Most countries have based their long-term planning ('vision') documents on harnessing science, technology and innovation to development.

Kevin Urama, Mammo Muchie and **Remy Twingiyimana**

A schoolboy studies at home using a book illuminated by a single electric LED lightbulb in July 2015. Customers pay for the solar panel that powers their LED lighting through regular instalments to M-Kopa, a Nairobi-based provider of solar-lighting systems. Payment is made using a mobile-phone money-transfer service.
Photo: © Waldo Swiegers/Bloomberg via Getty Images

19 · East and Central Africa

Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo (Republic of), Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Kenya, Rwanda, Somalia, South Sudan, Uganda

Kevin Urama, Mammo Muchie and Remy Twiringiyimana

INTRODUCTION

Mixed economic fortunes

Most of the 16 East and Central African countries covered in the present chapter are classified by the World Bank as being low-income economies. The exceptions are Cameroon, the Republic of Congo, Djibouti and the newest member, South Sudan, which joined its three neighbours in the lower middle-income category after being promoted from low-income status in 2014. Equatorial Guinea is the region's only high-income country but this classification masks great variations in income levels; poverty is widespread and life expectancy at birth is among the region's lowest, at 53 years (Table 19.1).

All but four nations are classified as heavily indebted poor countries, the exceptions being Djibouti, Equatorial Guinea, Kenya and South Sudan. Poverty and high unemployment are endemic in the region. Life expectancy varies between 50 and 64 years, a strong indicator of the developmental challenges facing the region.

The region's economic fortunes have been a mixed bag since 2010. Several countries have managed to raise their GDP growth rates, or at least maintain them at 2004–2009 levels: Burundi, Chad, Comoros, Eritrea and Kenya. Two have sustained some of the highest growth rates in Africa – Cameroon and Ethiopia – and one recorded 24% growth in its first year of existence: South Sudan. Of note is that only two of these countries are oil-exporters: Chad and South Sudan.

Five of the continent's top 12 oil-producing countries are found in East and Central Africa (Figure 19.1). Economic growth is expected to slow down in Africa's oil-exporting countries, following a slump in Brent crude prices since mid-2014, as African exporters have fewer reserves than the Gulf States to tide them over until prices recover. Analysts suggest several explanations for the current drop in value of conventional sources of oil. On the one hand, clean energy policies have fostered the development of more fuel-efficient technology, including in the automotive industry. In parallel, technological developments in hydraulic fracturing (fracking) and horizontal drilling have made it profitable to extract oil from unconventional sources, such as tight rock formations [shale oil in the USA and oil (tar) sands in Canada], deep-sea oil (most countries are now finding deposits) and biofuels (Brazil and others); high global oil prices until recently have allowed countries which invest in these technologies to take a growing share of the global oil market. This highlights the need for oil-producing African countries to invest in science and technology (S&T) to maintain their own competitiveness in the global market.

Half the region is 'fragile and conflict-affected'

Other development challenges for the region include civil strife, religious militancy and the persistence of killer diseases such as malaria and HIV, which sorely tax national health systems and economic productivity. Poor governance and corruption undermine economic activity and foreign investment in several countries. Those which score poorly in Transparency International's Corruption Perceptions Index also tend to rank poorly in the Ibrahim Index of African Governance (Table 19.1): Burundi, Central African Republic, Chad, Republic of Congo, Eritrea, Somalia and South Sudan. Interestingly, both indices consider Rwanda as having the best governance record in East and Central Africa.

Seven countries are classified as 'fragile and conflict-affected' by the World Bank, namely Burundi, Central African Republic, Chad, Comoros, Eritrea, Somalia and South Sudan. In particular, the Central African Republic and South Sudan have experienced civil war in recent years. These conflicts tend to affect their neighbours as well, such as by disrupting trade flows, creating streams of cross-border refugees, or giving rise to cross-border attacks. For instance, South Sudanese have been seeking asylum in Uganda and the Boko Haram (literally, 'books are forbidden') sect in Nigeria has made violent incursions into neighbouring Cameroon and Niger and could threaten the trade route between Cameroon and Chad.

Meanwhile, Kenya's economy has suffered from terrorist attacks by the Somalian Al-Shabaab group which have undermined the country's important tourist industry, in particular. In April 2015, Al-Shabaab massacred 148 students and staff at Garissa University, the only such institution in the north of the country, which had only opened in 2011. Across the border, Somalia is engaged in a fragile process of state- and peacebuilding, its economy in ruins after two decades of political instability and insecurity.

In the Central African Republic, the economy has suffered considerably since late 2012 when rebel groups took control of towns in the centre and north of the country. Despite the deployment of peacekeepers from the African Union, United Nations and France and the signing of a ceasefire in July 2014, the situation remains volatile. For the first decade of the century, the country had experienced positive, albeit erratic, growth.

Table 19.1: **Socio-economic indicators for sub-Saharan Africa, 2014 or closest year**

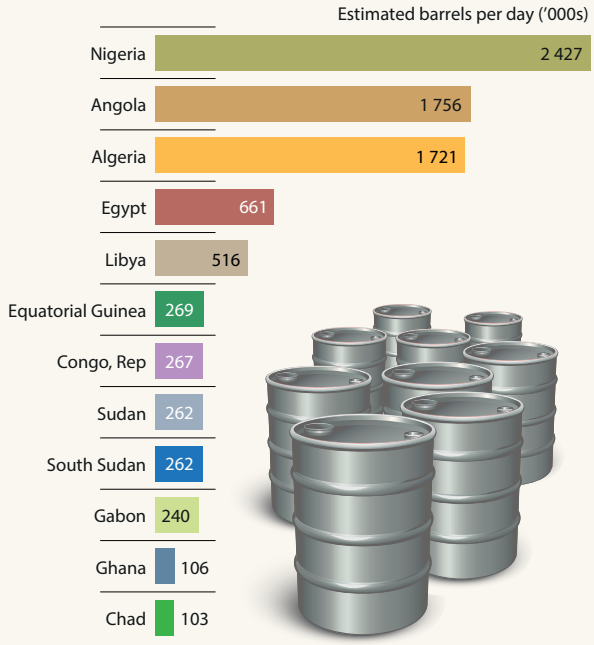
	Population ('000s), 2014	Annual population growth rate (%), 2014	Life expectancy at birth (years), 2013	GDP per capita (current PPP$), 2013	GDP growth rate (%), 2013	No of products accounting for more than 75% of exports, 2012	Ibrahim African governance Index, 2014	Access to improve d sanitation (%), 2011	Access to improved water, (%), 2011	Access to electricity (%), 2011	Internet access per 100 population, 2013	Mobile phone subscriptions per 100 population, 2013
Angola	22 137	3.05	51.9	7 736	6.80	1	44	88.6	93.9	99.4	19.10	61.87
Benin	10 600	2.64	59.3	1 791	5.64	9	18	5.0	57.1	28.2	4.90	93.26
Botswana	2 039	0.86	47.4	15 752	5.83	2	3	38.6	91.9	45.7	15.00	160.64
Burkina Faso	17 420	2.82	56.3	1 684	6.65	3	21	7.7	43.6	13.1	4.40	66.38
Burundi	10 483	3.10	54.1	772	4.59	3	38	41.7	68.8	–	1.30	24.96
Cabo Verde	504	0.95	74.9	6 416	0.54	8	2	–	–	–	37.50	100.11
Cameroon	22 819	2.51	55.0	2 830	5.56	6	34	39.9	51.3	53.7	6.40	70.39
Central African Republic	4 709	1.99	50.1	604	-36.00	4	51	14.6	58.8	–	3.50	29.47
Chad	13 211	2.96	51.2	2 089	3.97	1	49	7.8	39.8	–	2.30	35.56
Comoros	752	2.36	60.9	1 446	3.50	2	30	17.7	87.0	–	6.50	47.28
Congo, Rep.	4 559	2.46	58.8	5 868	3.44	1	41	–	–	37.8	6.60	104.77
Congo, Dem. Rep.	69 360	2.70	49.9	809	8.48	4	40	17.0	43.2	9.0	2.20	41.82
Côte d'Ivoire	20 805	2.38	50.8	3 210	8.70	10	47	14.9	76.0	59.3	2.60	95.45
Djibouti	886	1.52	61.8	2 999	5.00	7	35	61.4^{+1}	92.1^{+1}	–	9.50	27.97
Equatorial Guinea	778	2.74	53.1	33 768	-4.84	2	45	–	–	–	16.40	67.47
Eritrea	6 536	3.16	62.8	1 196	1.33	1	50	9.2	42.6	31.9	0.90	5.60
Ethiopia	96 506	2.52	63.6	1 380	10.49	6	32	2.4	13.2	23.2	1.90	27.25
Gabon	1 711	2.34	63.4	19 264	5.89	1	27	–	–	60.0	9.20	214.75
Gambia	1 909	3.18	58.8	1 661	4.80	4	23	–	75.8	–	14.00	99.98
Ghana	26 442	2.05	61.1	3 992	7.59	6	7	7.0	54.4	72.0	12.30	108.19
Guinea	12 044	2.51	56.1	1 253	2.30	2	42	8.3	52.4	–	1.60	63.32
Guinea-Bissau	1 746	2.41	54.3	1 407	0.33	1	48	–	35.8	–	3.10	74.09
Kenya	45 546	2.65	61.7	2 795	5.74	56	17	24.6	42.7	19.2	39.00	71.76
Lesotho	2 098	1.10	49.3	2 576	5.49	6	10	–	–	19.0	5.00	86.30
Liberia	4 397	2.37	60.5	878	11.31	8	31	–	–	–	4.60	59.40
Madagascar	23 572	2.78	64.7	1 414	2.41	30	33	7.9	28.6	14.3	2.20	36.91
Malawi	16 829	2.81	55.2	780	4.97	5	16	9.6	42.1	7.0	5.40	32.33
Mali	15 768	3.00	55.0	1 642	2.15	2	28	15.3	28.1	–	2.30	129.07
Mauritius	1 249	0.38	74.5	17 714	3.20	35	1	88.9	99.2	99.4	39.00	123.24
Mozambique	26 473	2.44	50.2	1 105	7.44	9	22	8.5	33.6	20.2	5.40	48.00
Namibia	2 348	1.92	64.3	9 583	5.12	8	6	23.6	67.2	60.0	13.90	118.43
Niger	18 535	3.87	58.4	916	4.10	3	29	4.8	34.3	–	1.70	39.29
Nigeria	178 517	2.78	52.5	5 602	5.39	1	37	36.9	45.6	48.0	38.00	73.29
Rwanda	12 100	2.71	64.0	1 474	4.68	5	11	30.2	60.3	–	8.70	56.80
Sao Tome & Principe	198	2.50	66.3	2 971	4.00	6	12	–	–	–	23.00	64.94
Senegal	14 548	2.89	63.4	2 242	2.80	25	9	35.1	59.9	56.5	20.90	92.93
Seychelles	93	0.50	74.2	24 587	5.28	4	5	97.1	96.3	–	50.40	147.34
Sierra Leone	6 205	1.84	45.6	1 544	5.52	4	25	10.9	36.7	–	1.70	65.66
Somalia	10 806	2.91	55.0	–	–	4	52	–	–	–	1.50	49.38
South Africa	53 140	0.69	56.7	12 867	2.21	83	4	58.0	81.3	84.7	48.90	145.64
South Sudan	11 739	3.84	55.2	2 030	13.13	1	–	–	–	–	–	25.26
Swaziland	1 268	1.45	48.9	6 685	2.78	21	24	48.5	38.9	–	24.70	71.47
Tanzania	50 757	3.01	61.5	2 443	7.28	27	19	6.6	55.0	15.0	4.40	55.72
Togo	6 993	2.55	56.5	1 391	5.12	11	15	13.2	48.4	26.5	4.50	62.53
Uganda	38 845	3.31	59.2	1 674	3.27	17	36	26.2	41.6	14.6	16.20	44.09
Zambia	15 021	3.26	58.1	3 925	6.71	3	13	41.3	49.1	22.0	15.40	71.50
Zimbabwe	14 599	3.13	59.8	1 832	4.48	9	46	40.6	79.2	37.2	18.50	96.35

+n = n years after reference year

Note: Not included in the African Governance column of this table are Algeria (20th), Egypt (26th), Libya (43rd), Mauritania (39th), Morocco (14th) or Tunisia (8th).

Source: World Bank's World Development Indicators, April 2015; for exports: AfDB, OECD & UNDP (2014) *African Economic Outlook 2014*; for African Governance Index: Mo Ibrahim Foundation (2014) *Ibrahim Index of African Governance – Country Profiles*: www.moibrahimfoundation.org; for water, sanitation and electricity: WHO, World Bank's World Development Indicators; UNICEF, UNDP and International Energy Agency, compiled by UNESCO

Figure 19.1: **Top 12 crude oil-producing countries in Africa, 2014**



Source: www.eia.gov

South Sudan's economic fortunes have been largely tied to its oil exports, which in turn have fluctuated wildly due to internal unrest and according to the state of political relations with neighbouring Sudan, through which its export pipeline runs. Over the past year, Equatorial Guinea has had to contend with stagnant world oil prices which have held its own GDP in check.

Ethiopia has been the shining star in the region, maintaining its double-digit growth rate over the past few years. Uganda has been another strong performer, although its growth seems to have been somewhat stunted by the slow global recovery from the 2008–2009 financial crisis. Eritrea has made some of the biggest gains, having managed to turn negative growth prior to 2010 into a 4.8% average ever since. On the whole, it does not appear as if the global crisis has had a major lasting impact on economies in the region, although the slowing-down of the Chinese economy since 2014 is a potential cause for concern for resource-exporting countries.

Regional integration can favour development

Most countries in East and Central Africa are still in the early stages of transition from traditional agrarian to modern industrial economies, as evidenced by the generally large contribution of agriculture to GDP (Figure 19.2). Agriculture even contributes more than half of GDP in Central African Republic, Chad and Sierra Leone. Notable exceptions to the rule are the Republic of Congo and Gabon, where the oil industry dwarfs all other economic activities.

Public spending on agriculture tends to be fairly low, at less than 5% of GDP for most countries (Table 19.2). This has obvious implications for expenditure on agricultural R&D as a subset of the total. So far, only three countries have reached the target in the *Maputo Declaration* (2003) of devoting 10% of GDP to agriculture: Burundi (10%), Niger (13%) and Ethiopia (21%). The large proportion of the working population employed in agriculture is another indicator of these countries' levels of development. The lack of economic diversification handicaps both agrarian and fossil-fuel based economies, as they tend to be heavily dependent on natural resources for foreign exchange, in particular.

Public expenditure on health is low in most countries, the exceptions being Burundi (4.4% of GDP), Djibouti (5.3%) and Rwanda (6.5%) in 2013. These same three countries also accord a high priority to education (more than 5% of GDP), as do Comoros (7.6% in 2008), the Republic of Congo (6.2% in 2010) and Kenya (6.7% in 2010).

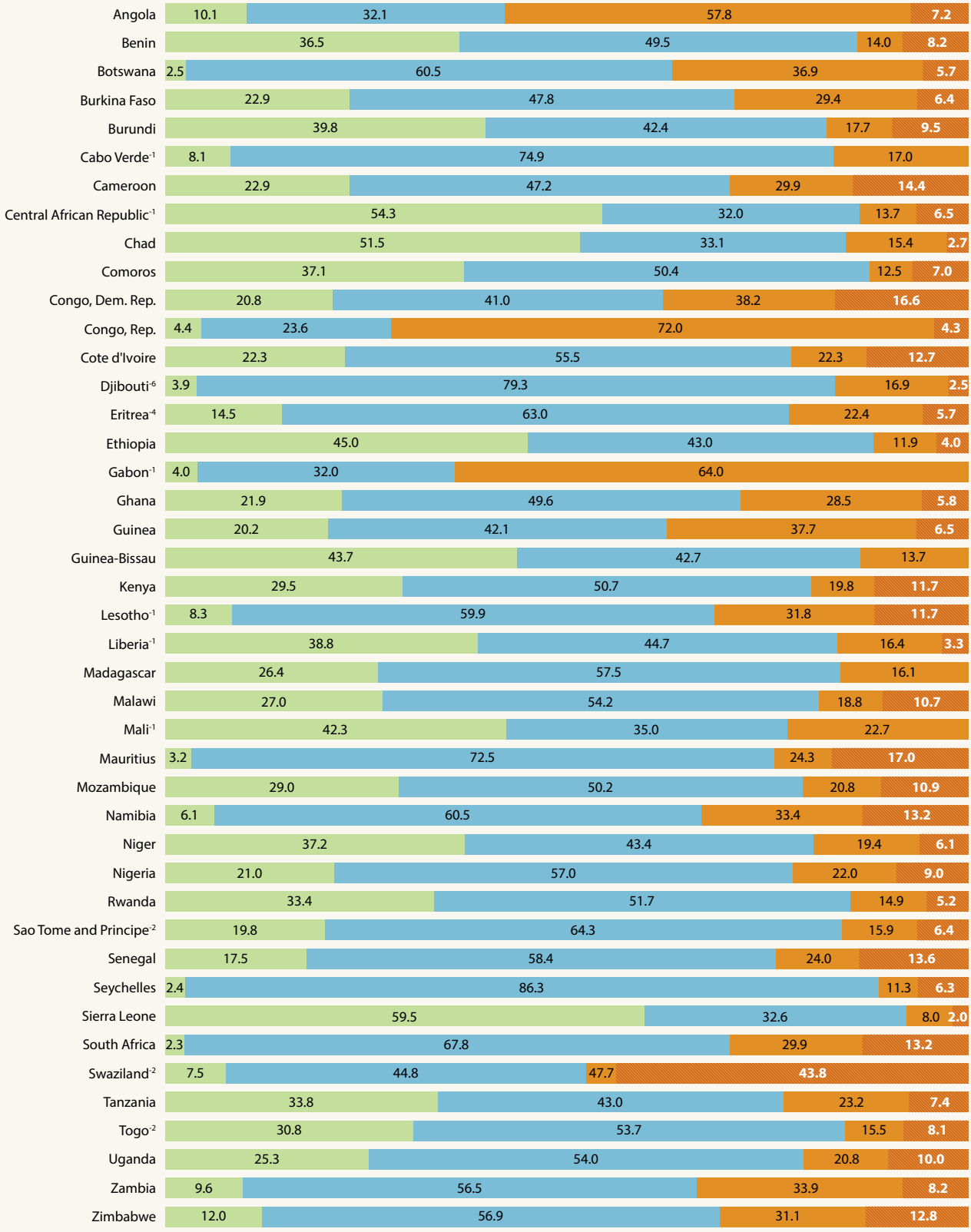
Military expenditure tends to account for less than 2% of GDP in the region, with the notable exception of Chad (2.0% in 2011), Burundi (2.2% in 2013), Central African Republic (2.6% in 2010), Djibouti (3.6% in 2008), Equatorial Guinea (4.0% in 2009) and, above all, South Sudan (9.3% in 2012) [Table 19.2].

