

Countries have made a big effort in recent years to expand their university and research networks; these must be nurtured.

**George Essegbey, Nouhou Diaby
and Almamy Konte**

Children washing their hands before eating a prepared meal at the Hope Kindergarten Elementary School in Buchanan City, Liberia, in June 2015, following the Ebola epidemic.
Photo: © Dominic Chavez/World Bank

18 · West Africa

Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo

George Essegbey, Nouhou Diaby and Almamy Konte

INTRODUCTION

A drive to achieve middle-income status by 2030

Most West African countries are striving to achieve lower or upper middle-income status¹ within the next 15 years. This goal is enshrined in the current development plans and economic policies of Côte d'Ivoire, Gambia, Ghana, Liberia, Mali, Senegal and Togo, for instance. Nigeria even plans to join the world's top 20 economies by 2020. Yet, for two-thirds of West African countries, middle-income status remains an elusive goal: annual GDP per capita remains below US\$ 1 045 in all of Benin, Burkina Faso, Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Sierra Leone and Togo.

Countries' development plans tend to have three main thrusts: wealth creation, greater social equity and more sustainable development. In their quest for middle-income status, they are giving priority to improving governance

1. Five countries have already achieved lower middle-income status, namely: Cabo Verde, Côte d'Ivoire, Ghana, Nigeria and Senegal. The next step will be upper middle-income status.

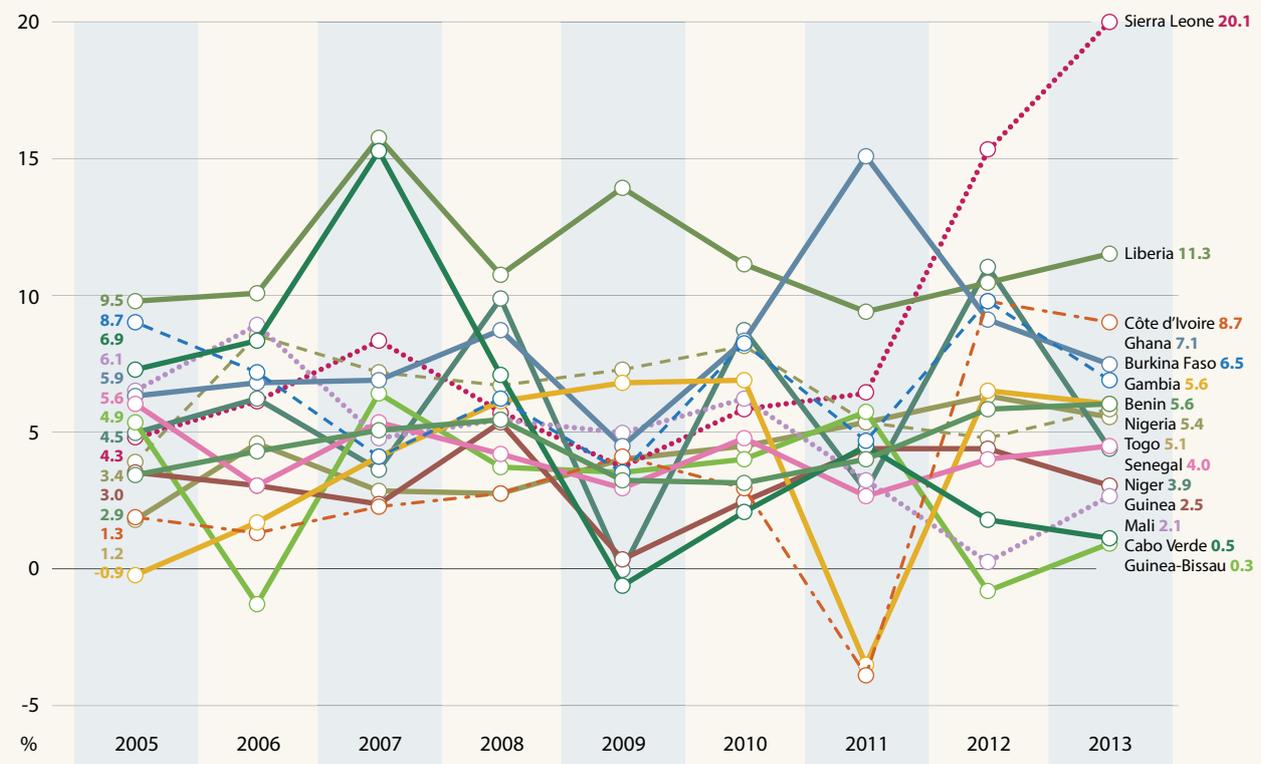
practices, creating a more business-friendly climate, stronger health and agricultural systems, modern infrastructure and a skilled labour force. These plans reflect a desire to exploit the resources which form the backbone of their economies in a more sustainable manner and a determination to diversify and modernize the economy. None of this will be possible without a skilled labour force and recourse to science, technology and innovation (STI).

