and Monicaland State Universities (UNESCO, 2014b).

The long-standing University of Zimbabwe is particularly active in research, producing more than 44% of Zimbabwe's scientific publications in 2013. Productivity is fairly low but the number of publications has grown since 2005 (Figure 20.6).

The past decade has seen an extraordinary rise in the number of copublications with foreign partners, which now represent 75–80% of all Zimbabwean publications in the Web of Science (UNESCO, 2014b).

Poor linkages with industry

Public–private linkages remain weak. With the exception of the long-standing tobacco industry and others oriented towards agriculture, there has traditionally been little collaboration between industry and academia in Zimbabwe. The current regulatory framework hampers the transfer of technology to the business sector and the development of industrial R&D, despite the commercialization of research results being one of the major goals of the *Second Science, Technology and Innovation Policy* (UNESCO, 2014b).

The government is currently analysing new legislation that would promote local cutting and polishing of diamonds to create an estimated 1 700 new jobs. It has already slashed license fees for local cutting and polishing firms. Mining accounts for 15% of GDP and generates about US\$ 1.7 billion in exports annually; despite this, the government receives royalties of only US\$ 200 million. Currently, the entire stock of diamonds is exported in raw form. The new legislation will require companies to pay a 15% value-added tax but they will incur a 50% discount if they decide to sell their diamonds to the Minerals Marketing Corporation of Zimbabwe (UNESCO, 2014b).

CONCLUSION

From economic integration to a regional innovation system?

To date, intra-African trade remains dismally low, at approximately 12% of total African trade,²⁵ in spite of the formation of numerous regional economic communities. Both prominent pan-African organizations, such as the African Union (AU) and the New Partnership for Africa's Development (NEPAD), and regional bodies such as SADC have clear visions of the criteria for integration and the rationale behind it. The development of regional STI programmes is high on the list of priorities. However, several factors are hampering economic integration, including the similar economic structure of countries – based on mineral resources and agriculture –, poor economic diversification and low levels of intraregional trade. Nevertheless, the most formidable obstacle of all to regional integration is probably the resistance of individual governments to relinquishing national sovereignty.

Some argue that the only feasible route to sustainable socio-economic development, which has eluded most African countries, is to pursue regional integration.

24. or 95 full-time equivalents

25. compared to about 55% in Asia and 70% in Europe

This counter-argument agitates the promise of a huge internal market and the opportunities that it would offer for the development of economies of scale and scope. Another convincing argument arises from the increasingly urgent requirement for Africa to engage in a unified manner with a world that is increasingly characterized by economic blocs and large emerging economic powers.

An important aspect of economic integration would be the transition from national innovation systems to a single regional innovation system. Along with the establishment of free trade areas in order to construct the planned common market with full mobility of goods and services, capital and people, this would require the convergence of formal institutions, including labour market legislation, environmental regulation and policies governing competition. The opening up of borders to the free movement of people and services would also enable informal cross-border pools of tacit knowledge and social capital to emerge. The ultimate goal would be the emergence of a regional innovation system on the back of the development of an increasingly diversified economic system.

The AU-NEPAD *African Action Plan* for 2010–2015 has identified a number of obstacles to the evolution of national innovation systems across the region which resonate with those identified by the *SADC Regional Indicative Strategic Development Plan* back in 2003, namely:

- SADC economies are dominated by agriculture and mining with a poorly developed manufacturing sector;
- The GERD/GDP ratio is significantly lower in most SADC countries than the 1% benchmark set by the African Union in 2003 for the African continent;
- Governments offer few incentives for private-sector investment in R&D;
- There are serious shortages of scientific and technological skills at all levels (from artisans and technicians to engineers and scientists); this shortage is exacerbated by the ongoing brain drain;
- School education in science and technology is poor, primarily due to a lack of qualified teachers and inappropriate curricula; this type of education is also heavily biased against girls and women;
- There is generally poor protection of intellectual property rights in legislation; and
- There is little co-operation in science and technology across the region.

KEY TARGETS FOR SOUTHERN AFRICA

- Raise GERD in SADC countries to at least 1% of GDP by 2015;
- Ensure that 50% of decision-making positions in the public sector in SADC countries are held by women by 2015;
- Increase trade among SADC countries to at least 35% of total SADC trade, compared to 10% in 2008;
- Increase the share of manufacturing in SADC countries to 25% of GDP by 2015;
- Achieve 100% connectivity to the regional power grid for all SADC member states by 2012;
- Raise the share of public expenditure on agriculture to 10% of GDP in all SADC countries;
- Raise the GERD/GDP ratio in Botswana from 0.26% in 2012 to over 2% by 2016;
- Raise public expenditure on R&D in Mauritius to 1% of GDP by 2025, with a further 0.5% of GDP to come from the private sector;
- Focus at least 60% of university education in Zimbabwe on developing skills in science and technology;
- Generate 100 000 PhDs in South Africa by 2030;
- Generate 100 PhDs by 2024 from Angola's new Centre of Excellence for Science Applied to Sustainability.

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