The credibility of political institutions and election outcomes remains a major challenge. Owing to instability and governance challenges in East Africa, the region was the continent's lowest recipient of foreign direct investment (FDI) in 2008 and 2009. In 2013, FDI flowed most abundantly into the economies of Djibouti (19.6% of GDP), the Republic of Congo (14.5%) and Equatorial Guinea (12.3%). Whereas the oil industry was the main pole of attraction in the latter two countries, FDI flowed mostly into Djibouti's port area, which is strategically located on trade routes to the Middle East. The region's resource potential is expected to attract greater FDI flows in future. Potential areas for investment include oil and mineral exploration in Chad, Ethiopia, Sudan and Uganda, intensified economic and business reforms led by Rwanda and large infrastructure projects, such as the ongoing construction of the Ethiopian Grand Renaissance Dam and the development of geothermal energy in Kenya (see p. 524).

Intraregional trade is important for many small or landlocked East and Central African economies but it is severely hindered by the poor state of transport infrastructure. A major challenge will be to develop railway and road linkages to ports, so as to better connect countries with one another and the global economy.

Regional integration offers one means of addressing the challenges outlined above. Political co-operation is just as essential as economic co-operation, however, in order to

Figure 19.2: **Composition of GDP in sub-Saharan Africa by economic sector, 2013 (%)**



n = data refer to *n* years before reference year

Agriculture Services Industry Manufacturing as a subset of industry

Note: Data are unavailable for Equatorial Guinea, Gambia, Somalia and South Sudan.

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

deal with civil, ethnic and cross-border conflicts, as well as to manage access to, and possible disputes over, natural resources that straddle national boundaries, including river catchments. The construction of the Ethiopian Grand Renaissance Dam on the Blue Nile illustrates the importance of intraregional dialogue. Once completed, it will be the largest hydroelectric power plant in Africa (6 000 MW) and the eighth-largest in the world. After Egypt expressed reservations, a Tripartite National Committee was set up with Sudan which met for the first time in September 2014. This led to the signing of a tripartite co-operation agreement in the Sudanese capital on 23 March 2015 which established the principle of energy-sharing by both upstream and downstream countries once the dam is completed. The ten points of the agreement were being debated in Egypt and Ethiopia in mid-2015.

Regional integration also offers an opportunity for greater solidarity in an emergency situation. One illustration of this new paradigm is the decision by the East African Community in October 2014 to send a contingent of 600 health professionals to West Africa, including 41 doctors, to combat the Ebola epidemic (see p. 472).

A step closer to regional integration

There are three main regional economic communities in East Africa: the Common Market for Eastern and Southern Africa (COMESA[1]), the East African Community (EAC) and the Intergovernmental Authority on Development (IGAD). There is quite a lot of overlap, with many member states belonging to more than one regional trade bloc. Djibouti, Eritrea, Ethiopia and Sudan belong to both COMESA and IGAD, for instance, Burundi and Rwanda to both COMESA and EAC and Kenya and Uganda to all three. Some countries also belong to the Southern African Development Community (SADC), such as Tanzania, which is a member of the EAC. This overlap can potentially strengthen regional co-operation, as long as the various blocs co-ordinate their policies. The ultimate goal for the African Union is to develop an African Economic Community by 2023 (see Box 18.2).

The EAC was established in 1967 but collapsed in 1977 before being resuscitated in 2000. COMESA was founded in 1993 as the successor to the Preferential Trade Area for Eastern and Southern Africa. Both founding treaties make provisions for co-operation to develop STI. A number of East and Central African countries have also entered into bilateral co-operation agreements with South Africa in science and technology, most recently Ethiopia and Sudan in 2014 (see Table 20.6).

1. For the members of these regional communities, see Annex 1. Tanzania is profiled in Chapter 20 on the SADC countries, see p. 559

The Inter-University Council for East Africa (IUCEA) was formally integrated into the operational framework of the EAC by the East African Legislative Assembly in 2009 through the IUCEA Act. IUCEA has been entrusted with the mission of developing a Common Higher Education Area by 2015. In order to harmonize higher education systems in EAC countries, IUCEA established the East African Quality Assurance Network in 2011, which is in the process of developing a regional policy and an East African qualifications framework for higher education. IUCEA also established a partnership with the East African Business Council in 2011 to foster joint research and innovation by the private sector and universities and identify areas for curricular reform. The two partners organized the region's first forum for academia and private firms under the auspices of the EAC in Arusha in 2012 and a second with the East African Development Bank in Nairobi in 2013.

On 1 July 2010, the five EAC members – Burundi, Kenya, Rwanda, Tanzania and Uganda – formed a common market; the agreement provides for the free movement of goods, labour, services and capital. In 2014, Rwanda, Uganda and Kenya agreed to adopt a single tourist visa. Kenya, Tanzania and Uganda have also launched the East African Payment System. On 30 November 2013, the EAC countries signed a Monetary Union Protocol with the aim of establishing a common currency within 10 years.

The EAC *Common Market Protocol* (2010) makes provisions for market-led research, technological development and the adaptation of technologies in the community, in order to support the sustainable production of goods and services and enhance international competitiveness. States are to collaborate with the East African Science and Technology Commission and other institutions to develop mechanisms for commercializing indigenous knowledge and ensuring intellectual property protection. Member states also undertake to establish a research and technological development fund for the purpose of implementing the provisions in the protocol. Other clauses include:

- promoting linkages among industries and other economic sectors within the EAC community;
- promoting industrial R&D and the transfer, acquisition, adaptation and development of modern technology;
- promoting sustainable and balanced industrialization to cater for the least industrialized members;
- facilitating the development of micro-, small and medium-sized (SME) enterprises and promoting indigenous entrepreneurs; and
- promoting knowledge-based industries.

Table 19.2: **Investment priorities in sub-Saharan Africa, 2013 or closest year**

	Military expenditure (% of GDP), 2013	Public health expenditure (% of GDP), 2013	Public expenditure on agriculture (% of GDP), 2010	Public expenditure on education (% of GDP), 2012	Government expenditure on tertiary education (% of GDP), 2012	Expenditure on tertiary education (% total public expenditure on education), 2012	FDI inflows (% of GDP), 2013
Angola	4.9	2.5	<5	3.5^{-2}	0.2^{-6}	8.7^{-6}	-5.7
Benin	1.0	2.5	<5	5.3^{-2}	0.8^{-2}	15.6^{-2}	3.9
Botswana	2.0	3.1	<5	9.5^{-3}	3.9^{-3}	41.5^{-3}	1.3
Burkina Faso	1.3	3.7	11	3.4^{-1}	0.8	20.2^{-1}	2.9
Burundi	2.2	4.4	10	5.8	1.2	20.6	0.3
Cabo Verde	0.5	3.2	<5	5.0^{-1}	0.8^{-1}	16.6^{-1}	2.2
Cameroon	1.3	1.8	<5	3.0	0.2	7.8	1.1
Central African Republic	2.6^{-3}	2.0	<5	1.2^{-1}	0.3^{-1}	27.3^{-1}	0.1
Chad	2.0^{-2}	1.3	6	2.3^{-1}	0.4^{-1}	16.3^{-1}	4.0
Comoros	–	1.9	–	7.6^{-4}	1.1^{-4}	14.6^{-4}	2.3
Congo, Rep.	1.1^{-3}	3.2	–	6.2^{-2}	0.7^{+1}	10.9^{-2}	14.5
Congo, Dem. Rep.	1.3	1.9	–	1.6^{-2}	0.4^{-2}	24.0^{-2}	5.2
Côte d'Ivoire	1.5^{-1}	1.9	<5	4.6^{-4}	0.9^{-5}	21.0^{-5}	1.2
Djibouti	3.6^{-5}	5.3	–	4.5^{-2}	0.7^{-2}	16.5^{-2}	19.6
Equatorial Guinea	4.0^{-4}	2.7	<5	–	–	–	12.3
Eritrea	–	1.4	–	2.1^{-6}	–	–	1.3
Ethiopia	0.8	3.1	21	4.7^{-2}	0.2^{-2}	3.5^{-2}	2.0
Gabon	1.3	2.1	–	–	–	–	4.4
Gambia	0.6^{-6}	3.6	8	4.1	0.3	7.4	2.8
Ghana	0.5	3.3	9	8.1^{-1}	1.1^{-1}	13.1^{-1}	6.7
Guinea	–	1.7	–	2.5	0.8	33.4	2.2
Guinea-Bissau	1.7^{-1}	1.1	<5	–	–	–	1.5
Kenya	1.6	1.9	<5	6.6^{-2}	1.1^{-6}	15.4^{-6}	0.9
Lesotho	2.1	9.1	<5	13.0^{-4}	4.7^{-4}	36.4^{-4}	1.9
Liberia	0.7	3.6	<5	2.8	0.1	3.6	35.9
Madagascar	0.5	2.6	8	2.7	0.4	15.2	7.9
Malawi	1.4	4.2	28	5.4^{-1}	1.4^{-1}	26.6^{-1}	3.2
Mali	1.4	2.8	11	4.8^{-1}	1.0^{-1}	21.3^{-1}	3.7
Mauritius	0.2	2.4	<5	3.5	0.3	7.9	2.2
Mozambique	0.8^{-3}	3.1	6	5.0^{-6}	0.6^{-6}	12.1^{-6}	42.8
Namibia	3.0	4.7	<5	8.5^{-2}	2.0^{-2}	23.1^{-2}	6.9
Niger	1.1^{-1}	2.4	13	4.4	0.8	17.6	8.5
Nigeria	0.5	1.1	6	–	–	–	1.1
Rwanda	1.1	6.5	7	4.8	0.6	13.3	1.5
Sao Tome & Principe	–	2.0	7	9.5^{-2}	–	–	3.4
Senegal	0.002	2.2	14	5.6^{-2}	1.4^{-2}	24.6^{-2}	2.0
Seychelles	0.9	3.7	<5	3.6^{-1}	1.2^{-1}	32.5^{-1}	12.3
Sierra Leone	0.001	1.7	<5	2.9	0.7	23.2	3.5
South Africa	1.1	4.3	<5	6.6	0.8	11.9	2.2
South Sudan	9.3^{-1}	0.8	–	0.7^{-1}	0.2^{-1}	25.3^{-1}	–
Swaziland	3.0	6.3	5	7.8^{-1}	1.0^{-1}	12.8^{-1}	0.6
Tanzania	0.9	2.7	7	6.2^{-2}	1.7^{-2}	28.3^{-2}	4.3
Togo	1.6^{-2}	4.5	9	4.0	1.0	26.1	1.9
Uganda	1.9	4.3	<5	3.3	0.4	11.5	4.8
Zambia	1.4	2.9	10	1.3^{-4}	0.5^{-7}	25.8^{-7}	6.8
Zimbabwe	2.6	–	–	2.0^{-2}	0.4^{-2}	22.8^{-2}	3.0

-n/+n: data refer to n years before or after reference year

Source: for education: UNESCO Institute for Statistics; for agriculture: ONE.org (2013) *The Maputo Commitments and the 2014 African Union Year of Agriculture*; for all other variables: World Bank's World Development Indicators, April 2015

Fourteen out of 20 COMESA members have formed a free-trade zone since 2000 (see Box 18.2). This agreement has facilitated trade in the tea, sugar and tobacco sectors, in particular. Intra-industry linkages have also evolved considerably, with trade in semi-manufactured goods among member states having overtaken trade in similar products with the rest of the world. In 2008, COMESA agreed to expand its free-trade zone to include EAC and SADC members. Negotiations are currently under way for a COMESA–EAC–SADC Tripartite Free Trade Agreement by 2016.

The Intergovernmental Authority on Development (IGAD) was created in 1996 to supersede the Intergovernmental Authority on Drought and Development, which had been founded by Djibouti, Ethiopia, Kenya, Somalia, Sudan and Uganda in 1986, after a severe famine. Eritrea and South Sudan joined IGAD after gaining independence in 1993 and 2011 respectively. The IGAD Climate Prediction and Applications Centre, based in Nairobi, Kenya, began life as the Drought Monitoring Centre in 1989, before being fully integrated into IGAD through a related protocol in 2007. In addition to the eight IGAD countries, the centre counts Burundi, Rwanda and Tanzania among its members. More recently, the Regional Centre on Groundwater Resources Education, Training and Research in East Africa was set up at the Kenya Water Institute in Nairobi in 2011, under the auspices of UNESCO.

IGAD's current flagship programme (2013–2027) sets out to develop drought-resilient communities, institutions and ecosystems in the IGAD region by 2027. The seven thrusts of IGAD's Drought Resilience programme are:

- Natural resources and environment;
- Market access, trade and financial services;
- Livelihoods support and basic social services;
- Research, knowledge management and technology transfer;
- Conflict prevention, resolution and peace-building; and
- Co-ordination, institutional development and partnership.

TRENDS IN STI POLICY AND GOVERNANCE

An alignment with the continent's long-term vision

The programmes of COMESA, EAC and IGAD have been aligned with those of *Africa's Science and Technology Consolidated Plan of Action* (CPA, 2005–2014). When implementation of the CPA was reviewed in 2012, on the recommendation of the Fourth African Ministerial Conference on Science and Technology in Egypt (AMCOST, 2013)[2], the reviewers noted that 'the COMESA region has developed an innovation strategy which calls for a strong collaboration between COMESA and the NEPAD Agency and the African Union Commission in implementing the strategy.' They went on to say that 'the CPA has also been used as a template for formulating the science and technology policy for IGAD. In the East African Community, a programme from the CPA has been embedded into the health sector, leading to the launch of the African Medicines Regulatory Harmonization programme in March 2012.'

The SADC and the Economic Community of West Africa (ECOWAS) have also 'domesticated the Plan of Action:' the SADC adopted a *Protocol on Science, Technology and Innovation* in 2008 (see p. 537) and the CPA has informed the formulation of the *ECOWAS Policy on Science and Technology* (see p. 476).

The review of the CPA revealed significant achievements in the following areas:

- Establishment of four networks of centres of excellence within the African Biosciences Initiative (Box 19.1), as well as two complementary networks, Bio-Innovate (Box 19. 1) and the African Biosafety Network of Expertise (see Box 18.1);
- Establishment of a virtual African Laser Centre, which counted 31 member institutions in 2012;
- Establishment of the African Institutes of Mathematical Sciences (see Box 20.4);
- Establishment of the Southern Africa and West Africa Networks of Water Centres of Excellence;
- Launch of the African Science, Technology and Innovation Indicators Initiative;
- Establishment of the African Observatory for Science, Technology and Innovation in Equatorial Guinea;
- Launch of the African Medicines Regulatory Harmonization programme in the EAC in 2012;
- Introduction of African Union Competitive Research Grants administered by the African Union Commission – the first and second calls for research proposals took place in December 2010 and January 2012 for projects in post-harvest technologies and agriculture; renewable and sustainable energy; water and sanitation; fisheries and climate change;

2. This review was conducted by a high-level panel of eminent scientists supported by a group of experts from the African Academy of Sciences, AUC, NEPAD Agency, AfDB, UNECA, UNESCO and the International Council for Science, among others.

Box 19.1: **Networks of centres of excellence in biosciences**

In 2002, the Biosciences Eastern and Central Africa Network (BecA) became the first of four subregional hubs to be established by NEPAD, with support from the Canadian government. The hubs were set up within the African Biosciences Initiative, a cluster of three programmes for biodiversity science and technology, biotechnology and indigenous knowledge systems.

BecA manages the African Biosciences Challenge Fund, established in 2010. The fund has the dual function of capacity-building and R&D project-funding on a competitive basis. BecA runs training workshops and provides fellowships to scientists and graduate students from African national agricultural research organizations and universities.*

BecA regularly launches calls for researchers interested in implementing their projects over a maximum 12-month period at the network's hub, the International Livestock Research Institute in Nairobi. Priority research areas include improving control of priority livestock diseases; harnessing genetic diversity for conservation, resistance to disease and improved productivity; molecular breeding of important food security crops; plant–microbe interactions; orphan crops; the biological control of crop pests, pathogens and weeds; genomics and metagenomics; climate-smart forage grasses; mixed livestock–crop systems; and soil health.

A number of institutes have offered their facilities to the hub for regional use. These nodes are the University of Buea (Cameroon), Ethiopian Institute of Agricultural Research, National Agricultural Research Organization (Uganda); Kigali Institute of Science and Technology (Rwanda) and the University of Nairobi (Kenya).

BecA has established a wide range of partnerships, including with African Women in Agricultural Research and Development and the Association for Agricultural Research in Eastern and Central Africa. In 2012 and 2013, UNESCO funded the participation of 20 women scientists in the hub's Advanced Genomics and Bioinformatics workshops.

The Bio-Innovate network was set up in 2010 under BecA as a successor of BioEARN. It promotes the use of biosciences to improve crop productivity, smallholder farmers' resilience to climate change and to add value to local bio-resources by increasing the efficiency of the agro-processing industry. Funded by Sweden, the network covers Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda.

An encouraging evaluation

An evaluation of the fund by Dalbert Global Development Advisors published in April 2014 observed that the fund had 'achieved considerable growth and impact, reaching *circa* 500 individual scientists and researchers across the region over the past three years'. Some 30 FTE scientists were due to receive fellowships in 2014, the same number as the previous year. Among the 250 respondents to the evaluators' survey, 90% gave the hub a high score of 4.2 out of five for the quality of the facilities and training. One in three researchers (33%) and 43% of workshop participants between 2010 and 2013 were women, noted the report, a proportion the hub wished to raise to 50%. This offers the hub a 'unique opportunity to provide mentoring opportunities' for women, the report states, recalling that 'the majority of those who produce, process and market Africa's food are women'.