Strong growth in recent years, despite a series of crises

The Economic Community of West African States (ECOWAS) has experienced strong economic growth in recent years, despite a series of crises.

In Mali, a Tuareg rebellion in January 2012 attempted to establish an independent homeland in the north through an alliance with jihadist groups. The situation has stabilized since the government appealed for French intervention in January 2013 but remains fragile. The conflict caused Mali's economy to shrink by 0.4% in 2012, after six years of sustained growth of 5% on average (Figure 18.1).

Figure 18.1: Economic growth in West Africa, 2005–2013 (%)



Source: World Bank's World Development Indicators, September 2014.

UNESCO SCIENCE REPORT

Guinea-Bissau suffered a military coup d'état in April 2012, prompting the African Union to impose sanctions which were lifted two years later following the election of President José Mario Vaz.

Côte d'Ivoire is still picking up the pieces after its civil war ended with the arrest of the ex-president for war crimes in April 2011. After stagnating for years, Côte d'Ivoire's economy rebounded by 9% in 2013.

Meanwhile, in the north of Africa's most populous country, the Boko Haram sect (literally 'books are forbidden') pursues its reign of terror against the Nigerian population, with growing incursions across the border into Cameroon and Niger. Nigerians can at least rejoice at the smooth handover of power from incumbent president Goodluck Jonathan to his successor Muhammadu Buhari after the election results were announced on 31 March 2015.

Farther north, in Burkina Faso, a popular revolt put an end to the 27-year rule of President Blaise Compaoré on 30 October 2014, after he tried to modify the Constitution in order to run for a fifth term. Former diplomat Michel Kafando has been designated interim president by consensus and charged with organizing a general election in November 2015.

In Guinea, Liberia and Sierra Leone, the Ebola epidemic has been a tragic reminder of the chronic underinvestment in West African health systems. Between March and December 2014, 8 000 people died, a mortality rate of about 40%. There has been a growing tide of solidarity. In September, Cuba dispatched hundreds of doctors and nurses to the afflicted countries. A month later, the East African Community sent its own contingent of 600 health professionals, including 41 doctors, to combat the epidemic. They were joined in early December by 150 volunteer health professionals from Benin, Côte d'Ivoire, Ghana, Mali, Niger and Nigeria, as part of a joint initiative by ECOWAS and its specialized agency, the West African Health Organisation. The European Union, African Union, USA and others have also pitched in with funding and other forms of support. The year before Ebola struck, Liberia and Sierra Leone had experienced remarkable growth of 11% and 20% respectively. Ebola could set these fragile economies back years (Figure 18.1).

Structural weaknesses masked by strong growth

Despite these crises, the ECOWAS Commission is optimistic about the subregion's prospects for growth. It projects an even better performance in 2014 (7.1% growth) than in 2013 (6.3%). This high growth rate nevertheless conceals serious structural weaknesses. For decades, West African economies have relied almost entirely on revenue from raw commodities: about 95% of Nigeria's export revenue is derived from crude oil and natural gas; gold and cocoa alone account for about

53% of Ghana's exports and nearly three-quarters of Mali's export earnings come from cotton (Figure 18.2). When raw materials are extracted or grown in West Africa but processed on other continents, this deprives the subregion of industries and jobs. Despite this axiom, West African countries have so far failed to diversify their economies and to tap export earnings from value-added and manufactured products.

It is true that some countries have made a start. Côte d'Ivoire, Ghana, Guinea, Nigeria and Senegal, for instance, have industries producing value-added goods. To enhance value addition and strengthen the raw material base of industries, these countries have all set up research institutes to transform raw products into semi-processed or processed goods. Both Ghana and Nigeria have also set up institutes specializing in aeronautics, nuclear energy, chemistry and metallurgy. The first technology parks and cybervillages are emerging in these countries (ECOWAS, 2011a).

Could Ghana fall prey to the 'oil curse'? A recent study by the Institute of Statistical, Social and Economic Research at the University of Ghana ponders whether 'the increased importance of oil in GDP [since petroleum exports began in 2011] signals the risk of Ghana becoming oil-dependent. [...] The advent of oil production seems to be changing the pattern of the country's exports,' the study observes (see Figure 19.1). 'Is Ghana teetering toward an oil-dominant country, or might the proceeds be employed wisely to diversify the economy?' (ISSER, 2014)

Economic diversification hampered by a skills shortage

One handicap to diversifying the economy is the shortage of skilled personnel, including technicians, in fast-growing sectors such as mining, energy, water, manufacturing, infrastructure and telecommunications. The lack of skilled personnel also impinges on the efficiency of national health systems and agriculture.

In this context, the launch of the African Centres of Excellence project in April 2014 by the World Bank comes as a welcome addition to the education matrix. Eight governments² are to receive almost US\$ 150 million in loans to fund research and training at 19 of the subregion's best universities (Table 18.1). The Association of African Universities will be responsible for co-ordination and knowledge-sharing among all 19 universities and has received World Bank funding for the purpose.

For all its virtues, the African Centres of Excellence project cannot be a substitute for national investment. Currently, just three³ West African countries devote more than 1% of

2. Nigeria (US\$ 70 million), Ghana (US\$ 24 million), Senegal (US\$ 16 million), Benin, Burkina Faso, Cameroon and Togo (US\$ 8 million each). Gambia will also receive a US\$ 2 million loan and a US\$ 1 million grant for short-term training.

3. Data are unavailable for Nigeria.

Figure 18.2: Top three export products in Africa, 2012

Algeria – Petroleum & other oils, crude (45.0%), natural gas in gaseous state (20.0%), light oils and preparations (8.7%)

Angola – Petroleum & other oils, crude (96.8%)

Benin – Cotton (19.0%), petroleum oils or bituminous minerals (13.7%), gold (13.4%)

Botswana – Unworked diamonds (74.3%), other non-industrial diamonds (7.2%), gold in semi-manufactured forms (5.4%)

Burkina Faso – Cotton (44.9%), gold in unwrought forms (29.4%), gold in semi-manufactured forms (5.4%)

Burundi – Unroasted coffee (58.0%), black tea (12.2%), niobium, tantalum, vanadium ores & concentrates (9.0%)

Cabo Verde – Mackerel (16.5%), skipjack or striped-bellied bonito (15.4%), yellowfin tunas (14.2%)

Cameroon – Petroleum & other oils, crude (48.1%), cocoa beans (9.0%), tropical woods (7.7%)

Central African Rep. – Unsorted diamonds (32.3%), tropical wood (26.6%), cotton (14.0%)

Chad – Petroleum & other oils, crude & preparations (97.0%)

Comoros – Cloves (56.1%), floating vessels for breaking up (21.2%), essential oils (9.8%)

Congo Rep. – Petroleum & other oils, crude (87.1%)

Congo Dem. Rep. – Cathodes (43.9%), unrefined copper (13.2%), petroleum & other oils, crude (13.2%)

Côte d'Ivoire – Cocoa beans (31.8%), petroleum & other oils, crude (12.3%), natural rubber (7.2%)

Djibouti – Live animals (23.0%), sheep (18.1%), goats (15.6%)

Egypt – Petroleum & other oils, crude (24.0%), liquefied natural gas (11.1%),

Equatorial Guinea – Petroleum & other oils, crude (73.6%), liquefied natural gas (19.8%)

Eritrea – Gold (88.0%), silver (4.9%)

Ethiopia – Unroasted coffee (39.5%), sesame seeds (19.7%), fresh cut flowers (10.2%)

Gabon – Petroleum & other oils, crude (85.4%), manganese ores & concentrates (6.7%)

Gambia – Wood (48.6%), cashew nuts (16.2%), petroleum & other oils (6.5%)

Ghana – Gold (36.0%), cocoa beans and paste (16.5%), petroleum & other oils, crude (22.0%)

Guinea – Gold (40.5%), bauxite (34.0%), alumine (9.0%)

Guinea-Bissau – Cashew nuts (83.9%)

Kenya – Black tea (20.0%), fresh cut flowers (12.1%), unroasted coffee (5.9%)

Lesotho – Diamonds (45.5%), men's/boys' cotton trousers & shorts (13.4%), women's/girls' synthetic trousers & shorts (6.1%)

Liberia – Iron ores & concentrates (21.1%), natural rubber (19.3%), tankers (12.3%)

Libya – Petroleum & other oils, crude (88.4%), natural gas in gaseous state (5.6%)

Madagascar – Cloves (15.8%), shrimps & prawns (7.2%), titanium ores & concentrates (5.5%)

Malawi – Tobacco (50.1%), natural uranium & its compounds (10.4%), raw sugar cane (8.0%)