Of some concern was that one in four research staff indicated spending more than 50% of their time on administrative tasks. The report also noted that the hub remained financially vulnerable, with a small number of primary donors and no evidence to suggest that alumni would return in large numbers as fee-paying users of the hub's modern facilities. Up until now, the programme has been supported primarily by the Australian and Swedish governments, the Syngenta Foundation for Sustainable Agriculture and the Bill and Melinda Gates Foundation.

One of four African bioscience networks

From 2005 onwards, NEPAD established three other networks within the African Biosciences Initiative. These are the Southern African Network for Biosciences (SANbio), with its hub at the Council for Scientific and Industrial Research in Pretoria (South Africa); the West African Biosciences Network (WABNet), with its hub at the Institut sénégalais de recherches agricoles in Dakar (Senegal), and; the Northern Africa Biosciences Network (NABNet), based at the National Research Centre in Cairo (Egypt).

Each network has several nodes which co-ordinate R&D in a particular area. Those for SANBio, for instance, are Northwest University in South Africa (indigenous knowledge), the University of Mauritius (bioinformatics), Mauritius National Livestock Research Centre (livestock production), University of Namibia (mushroom production and commercialization for rural communities), University of Malawi–Bunda College (fisheries and aquaculture); and the SADC Plant Genetics Resources Centre in Zambia (gene banking). Research programmes have also been strengthened at other partner institutions within each network.

Source: http://hub.africabiosciences.org; www.nepad.org/humancapitaldevelopment/abi

*from Burundi, Cameroon, Central Africa Republic, Democratic Republic of Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Kenya, Madagascar, Rwanda, São Tomé & Príncipe, Somalia, South Sudan, Sudan, Tanzania and Uganda

- institutionalization of a biennial ministerial forum on STI, in partnership with UNESCO, the African Development Bank (AfDB) African Union Commission and United Nations Economic Commission for Africa (UNECA). The first forum took place in in Nairobi in April 2012, the second in Rabat in October 2014.

The review also identified the following shortfalls in CPA implementation, among others:

- The failure to set up the 'African Science and Technology Fund was one of the landmark and visible weaknesses in implementation of the CPA; the modest achievements recorded should be viewed in this context.' With hardly any governments having raised GERD to the target level of 1% of GDP, more than 90% of funding mobilized for implementation of the CPA came from bilateral and multilateral donors.
- STI priorities ought to have been linked to priorities of other development sectors to enhance impact.
- There should have been a differentiated approach to enable countries with limited human and infrastructural capacity (such as in post-conflict countries) to participate fully in CPA programmes.
- The lack of targets and a robust monitoring and evaluation strategy to track progress in implementation has led to minimal demonstration of the CPA's achievements. There should have been a strong, operational accountability framework for implementing partners.
- There was a limited focus on assessing how research efforts are contributing to solving needs in agriculture, food security, infrastructure, health, human capacity development and poverty reduction.
- Recent research on indigenous knowledge has mainly focused on documentation rather than sustainable exploitation.
- There has been inadequate linkage of the CPA to other continental frameworks and strategies.

Adopted by the African Union in 2014, the *Science, Technology and Innovation Strategy for Africa* (STISA-2024) is the first of five ten-year plans which intend to accelerate Africa's transition to an innovation-led, knowledge-driven economy by the year 2063 (*Agenda 2063*). STISA-2024 focuses on the following six priority areas:

- Eradication of hunger and achieving food security;
- Prevention and control of diseases;
- Communication (physical and intellectual mobility);
- Protecting our space;
- Living together – building society; and
- Wealth creation.

In order to achieve the objectives within these six priority areas, the following four pillars have been defined:

- Upgrading and/or building research infrastructure;
- Enhancing technical and professional competences;
- Innovation and entrepreneurship; and
- Providing an enabling environment for STI development in Africa.

STISA-2024 can learn from the review of the CPA. For instance, the reviewers considered a pan-African fund as being vital to sustain the networks of centres of excellence, encourage creative individuals and institutions to generate and apply science and technology and to promote technology-based entrepreneurship. Although STISA-2024 states that 'it is urgent to set up' an African Science and Technology Innovation Fund, it identifies no specific funding mechanism. Notwithstanding this, the African Union Commission has already heeded another of the review's recommendations by encouraging member countries to align their national and regional strategies on STISA-2024.

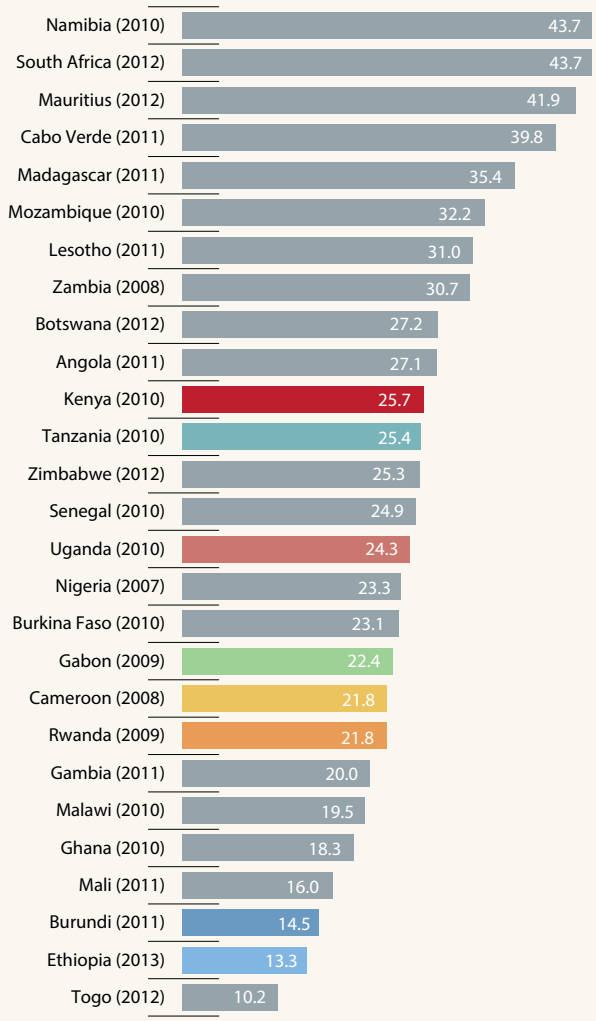
Gender equality on the development agenda

The 2012 review observed that, although the CPA did not have specific programmes in this area, implementing institutions had put initiatives in place to promote the role of women in STI. One initiative they cited were the regional scientific awards for women (US$ 20 000), which recompensed 21 recipients between 2009 and 2012. The EAC, ECOWAS, SADC and the Economic Community of Central African States have all participated in these awards.

A number of governments in East and Central Africa are also promoting gender equality in their policies and development plans. Examples are:

- Burundi's *Vision 2025* promises an energetic policy to promote gender equality and greater participation by women in education, politics and economic development. In 2011, 14.5% of researchers were women (Figure 19.3).
- Chad adopted a *National Policy on Gender* in 2011 which is being implemented by the Ministry of Social Action, Family and National Solidarity.
- In the Republic of Congo, a Ministry for the Promotion of Women and Integration of Women in National Development was established in September 2012.
- Ethiopia's *Growth and Transformation Plan 2011–2015* plans to raise the proportion of women university students to 40%. In 2013, 13.3% of researchers were women (Figure 19.3). The Ethiopian Minister of Science and Technology happens to be a woman, Demitu Hambisa.

Figure 19.3: **Women researchers in sub-Saharan Africa, 2013 or closest year (%)**



Note: Recent data are unavailable for some countries.

Source: UNESCO Institute for Statistics, April 2015

- Gabon adopted a *National Gender Equality and Equity Policy* in 2010. In 2009, 22.4% of researchers were women (Figure 19.3) and, in 2013, 16% of parliamentary seats were held by women (World Bank, 2013).
- In Rwanda, the Ministry of Gender and Family Promotion is situated in the Office of the Prime Minister. Rwanda's 2003 Constitution made provisions for a Gender Monitoring Office, which was established in 2007. The Constitution stipulates that both sexes should occupy no less than 30% of all decision-making bodies, thereby encouraging Rwandan women to compete for senior positions. Women won 51 out of the 80 seats (64%) in Rwanda's 2013 parliamentary elections, confirming Rwanda as world leader for this indicator. In research, however, women remain a minority (21.8% in 2009, Figure 19.3).
- The Government of Kenya produced a policy brief in 2014 on *Mainstreaming Gender in the National STI Policy of Kenya*, in partnership with UNESCO and the African Technology Policy Studies network; the policy brief served as an addendum to the draft National Science, Technology and Innovation Policy of 2012.

The emergence of technology and innovation hubs

In his blog for the World Bank, Tim Kelly observed in April 2014 that 'one of the key features of the African digital renaissance is that it is increasingly home-grown. In other sectors of the African economy, such as mining or agribusiness, much of the know-how is imported and the wealth extracted but Africa's 700 million or so mobile subscribers use services that are provided locally and they are also downloading more applications that are developed locally'.[3]

One of the main sources of locally developed applications are the technology hubs springing up across Africa (Figure 19.4). There are now over 90 such hubs across the continent, which vary in size and composition. Some have served as models, such as iHub in Kenya, BongoHive in Zambia, MEST in Ghana, the Co-creation hub in Nigeria and SmartXchange in South Africa. One of the more recent additions is the Botswana Innovation Hub (see p. 547).

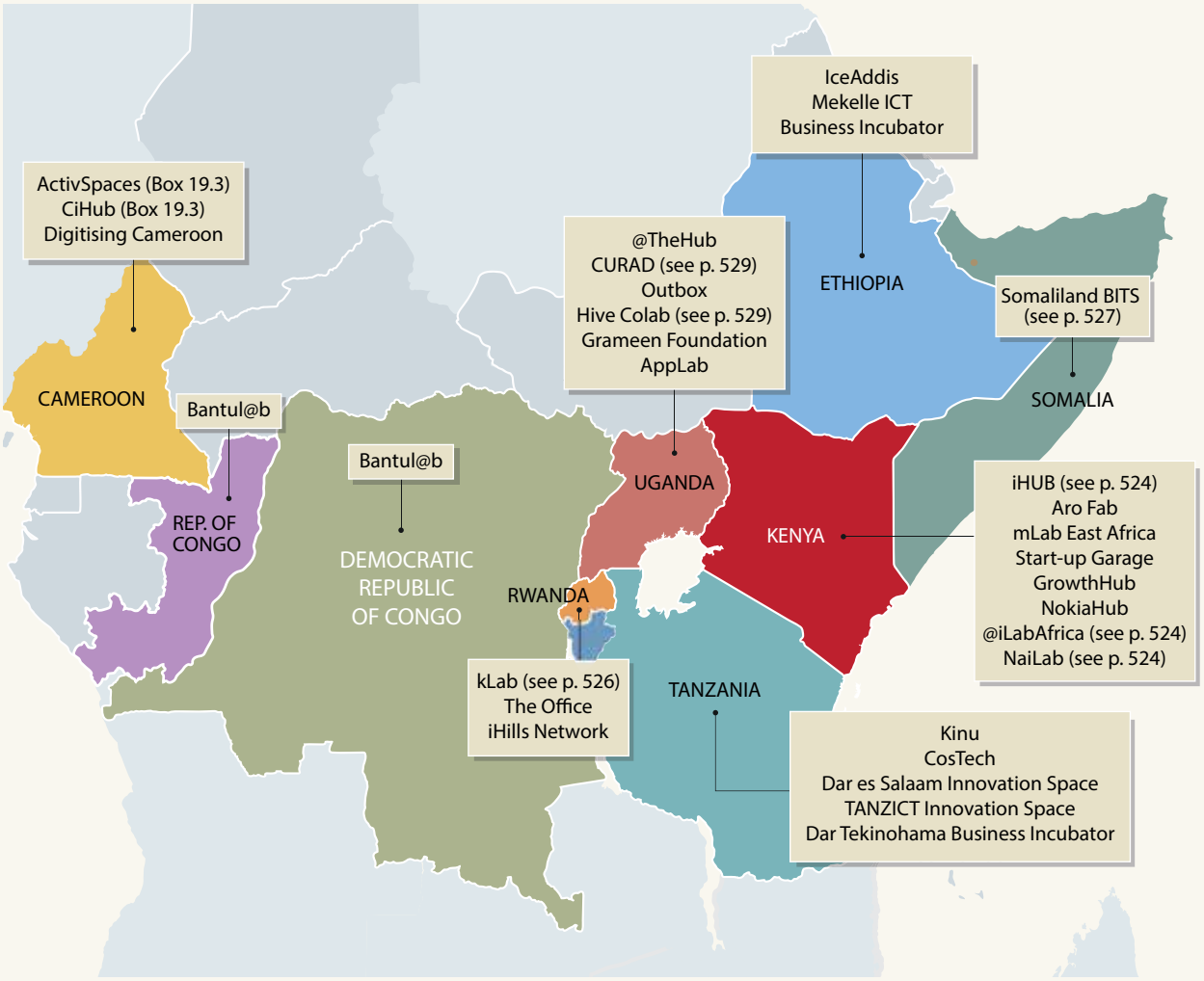
Spiralling from the MPesa, Kenya's money transfer service via a mobile phone, many applications have now been developed for different sectors ranging from agriculture and health to crowd-sourcing weather information for disaster risk reduction. While the impact of these technology hubs is yet to be systematically documented, an early prognosis is that this type of social innovation is already creating more prosperous societies in Africa (Urama and Acheampong, 2013).

Some of the start-ups graduating from incubators are tapping into the mobile phone app and banking revolution that is sweeping across East Africa. One example is MyOrder, an app which effectively enables street vendors to launch mobile web shops, with clients placing orders and making payments by mobile phone. Another app is Tusqee, which makes it possible for school administrators to send pupils' grades to their parents' phones (Nsehe, 2013).

If the start-ups cannot do it alone, neither can the technology incubators. Conscious of the economic impact of innovation, some governments are investing in the development of technology hubs. Kenya even plans to establish hubs in all 47 of its counties (see p.523). This is coherent with the adoption of policies in recent years which encompass innovation by Burundi in 2011, Ethiopia in 2010, Uganda in 2009 and Rwanda in 2005, among others.

3. See: http://blogs.worldbank.org/ic4d/tech-hubs-across-africa-which-will-be-legacy-makers

Figure 19.4: **Technology hubs in East and Central Africa, 2014**



Source: Adapted from iHB Research, World Bank and Bongohive

Persistently low internet penetration

Low internet penetration nevertheless prevents many East and Central African countries from seizing fully the opportunities offered by ICTs for socio-economic development. Penetration rates of less than 7% are found in Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo, Eritrea, Ethiopia and Somalia (Table 19.1). Kenya leads the region for this indicator, having realized the feat of raising internet penetration from 14% to 39% of the population between 2010 and 2013, a compound annual growth rate of 41%.

Mobile phone subscriptions are far more widespread, reaching from one-quarter (Burundi) to more than 200% (Gabon) of the population. Their ubiquity has inspired countless applications for mobile phones.

Prizes for science and innovation

A growing number of national and regional prizes have been introduced recently to encourage research and innovation. One example is the Olusegun Obasanjo Prize for Science and Innovation, named after the former president of Nigeria and implemented by the African Academy of Sciences. Also of note are the Annual Innovation Awards run by COMESA since February 2014 to celebrate individuals and institutions that have used STI to further the regional integration agenda.

Other actors are establishing prizes. In November 2014, the Moroccan Bank of Trade and Industry announced the creation of the African Entrepreneurship Award, with an endowment of US $1 million. This private bank operates in 18 African countries and around the world. In 2009, the annual Innovation Prize for Africa was established by the African Innovation Foundation, a Zurich-based, non-profit organization; the Innovation Prize is open to all Africans, with prize money valued at US$ 150 000. Now in its fourth year, the prize has been held in Ethiopia, South Africa and Nigeria. So far, it has attracted around 2 000 applications from 48 African countries.

TRENDS IN EDUCATION AND R&D

Generally low public spending on higher education

Public spending on education as a share of GDP varies considerably across the region (Table 19.2). The share of public education spending earmarked for tertiary education ranges from over 25% in some countries to just 3.5% in Ethiopia.

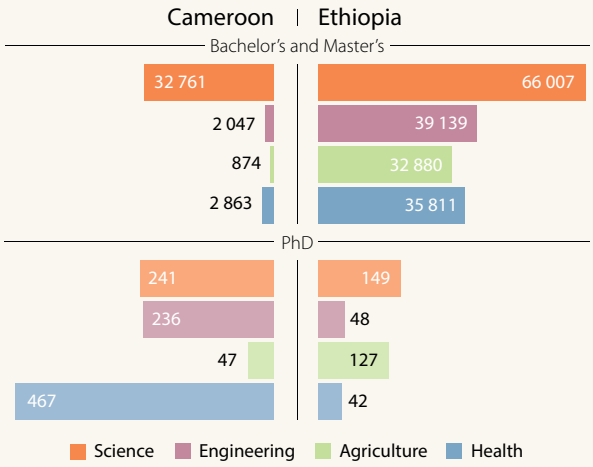
Primary school enrolment rates have grown in recent years in all countries for which data are available (Table 19.3). There is much greater variability in enrolment rates at secondary and tertiary levels; more than half of countries record secondary enrolment rates of less than 30% and, in the others, the enrolment of girls trails that of boys. Female secondary school enrolment rates remain below those of males in all but Rwanda and Comoros. At tertiary level, Cameroon, Comoros and Congo have recorded enrolment rates of over 10% in recent years, whereas Kenya's rate was a disappointing 4% at last count in 2009; Cameroon has recorded particularly rapid progress, raising its enrolment rate from 5.8% in 2005 to 11.9% in 2011. The gender disparity is also evident at tertiary level and is particularly pronounced in the Central African Republic, Chad, Eritrea and Ethiopia, where the male participation rate is more than 2.5 times higher than that for females (Table 19.3).

Data are only available by field of study for Cameroon and Ethiopia but these offer an interesting contrast. In both countries, most of those studying S&T at university were enrolled in scientific disciplines in 2010. The ratio of engineering to science students was much higher in Ethiopia (59%) than in Cameroon (6%). In Ethiopia, enrolment in agriculture was almost as high as in engineering or health sciences, whereas it was by far the least popular field of study in S&T in Cameroon (Figure 19.5), a state of affairs also observed in West and Southern Africa (see Chapters 18 and 20). The CPA review lamented the fact that young African researchers were reluctant to train in fields such as agricultural science which lacked popular appeal and was of the view that 'the shortage of qualified personnel in such fields was a big challenge for the continent.'

A greater R&D effort by some countries

In Kenya, gross domestic expenditure on research and development (GERD) is approaching the CPA target of 1% of GDP; it has also risen in recent years in Ethiopia (0.61%), Gabon (0.58%) and Uganda (0.48%) [Figure 19.6 and Table 19.5].

Figure 19.5: **Science and engineering students in Cameroon and Ethiopia, 2010**



Source: UNESCO Institute for Statistics, May 2015

Table 19.3: **Gross enrolment ratio for education in East and Central Africa, 2012 or closest year**

	Primary			Secondary			Tertiary		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Burundi	138.0	136.9	137.4	33.0	24.2	28.5	4.2^{-2}	2.2^{-2}	3.2^{-2}
Cameroon	117.9	103.2	110.6	54.3	46.4	50.4	13.7^{-1}	10.1^{-1}	11.9^{-1}
Central African R.	109.3	81.3	95.2	3.6	12.1	17.8	4.2	1.5	2.8
Chad	108.2	82.4	95.4	31.2	14.3	22.8	3.6^{-1}	0.9^{-1}	2.3^{-1}
Comoros	105.9^{+1}	99.9^{+1}	103.0^{+1}	62.8^{+1}	65.0^{+1}	63.9^{+1}	10.6	9.1	9.9
Congo, Rep.	105.5	113.4	109.4	57.5	49.8	53.7	12.7	8.0	10.4
Djibouti	73.1	65.9	69.5	49.4	38.1	43.8	5.9^{-1}	4.0^{-1}	4.9^{-1}
Equatorial Guinea	91.8	89.6	90.7	32.8^{-7}	23.6^{-7}	28.2^{-7}	–	–	–
Eritrea	–	–	–	–	–	–	3.0^{-2}	1.1^{-2}	2.0^{-2}
Ethiopia	93.4^{-6}	80.5^{-6}	87.0^{-6}	35.5^{-6}	22.3^{-6}	28.9^{-6}	4.2^{-7}	1.3^{-7}	2.8^{-7}
Kenya	114.1	114.6	114.4	69.5	64.5	67.0	4.8^{-3}	3.3^{-3}	4.0^{-3}
Rwanda	132.3	135.1	133.7	30.8	32.8	31.8	7.8	6.0	6.9
Somalia	37.6^{-5}	20.8^{-5}	29.2^{-5}	10.1^{-5}	4.6^{-5}	7.4^{-5}	–	–	–
South Sudan	102.9^{-1}	68.1^{-1}	85.7^{-1}	–	–	–	–	–	–
Uganda	106.5^{+1}	108.2^{+1}	107.3^{+1}	28.7^{+1}	25.0^{+1}	26.9^{+1}	4.9^{-1}	3.8^{-1}	4.4^{-1}

-n/+n: data refer to *n* years before or after reference year

Note: Gross enrolment includes pupils of all ages, including those below or above the official age for the given level of education. See also glossary, p. 738.

Source: UNESCO Institute for Statistics, May 2015

Table 19.4: **Tertiary enrolment by level of programme in sub-Saharan Africa, 2006 and 2012 or closest years**

	Year	Post-secondary non-degree	Bachelor's and master's	PhD or equivalent	Total tertiary	Year	Post-secondary non-degree	Bachelor's and master's	PhD or equivalent	Total tertiary
Angola	2006	0	48 694	0	48 694	2011	–	–	–	142 798
Benin	2006	–	–	–	50 225	2011	–	–	–	110 181
Botswana	2006	–	–	–	22 257	2011	–	–	–	39 894
Burkina Faso	2006	9 270	21 202	0	30 472	2012	16 801	49 688	2 405	68 894
Burundi	2006	–	–	–	17 953	2010	–	–	–	29 269
Cabo Verde	2006	–	–	–	4 567	2012	580	11 210	10	11 800
Cameroon	2006	14 044	104 085	2 169	120 298	2011	–	–	–	244 233
Central African Rep.	2006	1 047	3 415	0	4 462	2012	3 390	9 132	0	12 522
Chad	2005	–	–	–	12 373	2011	–	–	0	24 349
Comoros	2007	–	–	–	2 598	2012	–	–	0	6 087
Congo, Dem. Rep.	2006	–	–	–	229 443	2012	–	–	–	511 251
Congo, Rep.	–	–	–	–	–	2012	18 116	20 974	213	39 303
Côte d'Ivoire	2007	60 808	–	–	156 772	2012	57 541	23 008	269	80 818
Eritrea	–	–	–	–	–	2010	4 679	7 360	0	12 039
Ethiopia	2005	0	191 165	47	191 212	2012	173 517	517 921	1 849	693 287
Ghana	2006	27 707	82 354	123	110 184	2012	89 734	204 743	867	295 344
Guinea	2006	–	–	–	42 711	2012	11 614	89 559	0	101 173
Guinea-Bissau	2006	–	–	–	3 689	–	–	–	–	–
Kenya	2005	36 326	69 635	7 571	113 532	–	–	–	–	–
Lesotho	2006	1 809	6 691	0	8 500	2012	15 697	9 805	5	25 507
Liberia	–	–	–	–	–	2012	10 794	33 089	0	43 883
Madagascar	2006	9 368	37 961	2 351	49 680	2012	33 782	54 428	2 025	90 235
Malawi	2006	0	6 298	0	6 298	2011	–	–	–	12 203
Mali	–	–	–	–	–	2012	8 504	88 514	260	97 278
Mauritius	2006	9 464	12 497	260	22 221	2012	8 052	32 035	78	40 165
Mozambique	2005	0	28 298	0	28 298	2012	0	123 771	8	123 779
Namibia	2006	5 151	8 012	22	13 185	–	–	–	–	–
Niger	2006	2 283	8 925	0	11 208	2012	6 222	15 278	264	21 764
Nigeria	2005	658 543	724 599	8 385	1 391 527	–	–	–	–	–
Rwanda	2006	–	–	–	37 149	2012	–	–	0	71 638
Sao Tome & Principe	2006	0	0	0	0	2012	0	1 421	0	1 421
Senegal	2006	–	–	–	62 539	2010	–	–	–	92 106
Seychelles	2006	0	0	0	0	2012	–	–	–	100
South Africa	–	–	–	–	–	2012	336 514	655 187	14 020	1 005 721
Swaziland	2006	0	5 692	0	5 692	2013	0	7 823	234	8 057
Tanzania	2005	8 610	39 626	3 318	51 554	2012	–	142 920	386	166 014
Togo	2006	3 379	24 697	0	28 076	2012	10 002	55 158	457	65 617
Uganda	2006	–	–	–	92 605	2011	–	–	–	140 087
Zimbabwe	–	–	–	–	–	2012	26 175	–	–	94 012

Note: Data are unavailable for Equatorial Guinea, Gabon, Gambia, Sierra Leone, Somalia, South Sudan and Zambia.
Source: UNESCO Institute for Statistics, May 2015

The government tends to be the main source of R&D spending but the business enterprise sector contributes more than 10% of GERD in Gabon and Uganda (Table 19.5). Foreign sources contribute a sizeable share of GERD in Burundi (40%), Kenya (47%), Tanzania (42%) and Uganda (57%).

Although two R&D surveys have been published[4] since 2011 within Africa's Science, Technology and Innovation Indicators Initiative, there is a paucity of data on researchers in most of East and Central Africa. According to available data, Gabon and Kenya have the highest density of researchers by head count (Figure 19.7).

Distinct progress for the six most prolific countries

Four countries dominate scientific publishing (Cameroon, Ethiopia, Kenya and Uganda) but productivity is also rising in Gabon, the Republic of Congo and Rwanda, albeit from low levels (Figure 19.8). Gabon, Cameroon and Kenya count the most articles per million inhabitants but it is Ethiopia which has shown the most rapid progress, more than doubling its production since 2005 to take second place behind Kenya in terms of volume; Ethiopia's output remains modest, however, at just nine publications per million inhabitants.

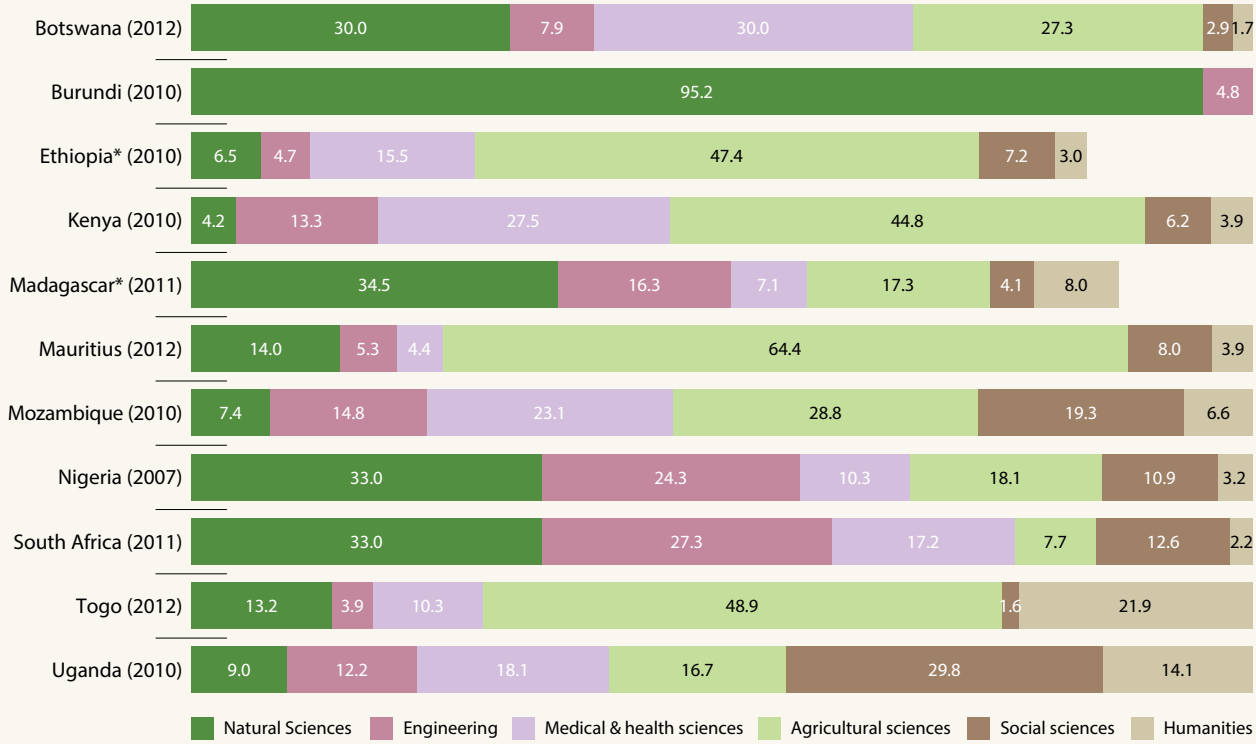
The lion's share of articles focus on life sciences but research is growing in geosciences in Cameroon, Ethiopia, Kenya and Uganda. Of note is that Cameroon has a diverse research portfolio, leading the region for the number of Web of Science articles in chemistry, engineering, mathematics and physics in 2014. Overall, the growth in scientific publications in most countries reflects greater political support for S&T.

Very few patents since 2010

Only two ECA countries have obtained patents from the United States Patent and Trademark Office in the past five years. Cameroon registered four utility patents (for new inventions) in 2010, followed by three in 2012 and four in 2013. This is a dramatic improvement on the two patents generated by Cameroon in the period 2005–2009. The other country is Kenya; it registered seven utility patents between 2010 and 2013, which is nevertheless a marked decline from the 25 patents it received in the previous five-year period. No other types of patent (design, plant or reissue) have been granted since 2010, indicating that ECA countries continue to struggle to generate and register new inventions.

4. The first surveys were published in the *African Innovation Outlook* in 2011 and 2014. Funds have been secured from Sweden to 2017 for the third edition of the *Outlook*.

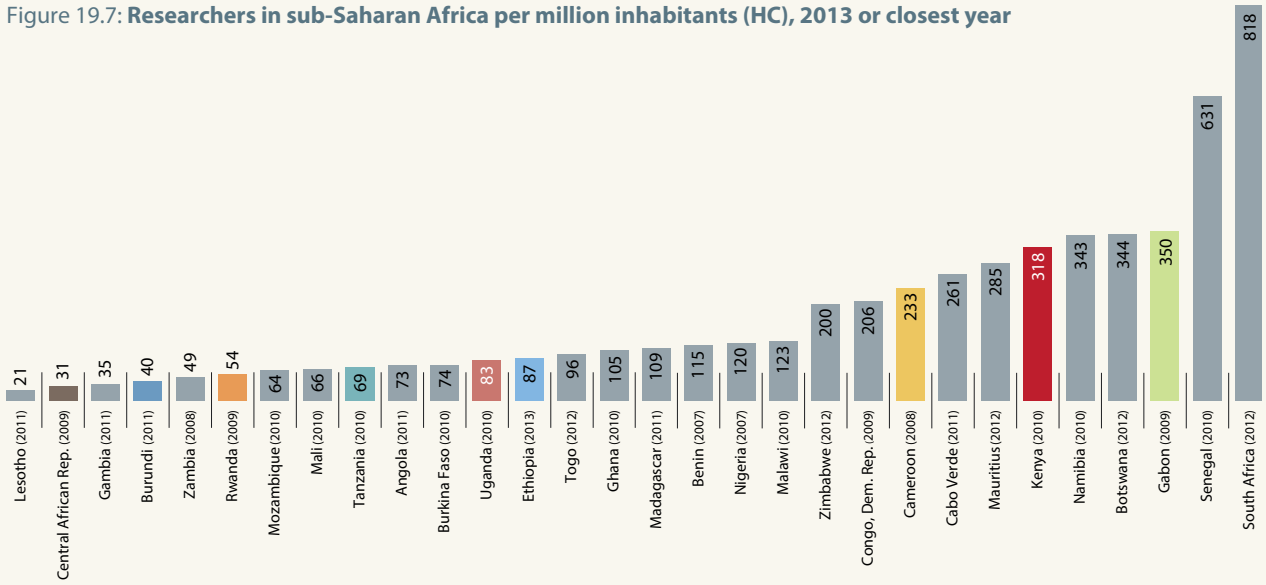
Figure 19.6: **GERD in sub-Saharan Africa by field of science, 2012 or closest year (%)**
Available countries



*Whenever data do not add up to 100% for this indicator, it is because part of the data remain unattributed.

Source: UNESCO Institute for Statistics, April 2015

Figure 19.7: **Researchers in sub-Saharan Africa per million inhabitants (HC), 2013 or closest year**



Source: UNESCO Institute for Statistics, April 2015

Table 19.5: **GERD in sub-Saharan Africa, 2011**

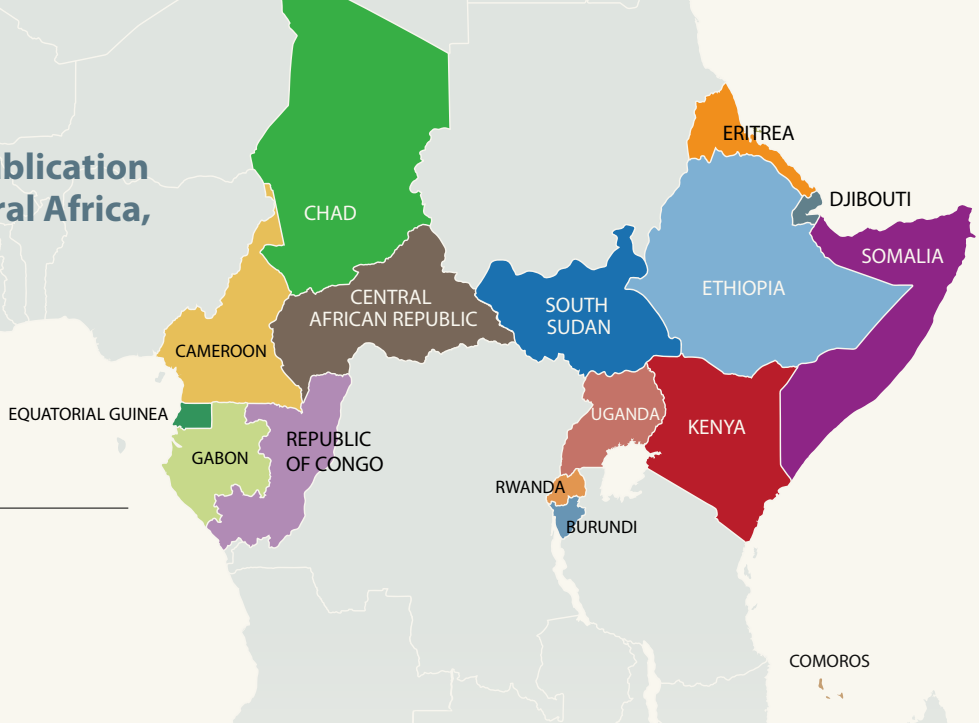
	GERD (% of GDP)	GERD per capita (current PPP$)	GERD per researcher (HC) in current PPP$ thousands	GERD by source of funds (%), 2011*				
				Business	Government	Higher education	Private non-profit	Abroad
Botswana	0.26^{+2}	37.8^{+2}	109.6^{+2}	5.8^{+2}	73.9^{+2}	12.6^{+2}	0.7^{+2}	6.8^{+2}
Burkina Faso	0.20^{-2}	2.6^{-2}	–	11.9^{-2}	9.1^{-2}	12.2^{-2}	1.3^{-2}	59.6^{-2}
Burundi	0.12	0.8	22.3	–	59.9^{-3}	0.2^{-3}	–	39.9^{-3}
Cabo Verde	0.07	4.5	17.3	–	100	–	–	–
Congo, Dem. Rep.	0.08^{-2}	0.5^{-2}	2.3^{-2}	–	100	–	–	–
Ethiopia	0.61^{+2}	8.3^{+2}	95.3^{+2}	0.7^{+2}	79.1^{+2}	1.8^{+2}	0.2^{+2}	2.1^{+2}
Gabon	0.58^{-2}	90.4^{-2}	258.6^{-2}	29.3^{-2}	58.1^{-2}	9.5^{-2}	-	3.1^{-2}
Gambia	0.13	2.0	59.1	–	38.5	–	45.6	15.9
Ghana	0.38^{-1}	11.3^{-1}	108.0^{-1}	0.1^{-1}	68.3^{-1}	0.3^{-1}	0.1^{-1}	31.2^{-1}
Kenya	0.79^{-1}	19.8^{-1}	62.1^{-1}	4.3^{-1}	26.0^{-1}	19.0^{-1}	3.5^{-1}	47.1^{-1}
Lesotho	0.01	0.3	14.3	–	–	44.7	–	3.4
Madagascar	0.11	1.5	13.3	–	100.0	–	–	–
Malawi	1.06^{-1}	7.8^{-1}	–	–	–	–	–	–
Mali	0.66^{-1}	10.8^{-1}	168.1^{-1}	–	91.2^{-2}	–	–	8.8-1
Mauritius	0.18^{+1}	31.1^{+1}	109.3^{+1}	0.3^{+1}	72.4^{+1}	20.7^{+1}	0.1^{+1}	6.4^{+1}
Mozambique	0.42^{-1}	4.0^{-1}	60.6^{-1}	-	18.8^{-1}	–	3.0^{-1}	78.1^{-1}
Namibia	0.14^{-1}	11.8^{-1}	34.4^{-1}	19.8^{-1}	78.6^{-1}	–	–	1.5^{-1}
Nigeria	0.22^{-4}	9.4^{-4}	78.1^{-4}	0.2^{-4}	96.4^{-4}	0.1^{-4}	1.7^{-4}	1.0^{-4}
Senegal	0.54^{-1}	11.6^{-1}	18.3^{-1}	4.1^{-1}	47.6^{-1}	0.0^{-1}	3.2^{-1}	40.5^{-1}
Seychelles	0.30^{-6}	46.7^{-6}	290.8^{-6}	–	–	–	–	–
South Africa	0.73^{+1}	93.0^{+1}	113.7^{+1}	38.3^{+1}	45.4^{+1}	0.8^{+1}	2.5^{+1}	13.1^{+1}
Tanzania	0.38^{-1}	7.7^{-1}	110.0^{-1}	0.1^{-1}	57.5^{-1}	0.3^{-1}	0.1^{-1}	42.0^{-1}
Togo	0.22^{+1}	3.0^{+1}	30.7^{+1}	-	84.9^{+1}	0.0^{+1}	3.1^{+1}	12.1^{+1}
Uganda	0.48^{-1}	7.1^{-1}	85.2^{-1}	13.7^{-1}	21.9^{-1}	1.0^{-1}	6.0^{-1}	57.3-^{1}
Zambia	0.28^{-3}	8.5^{-3}	172.1^{-3}	–	–	–	–	–

-n/+n: data refer to *n* years before or after reference year
*Whenever data do not add up to 100% for this indicator, it is because part of the data remain unattributed.

Note: Data are missing for some countries.

Source: UNESCO Institute for Statistics, April 2015; for Malawi: UNESCO (2014) *Mapping Research and Innovation in the Republic of Malawi* (p. 57)

Figure 19.8: **Scientific publication trends in East and Central Africa, 2005–2014**



11.3%

Share of Kenyan papers among 10% most cited, 2008–2012; the G20 average is 10.2%

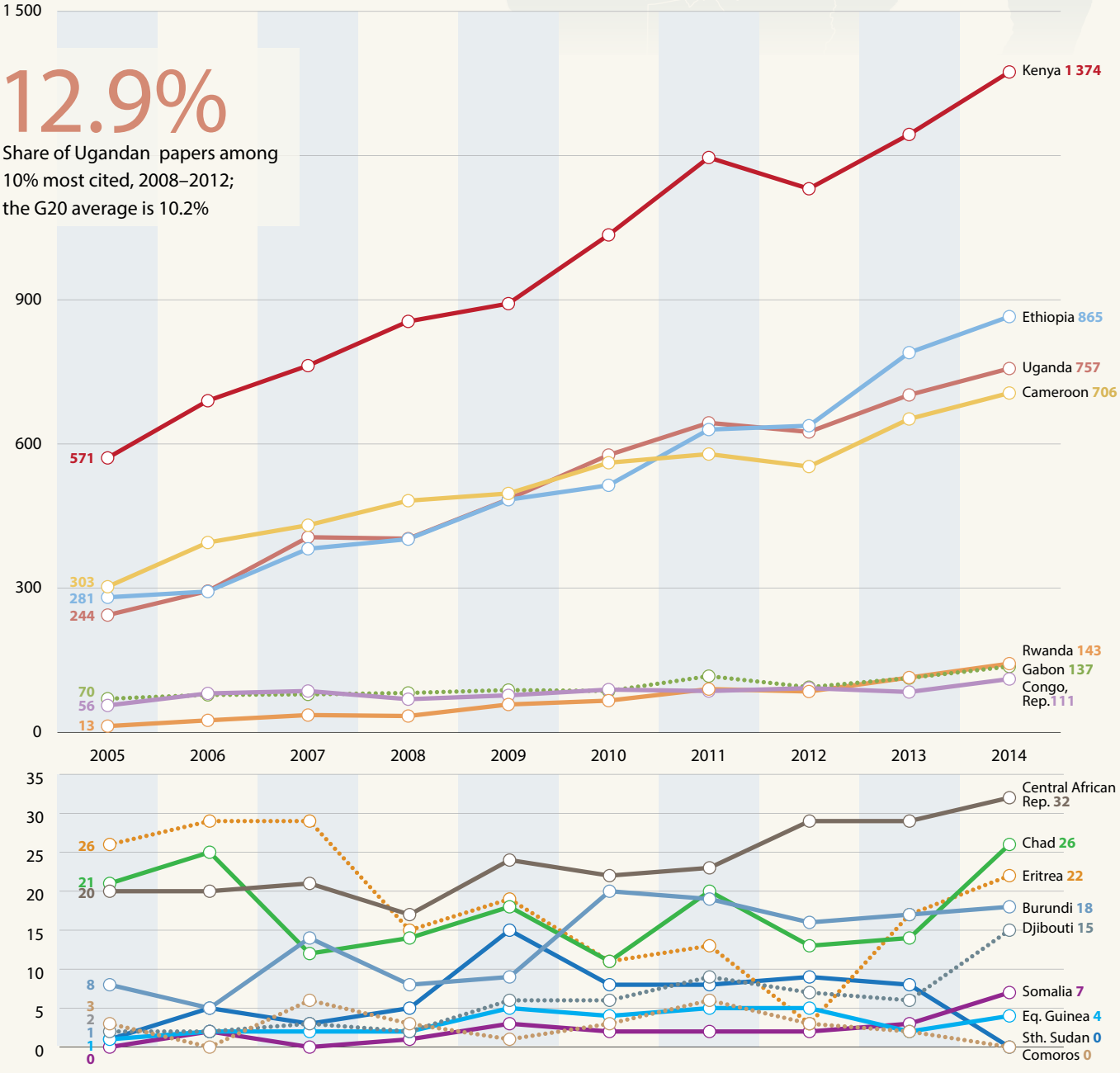
6.3%

Share of Ethiopian papers among 10% most cited, 2008–2012; the G20 average is 10.2%

12.9%

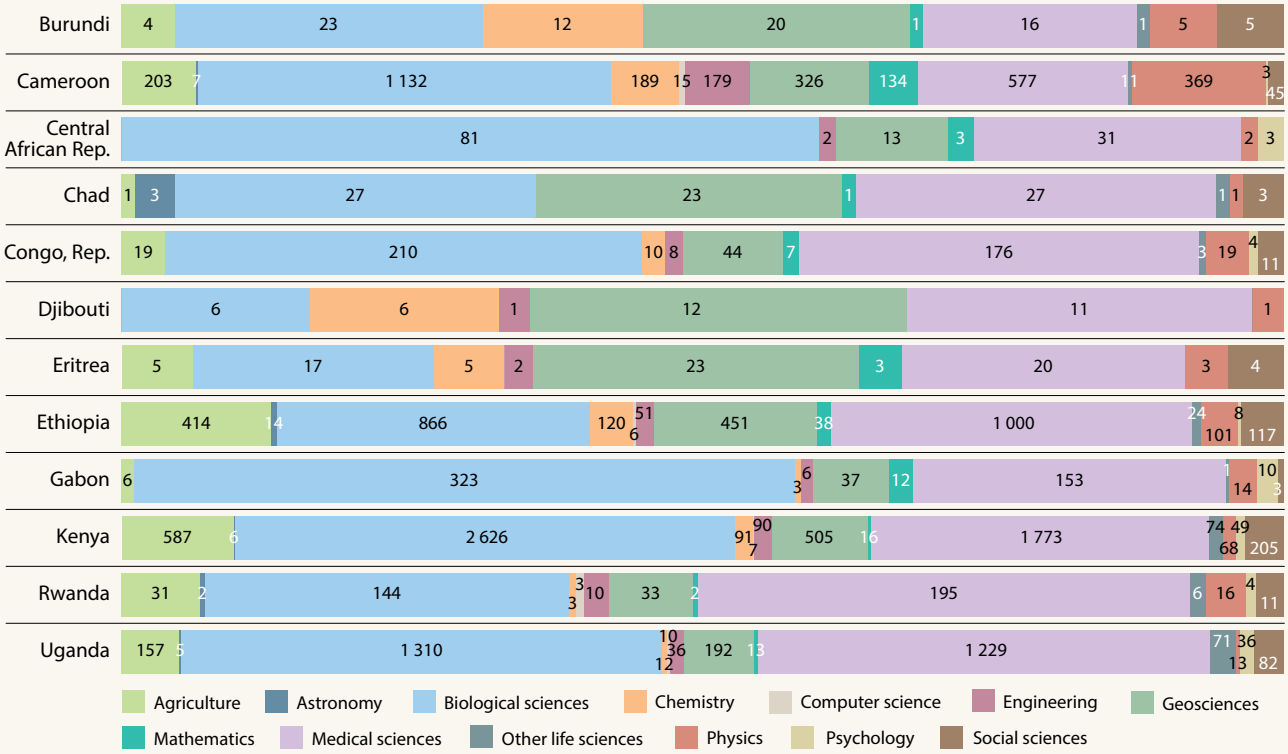
Share of Ugandan papers among 10% most cited, 2008–2012; the G20 average is 10.2%

Kenya, Ethiopia, Uganda and Cameroon produce the most publications



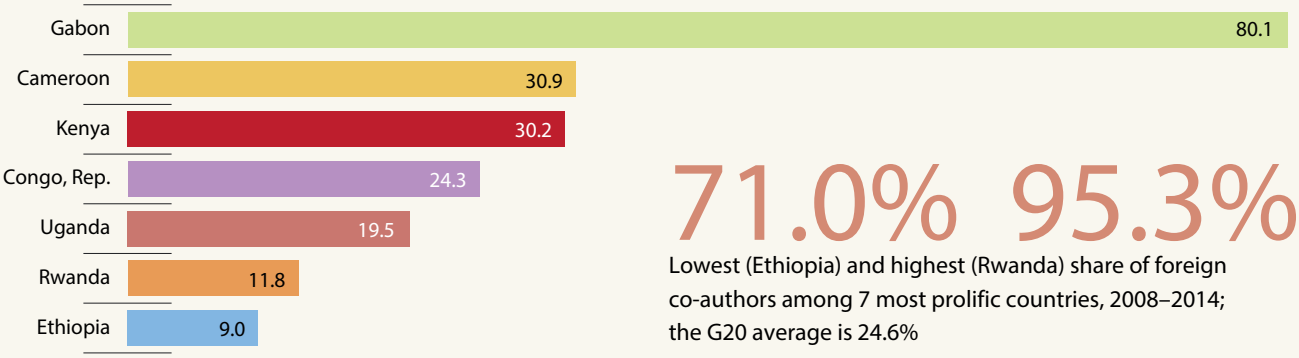
Life sciences dominate research in Central and East Africa

Cumulative totals by field, 2008–2014, for countries which recorded 15 articles or more in the Web of Science in 2014



Gabon was the most productive in 2014

Articles per million inhabitants for the most productive countries



71.0% 95.3%

Lowest (Ethiopia) and highest (Rwanda) share of foreign co-authors among 7 most prolific countries, 2008–2014; the G20 average is 24.6%

Scientists co-author most with partners outside Africa, some also with Kenya and South Africa

Main foreign partners of the 12 countries with the most publications, 2008–2014 (number of papers)

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Burundi	Belgium (38)	China (32)	USA (18)	Kenya (16)	UK (13)
Cameroon	France (1 153)	USA (528)	Germany (429)	South Africa (340)	UK (339)
Cent. African Rep.	France (103)	USA (32)	Cameroon (30)	Gabon (29)	Senegal (23)
Chad	France (66)	Switzerland (28)	Cameroon (20)	UK/USA (14)	
Congo, Rep.	France (191)	USA (152)	Belgium (132)	UK (75)	Switzerland (68)
Djibouti	France (31)	USA/UK (6)	Canada (5)	Spain (4)	
Eritrea	USA (24)	India (20)	Italy (18)	Netherlands (13)	UK (11)
Ethiopia	USA (776)	UK (538)	Germany (314)	India (306)	Belgium (280)
Gabon	France (334)	Germany (231)	USA (142)	UK (113)	Netherlands (98)
Kenya	USA (2 856)	UK (1 821)	South Africa (750)	Germany (665)	Netherlands (540)
Rwanda	USA (244)	Belgium (107)	Netherlands (86)	Kenya (83)	UK (82)
Uganda	USA (1 709)	UK (1 031)	Kenya (477)	South Africa (409)	Sweden (311)

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

COUNTRY PROFILES

BURUNDI

An STI policy and the launch of R&D surveys

Burundi is a landlocked country with an economy dominated by subsistence agriculture. It has enjoyed a period of political stability and rapid economic development since the end of the civil war a decade ago. The World Bank's *Doing Business* report even named Burundi one of the world's top economic reformers in 2011–2013 for its efforts to streamline business, attract foreign investment and climb out of the league of the world's poorest countries (World Bank, 2013).

In 2010, the Department of Science, Technology and Research was created within the Ministry of Higher Education and Scientific Research to co-ordinate STI across the economy. Burundi then adopted a *National Policy on Science, Research and Technological Innovation* in 2011 (Tumushabe and Mugabe, 2012).

In 2011, Burundi published its *Vision 2025* document. The main targets to 2025 are to:

- achieve universal primary education;
- instigate good governance in a state of law, with regular elections;
- curb population growth from 2.5% to 2% per year to preserve gains in agricultural productivity and arable land, 90% of the population currently living off the land and more than half the population being under 17 years[5] of age;
- halve the current level of poverty (67% of the population) and ensure food security;
- improve the country's capacity to absorb the latest technology, in order to foster growth and competitivity;
- raise GDP per capita from US$ 137 in 2008 to US$ 720 and ensure annual economic growth of 10%;
- expand the urbanized population from 10% to 40% to preserve land;
- make environmental protection and the rational use of natural resources a priority.

The EAC Secretariat commissioned an assessment in 2011, in order to designate five centres of excellence in the community for EAC funding. The National Institute of Public Health in Burundi was one of the five; it provides training, diagnosis and research (Box 19.2).

5. The annual population growth rate in Burundi had accelerated to 3.1% by 2014, see Table 19.1.

Box 19.2: African centres of excellence in biomedical sciences

The EAC commissioned a study in 2011 which designated 19 centres of excellence from five EAC partner states. In October 2014, the 10th ordinary meeting of the EAC Sectorial Council of Ministers responsible for Health selected five of these centres for first-phase EAC funding, namely: the National Institute of Public Health (Burundi), Rift Valley Technical Training Institute (Kenya), University of Rwanda,* Uganda Industrial Research Institute and *Taasisi ya Sanaa na Utamaduni Bagamoyo* (Tanzania).

Complementing the EAC project, the African Development Bank (AfDB) approved bilateral loans in October 2014 amounting to US$ 98 million to finance the first phase of its own East Africa's Centres of Excellence for Skills and Tertiary Education in Biomedical Sciences programme.

The AfDB project will contribute to developing a highly skilled labour force in biomedical sciences to meet the EAC's immediate labour market needs and support implementation of EAC's 'free' labour market protocols. One potential area for growth is medical tourism.

The first phase of the AfDB project will support the creation of specialized centres of excellence in nephrology and urology in Kenya, cardiovascular medicine in Tanzania, biomedical engineering and e-health in Rwanda and oncology in Uganda. During the project's second phase, a centre of excellence will open in Burundi in nutritional sciences. The East Africa Kidney Institute will operate as part of the University of Nairobi and its teaching hospital, Kenyatta National Hospital. The other centres of excellence will be established at the University of Rwanda's College of Medicine and Health Sciences, the Uganda Cancer Institute and, in Tanzania, at Muhimbili University of Health and Allied Sciences. Some 140 master's and 10 PhD students will benefit from the programme, as well as 300 interns.

The centres of excellence will be expected to collaborate with internationally renowned establishments to develop quality curricula, joint research, promote inter-university exchanges and mentoring programmes and to give access to documentary resources.

*formerly the Kigali Institute of Science and Technology

Source: AfDB press release and personal communication; authors

Since joining the African Science, Technology and Innovation Indicators Initiative in August 2013, Burundi has been conducting national surveys of research and innovation to inform policy-making.

CAMEROON

Developing ICTs to catch up

In September 2007, the National Agency for Information and Communication Technologies published the *National Policy for the Development of Information and Communication Technologies*. Several programmes and projects were established under this policy for the post-2010 period, including (IST-Africa, 2012):

- a training programme for state personnel working in ICTs;
- measures to enhance the legal, regulatory and institutional framework governing ICTs, in order to provide a competitive environment for companies offering electronic communications services, catalyse innovation and promote service diversification and cost reduction; and
- an upgrade of the telecommunications network, such as fibre-optic cables.

The policy has spawned the following initiatives to promote the deployment of ICTs, among others (IST-Africa, 2012):

- the Ministry of Scientific Research and Innovation has issued an action plan for an information and knowledge society;
- the Ministry of Higher Education has implemented an ICT development programme in tertiary institutions;
- the Ministry of Secondary Education has built multimedia resource centres at secondary schools;
- mandatory ICT-related programmes have been introduced in primary and secondary schools; and
- the Prime Minister's Office has implemented a National Governance Programme.

The policy's implementation has nevertheless been hampered by a lack of financial resources, the inadequate synergy between the government and external partners and the weak state capacity for project management. Between 2007 and 2013, internet penetration spread only from 2.9% to 6.4% of the population. Despite this, two innovation hubs have been set up in recent years (Box 19.3).

The government is also supporting companies and fostering linkages between research and professional communities, in order to develop an indigenous ICT sector to realize the country's *Vision 2035*. Adopted in 2009, this planning document aims to turn Cameroon into a newly industrialized country by 2035. *Vision 2035* estimates that the informal sector represents 80–90% of the economy. Targets include:

- raising the share of manufacturing from 10% to 23% of GDP (it had almost reached 14% by 2013, see Figure 19.2);
- reducing the share of products from forestry, agriculture and aquaculture from 20.5% to 10% of exports by developing manufacturing;
- raising investment from 17% to 33% of GDP to drive technological development;
- expanding the number of tractors from 0.84 per 100 hectares to 1.2 per hectare;
- raising the proportion of doctors from 7 to 70 per 100 000 inhabitants; similar progress is to be realized among teachers, including in engineering fields: ICTs, civil engineering, agronomists, etc.;

Box 19.3: ActivSpaces and CiHub: giving start-ups a head-start in Cameroon

One important complementary scheme to government initiatives has been the creation of community technology and innovation hubs. A pioneer in this field is ActivSpaces; it provides facilities for web and mobile programmers, designers, researchers and entrepreneurs at co-working spaces in two Cameroonian cities, Douala and Buea. The hub aims to promote African-made technology, innovation and entrepreneurship, especially among youth and women.

Since 2015, ActivSpaces has been offering a six-month incubator or accelerator programme called Activation Bootcamp, which provides entrepreneurs with legal advice, mentorship, assistance in registering a start-up company and financial seeding, in return for a 5% share of equity in the venture. ActivSpaces also hosts various events, including a Demonstration Day to allow bootcamp participants to showcase their products and services.

Another innovation hub and incubator, the Cameroon Innovation Hub (CiHub), provides a launchpad for young tech entrepreneurs to develop start-ups based on internet and mobile technology to help address the country's social challenges. CiHub facilitates interactions among developers, entrepreneurs, companies and universities.

Source: compiled by authors

- raising the share of secondary and tertiary students specializing in S&T subjects from 5% to 30%;
- reducing the annual population growth rate from 2.8% to 2.0% through economic development and the emancipation of women, which will in turn encourage family planning;
- increasing access to drinking water from 50% to 75% of the population; and
- doubling energy consumption, mainly through the development of hydropower and gas.

CENTRAL AFRICAN REPUBLIC

The priority: getting child refugees back to school

The civil war since 2012 has severely disrupted the country's social fabric, generating an estimated 200 000 displaced persons. Since President Bozizé fled the country in 2013, first Michael Djotodia then Catherine Samba-Panza have served as interim president, Ms Samba-Panza since January 2014.

With a fragile ceasefire agreement in place since July 2014 and international peacekeepers on the ground, the country has begun rehabilitating infrastructure. The current transitional government and the Ministry of National Education and Higher Education and Scientific Research have been given the mandate of promoting STI for the recovery and sustainable development of the country. The ministry's top priority, however, is to resuscitate the education system from primary to university levels. The greatest challenge facing the education sector are the many school-age children living in refugee camps, compounded by the exodus of educated people, including teachers and professors.

CHAD

Plans to diversify mining

In recent years, Chad has suffered from flooding and drought, as well as conflict on its borders. Relations with Sudan improved after the signing of a non-aggression pact in 2010 but instability in Libya, Nigeria and Central African Republic since 2012 has forced it to raise its defence budget to handle a flood of refugees and counter growing cross-border threats, including that posed by the Boko Haram sect.

The economy has become dependent on oil over the past decade. This has produced erratic growth patterns as oil production has fluctuated. Chad hopes to double production in 2016, thanks to increased output from its Mangara and Badila fields, which are operated by the mining company Glencore Xstrata, and a new field managed by a subsidiary of the China National Petroleum Corporation (CNPC). According to the Minister of Finance, Kordje Bedoumra, Chad has commissioned consultancy firms from France and the Russian Federation to inventory potential mineral deposits of gold, nickel and uranium, in an effort to diversify the economy (Irish, 2014).

Chad is one of the world's least developed countries, ranking 183rd in the 2012 Human Development Index. Despite improvements in school attendance and access to clean drinking water (Tables 19.3 and 19.1), many Chadians still face severe deprivation and most Millennium Development Goals will not be met, according to the World Bank.

Chad has no specific STI policy. However, the law of 2006 mandates the Ministry of Higher Education and Scientific Research to co-ordinate STI.

COMOROS

Mobile phone technology fairly developed

The three small islands which make up Comoros group a population of 752 000, half of whom are under the age of 15. The economy is agrarian (37.1% of GDP), with manufacturing accounting for just 7% of national income. Although less than 7% of the population had access to internet in 2013, nearly one in two inhabitants (47%) subscribed to a mobile phone. Improved sanitation reaches only 17% of the population but 87% have access to clean water (Table 19.1).

In 2008, Comoros devoted a relatively large share of GDP to education (7.6%), one-sixth of which went to higher education (Table 19.2). One in ten (11%) young people attend the country's single public university, the University of Comoros, founded in 2003. By 2012, the university had a student roll of over 6 000, double that in 2007, but no PhD students (Table 19.4).

REPUBLIC OF CONGO

A push to modernize and industrialize

The Republic of Congo was the world's fourth fastest-growing economy in 2010, according to the World Bank. The government plans to turn Congo into an emerging economy by 2025, through *Vision 2025*. Adopted in 2011, this document foresees the diversification and modernization of the economy, which is heavily dependent on oil, and the development of secondary and tertiary education to provide the necessary skills base. To promote the rule of

law, emphasis is being laid on strengthening participatory and inclusive democracy. There are programmes to develop physical (transportation) and virtual (ICTs) connections to domestic and foreign markets. Two key infrastructure projects are under way, the construction of a dam at Imboulou (120 MW) and the rehabilitation of the Congo Ocean railway.

Within a three-year agreement signed in December 2014, UNESCO is helping Congo to reinforce research and innovation by mapping Congo's STI ecosystem and developing instruments to ensure better policy implementation and a better status for researchers. One obstacle to innovation has been the lack of awareness of intellectual property rights, which has led to new knowledge being patented by better-informed competitors (Ezeanya, 2013). In 2004, Congo had requested UNESCO's support for the development of a national science and technology[6] policy. This led to the adoption of an action plan for 2010–2016. The new agreement reinforces existing programmes by focusing on modernization and industrialization.

To reflect the importance accorded to STI, the Ministry of Scientific Research and Technological Innovation has been separated from the Ministry of Higher Education, the Ministry of Primary and Secondary Education and the Ministry of Technical and Vocational Education. In January 2012, the Ministry of Scientific Research and Technological Innovation entered into a partnership with the Congolese company ISF Technologies to develop and integrate ICT solutions with business intelligence to optimize the performance of enterprises.

In Congo, university–industry ties tend to spring from initiatives by individual universities to support small enterprises. For example, the private non-profit ICAM School of Engineering in Pointe-Noire and Douala established a programme in November 2013 offering SMEs technical support.

DJIBOUTI

Education a priority

Expenditure on public education accounted for 4.5% of GDP in 2010. Schooling is free and seven out of ten children now attend primary school, although the ratio is higher for boys than for girls (Table 19.3). Until the founding of the University of Djibouti in 2006, students had to go abroad to study and could apply for a government sponsorship, a situation which fostered brain drain. In May 2014, the university launched an e-campus in the presence of the Minister of Higher Education and Research. The university plans to organize an international seminar on geohazards in early 2016. It is currently establishing an observatory to monitor climate change in East Africa, in collaboration with Yale University and the Massachusetts Institute of Technology in the USA.

Eight out of ten citizens work in the services sector, with manufacturing accounting for just 2.5% of GDP in 2007 (Figure 19.2). Djibouti's transformation into a modern hub is increasingly dependent on how well it can acquire technology from the global economy and adapt this to its level of development. FDI comes mainly from the Middle East and is high (19.6% of GDP in 2013) but tends to flow to the country's strategic port on the Red Sea. Investment projects with the potential for technology transfer and local capacity-building need strengthening. Greater statistical capability in STI indicators would also help the government to monitor improvements in this area.

Since joining the World Intellectual Property Organisation in 2002, Djibouti has enacted a law on the Protection of Copyright and Neighbouring Rights (2006) and a second law on the Protection of Industrial Property (2009).

EQUATORIAL GUINEA

International commitment, little domestic output

Founded in 1995, the National University of Equatorial Guinea is the country's main tertiary institution. It has faculties of agriculture, business, education, engineering, fisheries and medicine.

In 2012, President Obiang Nguema Mbasogo made funds available for the UNESCO–Equatorial Guinea International Prize for Research in the Life Sciences. In addition to rewarding research undertaken by individuals, institutions or other entities, the prize promotes the establishment and development of centres of excellence in the life sciences. The fact that the prize is international in character rather than aimed at citizens of Equatorial Guinea has attracted criticism within the country, which has high levels of poverty, despite being classified as a high-income country thanks to its oil-rent economy.

In February 2013, Equatorial Guinea applied to the African Union to host the African Observatory for Science, Technology and Innovation, the mandate of which is to collect data on the continent's STI capabilities. Having offered US$ 3.6 million and being the only applicant, Equatorial Guinea won the bid. Progress in establishing the facility has since been hampered by various administrative and political obstacles.

6. For details of UNESCO's work with the Republic of Congo since 2004, see the *UNESCO Science Report 2010*.

Despite these two high-profile international commitments, there is little information available on STI policy and implementation in Equatorial Guinea and, somewhat ironically, the country does not participate in STI data surveys. The Web of Science catalogued just 27 scientific articles from Equatorial Guinea between 2008 and 2014, placing Equatorial Guinea on a par with Comoros and Somalia for this indicator (Figure 19.8).

ERITREA

Urgent development challenges

Eritrea faces numerous development challenges. Just 0.9% of the population had access to internet in 2013 and 5.6% a mobile phone subscription (Table 19.1). There is also little access to improved sanitation (9%) and clean water (43%). To compound matters, the population is growing at one of the fastest rates in sub-Saharan Africa: 3.16% in 2014 (Table 19.1).

Two-thirds of the population worked in the services sector in 2009. With gold accounting for 88% of exports in 2012 (see Figure 18.1), there is an urgent need to diversify the economy to ensure sustainability and attract FDI, which contributed just 1.3% of GDP in 2013. Economic growth has been erratic, attaining 7.0% in 2012 but only 1.3% in 2013.

The Eritrea Institute of Technology is the main institution for higher studies in science, engineering and education. The facilities and capacity of the institute are continually being upgraded, thanks to largely external funding, although the Ministry of Education also contributes. The number of students graduating each year is rising steadily but from a low starting point. In 2010, just 2% of the 18–23 year-old cohort was enrolled in university and there were not as yet any PhD students (Tables 19.3 and 19.4). The number of Eritrean publications in the Web of Science dropped from 29 in 2006 to 22 in 2014 (Figure 19.8).

The National Science and Technology Council (NSTC), Eritrean Science and Technology Development Agency (ESTDA) and National Science and Technology Advisory Board were all established in 2002. The NSTC is responsible for the formulation, review and approval of policies but no specific S&T policy has been published since 2002, as far as can be ascertained. ESTDA is an autonomous corporate body with two main objectives: to promote and co-ordinate the application of S&T for development under the guidance of NSTC and to build the national capability for R&D.

ETHIOPIA

An ambitious plan for growth and transformation

For the past decade, Ethiopia has enjoyed some of the fastest economic growth in Africa among agrarian economies. The government is now focusing on modernization and industrialization to realize its ambition of turning Ethiopia into a middle-income economy by 2025.

The government recognizes that STI will be a prerequisite for realizing its *Growth and Transformation Plan for 2011–2015*. A government report has since mapped progress over the first two years of implementation (MoFED, 2013):

- improved crop and livestock productivity and soil and water preservation through research;
- greater generation and dissemination of geoscience data and more problem-solving research related to mining;
- the development of alternative construction technologies for road-building;
- the start of construction of a national railway network;
- sustainable technology transfer in medium and large-scale manufacturing industries to improve their export capacity, fostered through privatization and measures to attract foreign investors: by 2012, this sub-sector had registered growth of 18.6%, close to the target of 19.2%; there was 13.6% growth in value-added industrial products by 2012 but export earnings from textiles, leather goods, pharmaceuticals and agroprocessing have been disappointing, owing to low productivity and inadequate technological capability, a lack of inputs and other structural problems;
- the development of renewable energy, including through the Ashegoda and Adama-2 wind energy projects, the Great Ethiopian Renaissance Dam on the Blue Nile and the ongoing development of biofuel plants (jatropha, caster, etc.) on 2.53 million hectares of land;
- the development of a *Climate Resilient Green Economy Vision and Strategy*, as well as the enforcement of compliance with environmental laws and capacity-building in the mitigation of greenhouse gases;
- the number of tertiary-level students rose from 401 900 to 693 300 between 2009 and 2011; the target is for 40% of students to be women by 2015;
- a national survey of research and innovation in 2011–2012 found that 0.24% of GDP was being devoted to GERD, the same level as in 2009. The survey also inventoried 91 researchers per million population;

In parallel, the *National Science and Technology Policy* (2007) has been revised with UNESCO support, in order to take the following considerations into account:

- the transformation of the Ethiopian economy from a centralized to an open market economy, with concomitant political power decentralization;
- global advances in the understanding and application of STI and rapid socio-economic changes at national level;
- the imperative of developing a national STI capability, in order to seize the opportunities offered by global progress in scientific knowledge and technology; and
- the fragmented, unco-ordinated and uneconomic use of limited resources which characterized STI at the time.

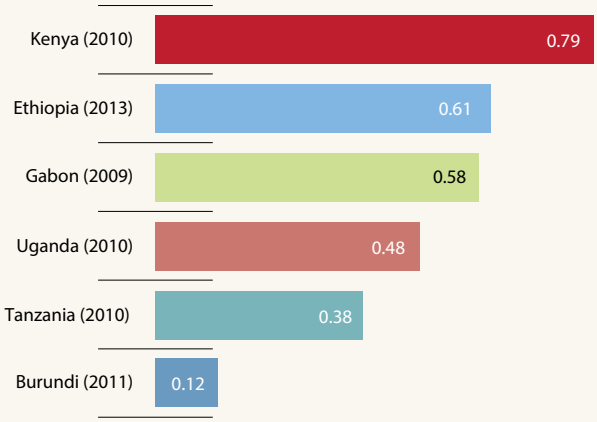
The revised *National Science, Technology and Innovation Policy* has been operational since 2010. It seeks to 'build competitiveness through innovation.' Its strengths include upgrading the Science and Technology Commission to ministerial level with a consequential name change to Ministry of Science and Technology, advocating an annual government allocation of at least 1.5% of GDP for STI in all sectors and the creation of a centralized innovation fund for R&D resourced from a contribution of 1% of the annual profits realized in all productive and service sectors. As of mid-2015, neither the annual government allocation, nor the innovation fund were yet operational. The GERD/GDP ratio has risen, though, to 0.61% of GDP in 2013 (Figure 19.9), according to the UNESCO Institute for Statistics, which also reported a steep increase in the proportion of women researchers from 7.6% to 13.3% between 2010 and 2013.

Two programmes stand out:

- the National Priority Technology Capability Programmes launched in 2010 in the areas of agricultural productivity improvement, industrial productivity and quality programmes, biotechnology, energy, construction and material technologies, electronics and microelectronics, ICTs, telecommunications and water technology; and
- the ongoing Engineering Capacity-Building Programme launched in 2005, which is jointly financed and implemented by the governments of Ethiopia and Germany within Ethiopian–German Development Co-operation. Priority sectors include textiles, construction, leather, agro-processing, pharmaceuticals/chemicals and metal.

In 2014, it was decided to place universities specializing in science and technology which have ties with industry under the new Ministry of Science and Technology to promote innovation in academia and stimulate technology-driven enterprises. The first two universities in Addis Ababa and Adama were transferred from the Ministry of Higher Education in 2014.

Figure 19.9: **GERD/GDP ratio in East and Central Africa, 2013, or closest year (%)**
Selected countries



Source: UNESCO Institute for Statistics

GABON

A plan to green Gabon by 2025

Gabon is one of the most stable countries in Africa. Despite being one of the continent's rare upper middle-income economies, it is characterized by considerable inequality in income distribution. There is also limited infrastructure, including in the transport, health, education and research sectors (World Bank, 2013).

The economy is dominated by oil but, with production starting to decline, the government has been implementing political and economic reforms since 2009 to transform Gabon into a developed country by 2025. This ambition is encapsulated in the government strategy, *Emerging Gabon: Strategic Plan to 2025*, which aims to set the country on the path to sustainable development, 'which is at the heart of the new executive's policy',[7] according to the *Strategic Plan.* Adopted in 2012, it identifies two parallel challenges: the need to diversify an economy dominated by oil exports (84% in 2012, see Figure 18.2) and the imperative of reducing poverty and fostering equal opportunity.

The three pillars of the plan are:

- *Green Gabon:* to develop the country's natural resources in a sustainable manner, beginning with an inventory of 22 million ha of forest (85% of the land cover), 1 million ha of arable land, 13 national parks and 800 km of coastline;
- *Industry Gabon:* to develop local processing of raw materials and the export of high value-added products;

7. Gabon's President Ali Bongo Ondimba took office in October 2009.

- *Services Gabon:* to foster quality education and training, in order to turn Gabon into a regional leader in financial services, ICTs, green growth, tertiary education and health.

The plan foresees the adoption of a *National Climate Plan* to limit Gabon's greenhouse gas emissions and forge an adaptation strategy. The share of hydropower in Gabon's electricity matrix is to progress from 40% in 2010 to 80% by 2020. In parallel, inefficient thermal power stations are to be replaced with clean ones to bring the share of clean energy to 100%. By 2030, Gabon plans to export 3 000 MW of hydropower to its neighbours. Efforts will also be made to improve energy efficiency and reduce pollution in such areas as construction and transportation.

This new paradigm is to be ensconced in a law on sustainable development which will create a fund compensating the negative effects of development. Moreover, in conformity with the *Gaborone Declaration* (see Box 20.1), natural capital is to be integrated into the national accounting system.

Quality education a priority

Quality education is another priority of the *Strategic Plan* to 2025. Four technical secondary schools offering 1 000 places are to be established to raise the proportion of pupils benefiting from this education from 8% to 20% and thereby provide key economic sectors such as the wood, forestry, mining,[8] metallurgy and tourism industries with skilled personnel.

In order to adapt university curricula to market needs, existing universities will be modernized and a *Cité verte de l'éducation et du savoir* (Green City of Education and Knowledge) will be created in the heart of the country in Booué. Constructed using green materials and running on green energy, this complex will group a campus, research centres and modern housing. Foreign universities will be encouraged to set up campuses on site. A research fund will be created for academic projects selected on a competitive basis and an information technology park will be set up in partnership with the National Agency for Digital Infrastructure and Frequencies.

All primary and secondary schools are to be equipped with a multimedia room and a mechanism will be put in place to enable all teachers and university students to acquire a computer.

In parallel, the plan foresees a broad administrative and legal reform to improve efficiency and foster the rule of law. A number of new bodies will be established to foster quality education, including the Council for Education, Training and Research, which will be responsible for evaluating the implementation of the government's education policy.

Steps taken to implement the *Strategic Plan*

Since 2011, the government has taken a number of steps to implement *Emerging Gabon: Strategic Plan to 2025*, including:

- the creation of a Research Unit on Tuberculosis at the Albert Schweitzer Hospital in Lambaréné in February 2011, in response to the growing prevalence of tuberculosis;
- the creation of a joint Centre for Environmental Research by Gabon and the University of Oregon (USA) in June 2011, with a focus on the mitigation of, and adaptation to, climate change and environmental governance, including the development of ecotourism;
- the construction of a School of Mining and Metallurgy in Moanda in October 2012 to produce more scientists and engineers in these areas;
- the opening of a digital campus at the School of Water Affairs and Forestry in February 2013 to produce more engineers;
- the creation of three new vocational training centres in June 2013;
- the official presentation of the *National Climate Plan* to the president in November 2013 by the National Council on Climate Change, a body created by presidential decree in April 2010;
- the establishment of a Ministry of Higher Education and Scientific Research in April 2014; and
- the adoption of the law on sustainable development in August 2014; this law has raised some concerns in civil society as to whether it will protect the territorial rights of third parties, particularly those of local and indigenous communities (Malouna, 2015).

The government has recently entered into two public–private partnerships. In December 2012, it established a 'fun' approach to learning about HIV which targets youth, called Gaming for HIV Prevention, in partnership with Shell Gabon. In February 2013, the government also partnered with Ireland Blyth Limited to develop the Gabonese seafood and maritime industries.

8. In 2010, Gabon attracted over US$ 4 billion for the wood, agriculture and infrastructure sectors, according to the government.

KENYA

A game-changing act?

STI policy in Kenya has been given a major boost by the Science, Technology and Innovation Act passed in 2013. The act contributes to the realization of *Kenya Vision 2030*, which foresees the country's transformation into a middle-income economy with a skilled labour force between 2008 and 2030. Kenya already hosts[9] several hubs for training and research in life sciences, including the Biosciences Eastern and Central Africa Network (Box 19.1) and the International Centre for Insect Physiology and Ecology. In line with *Vision 2030*, Kenya is participating in the AfDB's East Africa's Centres of Excellence for Skills and Tertiary Education in Biomedical Sciences programme (Box 19.2).

Flagship projects within *Vision 2030* include the following:

- Five industrial parks are being established for SMEs in key urban centres, the majority in agro-processing.
- The Nairobi Industrial and Technology Park is being developed within a joint venture with Jomo Kenyatta University of Agriculture and Technology.
- Konza Technology City is under construction in Nairobi (Box 19.4).
- Geothermal energy is being developed in the Rift Valley, within a programme to increase energy generation to 23 000 MW that is mobilizing private capital for the development of renewable energy (Box 19.5).
- Construction of Africa's largest wind farm began in 2014, within the Lake Turkana Wind Power Project;
- In recognition of the economic potential of ICTs, the government announced in December 2013 that it would be establishing technology incubation hubs in all 47 counties.

Under the Science, Technology and Innovation Act of 2013, the Ministry of Education, Science and Technology is attributed responsibility for formulating, promoting and implementing policies and strategies in higher education, STI in general and R&D in particular, as well as technical, industrial, vocational and entrepreneurship training.

The act established a National Commission for Science, Technology and Innovation, a regulatory and advisory body that is also responsible for quality assurance. Its specific functions include:

- developing priority areas for STI; co-ordinating the implementation and financing of policies with other institutional bodies, including local governments, the new National Innovation Agency and the new National Research Fund (see overleaf);
- providing accreditation for research institutes;
- fostering private-sector involvement in R&D; and
- undertaking annual reviews of scientific research systems.

The act further empowered the National Commission for Science, Technology and Innovation to establish advisory research committees to counsel the commission on specific programmes and projects and maintain a database of these and to foster R&D and education in relevant areas, in particular. The act also establishes a requirement for any person wishing to engage in R&D to obtain a government license.

9. Nairobi is also home to the African Network of Scientific and Technological Institutions (ANSTI), an NGO hosted by UNESCO since its inception in 1980. ANSTI awards PhD and master's scholarships and travel grants. Since 2010, ANSTI has awarded 45 L'Oréal-UNESCO Fellowships for Women in Science to foster research and innovation.

Box 19.4: Konza Technology City, Kenya's 'Silicon Savannah'

Konza Technology City was originally designed as a technology park centred on business process outsourcing and information technology-enabled services. The Kenyan government contracted the International Finance Corporation to conduct an initial feasibility study in 2009. However, while the study was being conducted, the consulting design partners recommended that the project be expanded into a technology city. The Kenyan government agreed and has branded Konza the 'Silicon Savannah'.

A 5 000-acre site located some 60 km from Nairobi was procured in 2009 and the new greenfield investment (see glossary, p. 738) commenced. The financing arrangement is based on a public–private partnership model, whereby the government provides basic infrastructure and supporting policy and regulatory frameworks, leaving private investors to build and operate the industrial development. Ultimately, Konza should include a university campus, residential accommodation, hotels, schools, hospitals and research facilities.

Development of the techno-city is being directed by the Konza Technopolis Development Authority, which has authority over marketing, the subleasing of land, guiding real estate development, managing funding from public and private sources and liaising with local authorities to ensure quality services. Construction of Konza Technology City began in early 2013 and is expected to take 20 years. It is hoped to create 20 000 jobs in information technology by 2015 and 200 000 by 2030.

Source: www.konzacity.go.ke; BBC (2013)

The Kenya National Innovation Agency was established under the act to develop and manage the national innovation system. It has been tasked *inter alia* with the following:

- institutionalizing linkages between relevant stakeholders, including universities, research institutions, the private sector and government;
- setting up science and innovation parks;
- promoting a culture of innovation;
- maintaining relevant standards and databases; and
- disseminating scientific knowledge.

The act also created the National Research Fund and made provisions for the fund to receive 2% of Kenya's GDP each financial year. This substantial commitment of funds should enable Kenya to reach its target of raising GERD from 0.79% of GDP in 2010 to 2% by 2014.

Kenya reviewed its *Science, Technology and Innovation Policy* in 2012 but the revised policy is still before parliament. The draft is nonetheless serving as a reference document for the Ministry of Education, Science and Technology.

Towards a digital Kenya

In August 2013, the Ministry of Information, Communication and Technology established a state-owned corporation named the Information and Communication Technology Authority. Its functions include centralized management of all government ICT functions; maintenance of ICT standards across government; and the promotion of ICT literacy, capacity, innovation and enterprise, in accordance with the *Kenya National ICT Master Plan: Towards a Digital Kenya*, which runs from 2014 to 2018.

In the past few years, there has been an explosion in ICT activity in Kenya, often centred on innovation hubs. One pioneer is iHub, set up in Nairobi in 2010 by an independent technologist named Erik Hersman to provide an open space for the technology community, including young tech entrepreneurs, programmers, investors and technology companies. iHub has forged relationships with several multinational corporations, including Google, Nokia and Samsung, as well as with the Kenyan government's ICT Board (Hersman, 2012).

Another innovation hub is @iLabAfrica, established in January 2011 as a research centre within the Faculty of Information Technology at Strathmore University, a private establishment based in Nairobi. It stimulates research, innovation and entrepreneurship in ICTs.

A related development in Kenya is the formation of innovation incubation programmes. A prominent example is NaiLab, an incubator for start-up ICT businesses which offers a three-to-six-month programme in entrepreneurship training. NaiLab started out as a private company in 2011, in collaboration with the crowdfunding platform 1%CLUB and consultancy firm Accenture. In January 2013, the Kenyan government formed a partnership with NaiLab to launch a US$ 1.6 million, three-year technology incubation programme to support the country's burgeoning technology start-up

Box 19.5: Geothermal energy for Kenya's development

Just one in five Kenyans has access to electricity and demand is rising (Table 19.1). Almost half of electricity comes from hydropower but the growing frequency of drought is causing water and power shortages which affect all sectors of the Kenyan economy. As a stop-gap measure, the government has engaged private energy companies which import fossil fuels such as coal and diesel, a costly option which also causes considerable air pollution.

Vision 2030 (2008) has identified energy as being a pillar of the country's development strategy. *Vision 2030* is being implemented through successive five-year medium-term plans. It sets an ambitious goal of increasing the capacity of the national power supply from 1 500 MW at present to about 21 000 MW by 2030.

To address the energy challenge while maintaining a low carbon footprint, Kenya plans to develop its geothermal fields in the Rift Valley. These fields have been inadequately tapped until now, despite their potential to produce an estimated 14 000 MW. Current installed geothermal capacity corresponds to just 1.5% of this potential.

The Geothermal Development Company (GDC) was formed in 2009 under the Energy Act (2006) to implement the *National Energy Policy*. The GDC is a government body which cushions investors from the high capital investment risks associated with drilling geothermal wells. The GDC is expected to drill as many as 1 400 wells to explore steam prospects and make productive wells available to successful bidding investors from both public and private power companies.

In the fiscal year budget for 2012–2013, the Kenyan government allocated US$ 340 million to the exploration and development of geothermal energy and coal. Of this amount, just US$ 20 million went to the GDC.

Source: WWAP (2014)

sector (Nsehe, 2013). These funds will enable NaiLab to broaden its geographical scope to other Kenyan cities and towns, helping start-ups to obtain information, capital and business contacts.

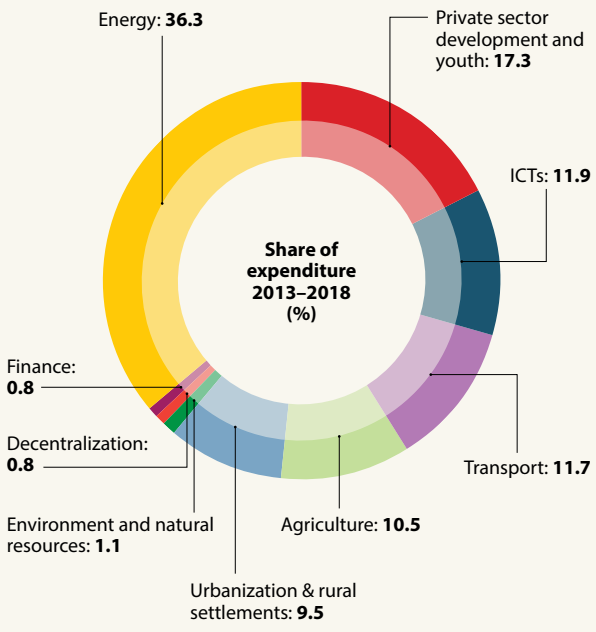
Nairobi is also home to m:Lab East Africa, which provides a platform for mobile entrepreneurship, business incubation, developer-training and application-testing.

RWANDA

Infrastructure, energy and 'green' innovation a priority

In a context of rapid economic and demographic growth, STI holds one of the keys to Rwanda's sustainable development. This conviction is embodied in *Rwanda's Vision 2020* (2000) for becoming a middle-income country by 2020 and in its *National Policy on Science, Technology and Innovation*, published in October 2005 with support from UNESCO and the United Nations University. The priority given to STI is also reflected in Rwanda's *First Economic Development for Poverty Reduction Strategy*, 2007–2012. If STI is not an explicit priority in the *Second Economic Development for Poverty Reduction Strategy*, 2013–2018, it is implicit in the priority given in the document to ICTs, energy and 'green' innovation (Figure 19.10), as well as in the proposal to create a Climate Change and Environment Innovation Centre. The five priorities are to:

Figure 19.10: **Breakdown of priority areas for *Rwanda's Economic Transformation* to 2018**



Source: Government of Rwanda (2013) *Second Economic Development for Poverty Reduction Strategy*, 2013–2018

- invest in hard and soft infrastructure to meet the energy demand of the private sector; in line with the *Energy Policy* (2012), the procurement process will be made more transparent and competitive; public finance will be used to 'de-risk' electricity generation projects for the private sector, in order to attract a wider range of investors on better terms; an energy development fund will be established with donor support to finance feasibility studies on geothermal, peat and methane resources and hydropower; in addition, the Kigali Economic Zone will also be finalized with an associated technopole;
- increase access to public goods and resources in priority economic sectors by building a new international airport, expanding the national airline, Rwandair, and finalizing plans for the establishment of a railway connection; a strategic focus on exports and re-exports to Burundi and eastern Democratic Republic of Congo; investment in hard and soft infrastructure to accelerate growth in the tourism and commodity sectors and expand exports in manufacturing and agro-processing;
- strengthen the investment process by targeting large foreign investors in priority economic sectors, increasing long-term savings and thereby raising the amount of credit available to the private sector to 30% of GDP by 2018, as well as by strengthening the private sector through tax and regulatory reform;
- facilitate and manage urbanization, including the promotion of affordable housing;
- pursue a 'green economy' approach to economic transformation, with a focus on green urbanization and green innovation in public and private industry; a pilot green city is being launched by 2018 to 'test and promote a new approach to urbanization' that employs various technologies to create sustainable cities; in parallel, a green accounting framework is being put in place to assess the economic benefits of environmental protection.

There is no dedicated ministry for science and technology in Rwanda but, in 2009, the Directorate-General of Science, Technology and Research was established under the Ministry of Education to implement the *National Policy on Science, Technology and Innovation*. In 2012, the government officially launched the National Commission for Science and Technology (NCST). The NCST has been strategically positioned in the Prime Minister's Office to serve as an advisory body on matters related to STI across all economic sectors. It became operational in 2014.

The National Industrial Research and Development Agency (NIRDA) was established in June 2013, in line with the *National Industrial Policy* of April 2011. The main mission of this research body is to produce home-grown technological and industrial solutions to meet national and regional market needs.

Plans to become an African ICT hub

In the past five years, Rwanda has put infrastructure in place to enable it to become an ICT hub in Africa. This infrastructure includes the Kigali Metropolitan Network, a fibre optic network linking all government institutions with a high-capacity national backbone connecting the whole country. The national backbone also links Rwanda with neighbouring countries, including Uganda and Tanzania, and through them to the submarine cables SEACOM and EASSy.

The Information Technology Innovation Centre (kLab) was established in 2012. It has been conceived as a place where young software developers and recent university graduates from computer science and engineering programmes can come to work on their entrepreneurial projects. This technology incubator partners with universities, research centres and private companies to provide mentoring for innovative start-ups, helping them to acquire business skills and transfer technology. Since its inception, kLab has been supported by the Rwanda Development Board.

In 2012, Rwanda constructed a state-of-the-art data-hosting facility for public and private institutions, the National Data Centre. A Health Management Information System (TRACnet) has also been deployed since 2005 to increase the efficiency of Rwanda's HIV and AIDS programme and enhance the quality of patient care country-wide.

The government is currently developing an ICT park in Kigali, in partnership with Carnegie Mellon University and the AfDB, for a total investment of US$ 150 million. The park will support growth of the following clusters: energy; internet, multimedia and mobile telecommunications; knowledge; e-government; finance; and ICT services and exports.

Towards more scientists and engineers with better skills

In 2012, Carnegie Mellon University in Rwanda was established as a regional centre of excellence in ICTs. It is the first US research institution to offer degrees in Africa through an in-country presence. The government decided to partner with this leading private research university in the USA, in order to produce ICT engineers and leaders who understand the balance between technology, business and innovation to meet the needs of industry.

Rwanda had only 11.8 articles per million inhabitants indexed in the Web of Science in 2014 (Figure 19.8). In September 2013, parliament passed a law establishing the University of Rwanda as an autonomous academic research institution. This large university is the product of the merger of seven public institutions of higher learning into a single university. The philosophy behind creating the University of Rwanda was to produce better-trained graduates and to strengthen the research capacity of Rwanda's higher education system. The University of Rwanda has already entered into an agreement with the Swedish International Development Agency to produce 1 500 PhDs between 2012 and 2022.

In October 2013, UNESCO's Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste (Italy) established a branch in Rwanda. Hosted by the College of Science and Technology at the University of Rwanda, ICTP Rwanda aims to increase the number of scientists graduating at master's and PhD levels in strategic areas of science, technology, engineering and mathematics. In 2012, the government adopted a policy of allocating 70% of university scholarships to students enrolled in S&T fields to increase the number of graduates. Moreover, through the Presidential Scholarship Programme established in 2006, pupils from science streams who excel in their secondary schooling get the chance to study in the USA in science or engineering. In 2013, two-thirds of graduates at bachelor level

Table 19.6: **University graduates in Rwanda, 2012/2013**

	Bachelor's		Master's		PhD	
	Male	Female	Male	Female	Male	Female
Education	763	409	3	3	0	0
Humanities and arts	187	60	0	0	1	0
Social sciences, business and law	3 339	3 590	261	204	0	0
Science	364	204	1	6	0	0
Engineering, manufacturing and construction	462	205	39	11	0	0
Agriculture	369	196	0	0	0	0
Health and welfare	125	211	5	4	0	0
Services	171	292	0	0	0	0
TOTAL	**5 780**	**5 167**	**309**	**228**	**1**	**0**

Source: Government of Rwanda

obtained their degree in social sciences, business and law, compared to 19% in S&T fields: 6% in engineering, 5% each in science and agriculture and 3% in health and welfare. Among graduates in S&T fields, engineering students were the most likely to enrol in a master's programme (Table 19.6).

Schemes to boost innovation and a green economy

The Rwanda Innovation Endowment Fund was established in 2012 by the Ministry of Education, in partnership with UNECA. The fund supports R&D to develop innovative market-oriented products and processes in three priority sectors of the economy: manufacturing, agriculture and ICTs. For the initial phase, seed funding of US$ 650 000 was provided: US$ 500 000 by the government and the remainder by UNECA. The first call for project proposals drew 370 applications, leading to the selection of just eight projects, which each received about US$ 50 000 in May 2013. After this proof of concept, it was decided to conduct a second round which is expected to fund ten inventions by March 2015.

In January 2013, the Ministry of Education established the Knowledge Transfer Partnership programme, in collaboration with the AfDB to foster industrial development. So far, the programme has sponsored five partnerships between private companies and the University of Rwanda's two Colleges of Science and Technology and Agriculture and Veterinary Medicine. The company contributes its idea for product or service development and the university provides the appropriate expertise.

In September 2008, Rwanda banned plastic bags. The law prohibits the manufacture, usage, importation and sale of polythene bags in Rwanda. These have been replaced by biodegradable bags made from materials such as cotton, banana and papyrus.

In parallel, the government introduced a National Fund for Environment and Climate Change in Rwanda (FONERWA), which acts as a cross-sectorial financing mechanism to further Rwanda's objectives of green and resilient growth within the *National Green Growth and Climate Resilience Strategy*. For instance, FONERWA is involved in identifying funding for the pilot 'green city' to be launched by 2018.

FONERWA's most recent (sixth) call for proposals resulted in 14 projects receiving funding; these had been put forward by private companies, NGOs, Rwandan districts and the Ministry of Infrastructure. The projects include the provision of solar power to off-the-grid communities, the construction of microhydropower plants, rainwater harvesting and re-use and gardening for urban poor in developed marshlands of Kigali.

SOMALIA

A first innovation hub

Somalia is in the process of state- and peacebuilding. In the run-up to elections in 2016, it is developing a constitution with key provisions on power- and resource-sharing. The government is also pursuing the development of federalism by building the capacity of interim regional administrations and establishing such bodies where none exists. The government has also recently applied to become a member of the EAC.

The Al-Shabaab group continues to terrorize the population in parts of the country under its control. About 730 000 Somalis face acute food insecurity, the vast majority of them internally displaced people. Some 203 000 children require emergency nutrition, mainly due to lack of access to clean water, sanitation infrastructure and better hygiene, according to the United Nations Humanitarian Co-ordinator for Somalia, Philippe Lazzarini, in January 2015.

Agriculture is the mainstay of Somalia's largely informal economy, accounting for about 60% of GDP and employing two-thirds of the labour force. The country continues to rely heavily on international aid and remittances, as well as imports of food, fuel, construction materials and manufactured goods. The more stable parts of the country can nevertheless boast of a vibrant private sector, including as concerns the provision of such vital services as finance, water and electricity.

Somalia's first innovation hub was established in 2012. Somaliland provides mobile and internet services and fosters social enterprise incubation and social and disruptive innovation (see glossary, p. 738), accompanied by training. The hub was set up by Reconstructed Living Lab, a registered social enterprise based in South Africa, with its partner Extended Bits and funding from the Indigo Trust, a UK-based foundation.

SOUTH SUDAN

Priorities: raising education and R&D spending

The world's youngest nation and Africa's 55th country, South Sudan gained independence after seceding from Sudan in July 2011. Its economy is highly dependent on oil, which generates about 98% of government revenue. Part of this revenue goes towards paying Sudan for the right to use its pipelines to transport oil to the sea for export.

With the economy suffering from a dearth of skilled human resources in all the key sectors, education is a government priority. The Education Act (2012) states that 'primary education shall be free and compulsory to all citizens in South

Sudan without discrimination.' The government's education plan is placing emphasis on teachers and on raising public expenditure on education to improve access and learning outcomes. South Sudan has the second-highest rate of population growth in sub-Saharan Africa after Niger (3.84%, see Table 19.1) and there is a big discrepancy in access to primary education: whereas there is universal primary education for boys, the gross enrolment ratio for girls was just 68% in 2011.

Tertiary education in South Sudan is provided by five government-sponsored universities and more than 35 private tertiary institutions. An estimated 20 000 students were enrolled in the country's universities in 2011, according to data from various universities; these data also indicate that enrolment is higher in social sciences and humanities than in S&T fields. The S&T-based faculties are particularly affected by a shortage of teaching staff.

The Ministry of Higher Education, Science and Technology has six directorates, including the Directorate of Technical and Technological Innovation (DTTI). The latter is a programme unit supporting the modernization of South Sudan through investment in technical education and the generation and transfer of technology. DTTI is composed of two departments covering technology and entrepreneurship. Whereas the former is responsible for developing technology policies and managing S&T-based institutions and programmes, the latter is responsible for establishing and managing institutions offering technical, vocational and entrepreneurial training and for laying the foundations for cottage industries. There are no official government statistics available on R&D but the government has expressed the intention of raising spending on research, with emphasis on applied sciences to improve living standards.

UGANDA

Sustainability at the heart of STI policy

The overarching arm of the *National Science, Technology and Innovation Policy* (2009) is to 'strengthen national capability to generate, transfer and apply scientific knowledge, skills and technologies that ensure sustainable utilisation of natural resources for the realisation of Uganda's development objectives.'

The policy precedes *Uganda Vision 2040*, which was launched in April 2013 to transform 'Ugandan society from a peasant to a modern and prosperous country within 30 years,' in the words of the Cabinet. *Uganda Vision 2040* vows to strengthen the private sector, improve education and training, modernize infrastructure and the underdeveloped services and agriculture sectors, foster industrialization and promote good governance, among other goals. Potential areas for economic development include oil and gas, tourism, minerals and ICTs.

A Millennium Science Initiative and innovation fund

The National Council for Science and Technology (NCST) falls under the Ministry of Finance, Planning and Economic Development. The council's strategic objectives include: the rationalization of S&T policy to boost technological innovation; enhancing the national system of research, intellectual property, product development and technology transfer; strengthening public acceptance of science and technology; and upgrading institutional research capacity.

In 2007, the NCST launched the Millennium Science Initiative (2007–2013), which was co-financed by the World Bank. At a time when the economy's formal sector was expanding rapidly and real investment was rising sharply, the NCST considered that continued economic progress would require more and better use of knowledge and more and better qualified human resources for science and technology.[10] The NCST identified the following shortcomings in higher education:

- Very few science degree programmes exist; enrolment in basic sciences is negligible. Laboratories are generally scarce, under-equipped and obsolete.
- Very limited funding exists for capital or recurrent expenses for S&T training; almost all research funding comes from external (donor) sources, making it unsustainable and difficult to ensure a national research for development-driven agenda.
- Despite the burgeoning enrolment, very little systematic attention is being paid to the development of domestic graduate education. Fewer than 500 professors in the entire country have PhDs and fewer than 10 new PhDs are awarded annually in sciences and engineering.
- Fee policies and lack of adequate S&T infrastructure encourage the expansion of undergraduate programmes in arts and humanities, resulting in a dwindling intake for S&T courses and a general lack of interest in, and focus on, S&T.
- The universities and the general tertiary system, be it public or private, lack strategies to improve conditions for research.

To correct these shortcomings, the Millennium Science Initiative incorporated the following components:

- A funding facility provided competitive grants through three windows: top-end research involving both senior researchers and graduate students; the creation of undergraduate programmes in basic science and engineering; and, thirdly, support for co-operation with the private sector, which consisted in company internships for students and grants for technology platforms through

10. see: www.uncst.go.ug/epublications/msi_pip/intro.htm

which firms and researchers could collaborate on solving problems of direct interest to industry.

- An Outreach Programme proposed a series of school visits by top scientists and researchers to change negative perceptions that deterred Ugandans from pursuing careers in science. A National Science Week was also established. In parallel, this second component sought to strengthen the institutional capacity of the NCST and Uganda Industrial Research Institute and, more generally, to improve policy implementation, evaluation and monitoring.

In July 2010, the Presidential Initiative on Science and Technology offered a further boost by creating a fund to foster innovation at Makerere University over the next five years (Box 19.6).

Thriving innovation hubs

The Uganda Investment Authority is a parastatal agency that works in conjunction with the government to facilitate private sector investment. One of the authority's most flourishing sectors is ICTs. This sector has seen major investment in recent years to develop Uganda's backbone infrastructure network, which is comprised of fibre-optic cables and related equipment, as well as mobile broadband infrastructure.

Uganda has a thriving innovation hub named Hive Colab, which was launched in 2010 by AfriLabs and is headed by Barbara Birungi. It serves as a collaborative space to facilitate interaction among technology entrepreneurs, web and mobile app developers, designers, investors, venture capitalists and donors. Hive Colab provides facilities, support and advice to members to help them launch successful start-up enterprises. The hub offers a virtual incubation platform that is intended to assist entrepreneurial activity, particularly in rural areas. Its three programme focus areas are ICTs and mobile technologies, climate technologies and agribusiness innovation.

Another incubator, the Consortium for enhancing University Responsiveness to Agribusiness Development Limited (CURAD), is a public–private partnership which targets young innovators in the agribusiness sector with the goal of generating new enterprises and employment. This non-profit company was launched in May 2014 and is based at Makerere University.

In September 2013, the government launched a Business Process Outsourcing Incubation Centre at the Uganda Bureau of Statistics House (Biztech Africa, 2013). The facility can accommodate 250 agents and is run by three private companies. The Government of Uganda has targeted this industry to address youth unemployment and stimulate investment in information-technology-enabled services Business incubation and STI research are also promoted by the Uganda Industrial Research Institute.

Two annual prizes have also incentivized innovation in Uganda. Each year since 2012, Orange Uganda, a division

Box 19.6: The Presidential Innovations Fund in Uganda

When President Museveni visited Makerere University in December 2009, he noticed that many undergraduate students had produced interesting prototypes of machines and implements and that PhD students and senior researchers were working on inventions with potential for transforming rural Ugandan society but that innovation was being held back by the lack of modern research and teaching laboratories.

After the visit, he decided to create a Presidential Innovations Fund endowed with UGX 25 billion (*circa* US$ 8.5 million) over five years to support innovation-related projects at the university's College of Engineering, Art, Design and Technology.

The fund became operational in July 2010. It covered the cost of modernizing laboratories and the implementation of ten projects at the university. It also financed undergraduate science and engineering programmes, academia–private sector partnerships, student internships, science policy formulation and science popularization in schools and communities.

By 2014, the projects had developed:

- an academic records management system;
- more than 30 internet laboratories (ilabs) in the Department of Electrical and Computer Engineering;
- a business incubator, the Centre for Technology Design and Development;
- a Centre for Renewable Energy and Energy Conservation;
- more than 30 innovation clusters for metal, salt, coffee, milk, pineapple, etc.;
- appropriate irrigation;
- a vehicle design project (the Kiira EV car), which evolved into the Centre for Research in Transportation Technologies;
- makapads, the only sanitary wear for women in Africa made from natural materials (papyrus and paper), including for maternity use;
- a Community Wireless Resource Centre.

Source: http://cedat.mak.ac.ug/research/presidential-initiative-project.html

of France Telecom, has sponsored the Community Innovations Awards, a competition for mobile apps that encourages university students to innovate in the areas of agriculture, health and education. Since 2010, the Uganda Communications Commission has also organized the Annual Communications Innovation Awards, which reward excellence in ICT innovation that contributes to national development goals. The prizes are awarded in several categories, including digital content, ICT for development, service excellence, business excellence and young ICT innovators.

A rise in researchers and R&D spending

Uganda provides quite detailed data on research, making it possible to monitor progress. R&D funding climbed between 2008 and 2010 from 0.33% to 0.48% of GDP. The business enterprise sector's share of R&D funding progressed from 4.3% to 13.7% over this period and spending on engineering from 9.8% to 12.2%, to the detriment of agricultural R&D, which appears to have shrunk from 53.6% to 16.7% of total spending, according to the UNESCO Institute for Statistics.

The number of researchers has climbed steadily over the past decade, even doubling between 2008 and 2010 in head counts from 1 387 to 2 823, according to the UNESCO Institute for Statistics. This represents a leap from 44 to 83 researchers per million inhabitants. One in four researchers is a woman (Figure 19.3).

Enrolment in higher education rose from 93 000 to 140 000 between 2006 and 2011, in a context of strong population growth of 3.3% per year. In 2011, 4.4% of young Ugandans were enrolled at university (Tables 19.1, 19.3 and 19.4).

The number of scientific publications tripled between 2005 and 2014 but research remains focused on life sciences (Figure 19.8). In 2014, the Uganda Industrial Research Institute was selected for a programme which is developing centres of excellence in biomedical sciences (Box 19.2). Interestingly, Kenya and South Africa count among Uganda's top five research partners (Figure 19.8).

CONCLUSION

Social and environmental innovation emerging priorities

The period since 2009 has witnessed a considerable gain in interest for STI in East and Central Africa. Most countries have based their long-term planning ('vision') documents on harnessing STI to development. Most governments are perfectly cognizant of the need to seize the opportunity of sustained growth to modernize and industrialize, in order to participate effectively in a rapidly evolving world economy and ensure sustainability. They know that infrastructure development, better health care, food, water and energy security and economic diversification will require a critical mass of scientists, engineers and medical staff who are currently in short supply. These planning documents tend to reflect a common vision for the future: a prosperous middle-income country (or higher) characterized by good governance, inclusive growth and sustainable development.

Governments are increasingly looking for investors rather than donors. Conscious of the importance of a strong private sector to drive investment and innovation for socio-economic development, governments are devising schemes to support local businesses. As we have seen, the fund developed by Rwanda to foster a green economy provides competitive funds to successful public and private applicants. In Kenya, the Nairobi Industrial and Technology Park is being developed within a joint venture with a public institution, Jomo Kenyatta University of Agriculture and Technology.

In the past few years, governments have witnessed the economic spin-offs from the first technology incubators in Kenya, which have been incredibly successful in helping start-ups capture markets in information technology, in particular. Many governments are now investing in this dynamic sector, including those of Rwanda and Uganda. Spending on R&D is on the rise in most countries with innovation hubs, driven by greater investment by both the public and private sectors.

Most of the social innovation observed in East and Central Africa since 2009 tackles pressing development issues: overcoming food insecurity, mitigating climate change, the transition to renewable energy, reducing disaster risk and extending medical services. The leading technological breakthrough in the region (the MPesa payment service via a mobile phone) had been designed to bridge the rural–urban divide in access to banking services, addressing the financial needs of the poor masses at the bottom of the pyramid. This technology has since permeated virtually all sectors of the East African economy, mobile payments having become a common feature of banking services.

We have seen that both pan-African and regional bodies are themselves now convinced that STI is one of the keys to

the continent's development. This is illustrated by the prizes for science and innovation offered by the African Union Commission and COMESA, for instance, and by the programme launched in 2014 by the African Development Bank to develop five centres of excellence in biomedical sciences.

The sources of East and Central Africa's heightened interest in STI are multiple but the global financial crisis of 2008–2009 certainly played a role. It boosted commodity prices and focused attention on beneficiation policies in Africa. The global crisis also provoked a reversal in brain drain, as visions of Europe and North America struggling with low growth rates and high unemployment discouraged emigration and encouraged some to return home. Returnees are today playing a key role in STI policy formulation, economic development and innovation. Even those who remain abroad are contributing: remittances are now overtaking FDI inflows to Africa.

The focus on sustainable development is a fairly new trend. The commodities boom in recent years has brought home to governments that they are sitting on a gold mine – literally, in some cases. Growing foreign interest in the natural endowments of countries such as Burundi, Cameroon, Gabon and Rwanda has made them increasingly conscious of the need to preserve their rare and valuable ecosystems to ensure their own sustainable development.

With 1 billion potential consumers across the continent, one key challenge will be to remove the barriers to intraregional and pan-African trade. An important step forward in this regard would be an overhaul of immigration laws within Africa. Currently, it is much easier for an average British or American citizen, for instance, to travel across Africa than for the average African. Reducing immigration requirements for Africans within Africa would considerably enhance the mobility of skilled personnel and knowledge spillovers.

By modernizing infrastructure, developing manufacturing and value addition, improving the business climate and removing barriers to pan-African trade, countries should be in a position to develop the local industries and jobs they will need to employ their rapidly growing populations. Greater regional integration will not only foster socio-economic development but also better governance and political stability, such as by favouring the multilateral resolution of disputes through dialogue, whenever possible, and through military means whenever unavoidable. The current co-operation between Cameroon, Chad, Niger and Nigeria to combat the Boko Haram terrorist sect illustrates this new paradigm of intra-regional co-operation. Another example is the EAC's decision to send a contingent of medical personnel to West Africa in October 2014 to help combat the Ebola epidemic.

KEY TARGETS FOR CENTRAL AND EAST AFRICA

- Raise GERD to 1% of GDP in countries of the region;
- Raise GERD in Kenya from 0.98% (2009) to 2% of GDP by 2014;
- Countries that signed the *Maputo Declaration* are to devote at least 10% of GDP to agriculture;
- Raise the proportion of Ethiopian women university students to 40%;
- Establish four technical secondary schools to raise the share of Gabonese pupils benefiting from this type of education from 8% to 20% by 2025;
- Raise the share of hydropower in Gabon's electricity matrix from 40% in 2010 to 80% by 2020;
- Establish a Green City of Education and Knowledge in Gabon by 2030, as well as a research fund and information technology park;
- Raise the amount of credit available to the private sector in Rwanda to 30% of GDP by 2018;
- Launch a pilot green city in Rwanda by 2018.

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