Mali – Cotton (72.7%), sesame seeds (8.8%)

Mauritania – Iron ores and concentrates (46.7%), copper ores and concentrates (15.6%), octopus (10.5%)

Mauritius – Tunas, skipjack & bonito (15.3%), solid cane or beef sugar (10.5%), cotton t-shirts & the like (7.4%)

Morocco – Phosphoric acid and polyphosphoric (8.2%), ignition wiring sets and other wiring sets of a type used for vehicles, aircrafts, ships (6.1%), diammonium hydrogenorthosphosphate (4.5%)

Mozambique – Aluminium, not alloyed (28.8%), light oils & preparations (12.1%), liquefied natural gas (5.4%)

Namibia – Unworked diamonds (30.1%), unrefined copper (13.4%), natural uranium & its compounds (13.2%)

Niger – Natural uranium & its compounds (62.2%), light oils & preparations (12.1%), live animals (6.0%)

Nigeria – Petroleum & other oils, crude (84.0%), liquefied natural gas (10.8%)

Rwanda – Niobium, tantalum, vanadium ores & concentrates (23.7%), unroasted coffee (23.5%), tin ores & concentrates (19.2%)

Sao Tome & Principe – Cocoa beans (47.6%), wristwatches (9.2%), jewellery (6.4%)

Senegal – Petroleum & other oils (20.8%), inorganic chemical elements, oxides & halogen salts (12.0%), fresh & frozen fish (9.0%)

Seychelles – Tunas, skipjack & bonito (52.5%), bigeye tunas (13.2%), yellowfin tunas (7.1%)

Sierra Leone – Iron ores & concentrates (45.2%), titanium ores & concentrates (16.4%), unworked diamonds (12.1%)

Somalia – Sheep (29.4%), goats (28.2%), live bovine animals (17.3%)

South Africa – Gold (11.6%), iron ores & concentrates (7.6%), platinum (6.6%)

South Sudan – Petroleum & other oils, crude (99.6%)

Sudan – Petroleum & other oils, crude (65.6%), Sheep (10.6%), sesame seeds (4.2%)

Swaziland – Raw sugar cane (17.4%), odoriferous substances used in food & beverages (14.8%), iron ores & concentrates (10.9%)

Tanzania – Precious metal ores & concentrates (11.7%), tobacco (11.5%), unroasted, not decaffeinated coffee (6.6)

Togo – Gold (12.1%), natural calcium phosphates, phosphatic chalk (11.7%), light oils & preparations (10.3%)

Tunisia – Petroleum & other oils, crude (11.2%), ignition wiring sets and other wiring sets of a type used for vehicles, aircrafts, ships (6.2%); men's/boys' cotton trousers and shorts (4.3%)

Uganda – Unroasted, not decaffeinated coffee (30.6%), cotton (5.6%), tobacco (5.5%)

Zambia – Cathodes (47.6%), unrefined copper (26.1%), maize, excl. seed (5.0%)

Zimbabwe – Tobacco (30.8%), ferro-chromium (11.6%), cotton (9.6%)

Note: Data for Ghana are for 2013.

Source: ADB et al. (2014), Table 18.7; for Ghana: calculated for 2013 from ISSER (2014)



UNESCO SCIENCE REPORT

GDP to higher education: Ghana and Senegal (1.4%) and Mali (1.0%). In Liberia, the proportion is even lower than 0.3% (see Table 19.2). Up to now, the priority has been to achieve the Millennium Development Goal of universal primary education by 2015. Low investment in higher education has led to a surge in private universities over the past decade, which now represent more than half of all universities in some countries (ECOWAS, 2011a).

Table 18.1: The African Centres of Excellence Project, 2014

	Centre of excellence	Lead institution
Benin	Applied Mathematics	University of Abomey-Calavi
Burkina Faso	Water, Energy, Environmental Sciences and Technologies	International Institute of Water and Environmental Engineering (2iE)
Cameroon	Information and Communication Technologies	University of Yaoundé
Ghana	Training Plant Breeders, Seed Scientists and Technologists	University of Ghana
	Cell Biology of Infectious Pathogens	University of Ghana
	Water and Environmental Sanitation	Kwame Nkrumah University of Science and Technology
Nigeria	Agricultural Development and Sustainable Environment	Federal University of Agriculture
	Dryland Agriculture	Bayero University
	Oil Field Chemicals	University of Port Harcourt
	Science, Technology and Knowledge	Obafemi Awolowo University
	Food Technology and Research	Benue State University
	Genomics of Infectious Diseases	Redeemers University
	Neglected Tropical Diseases and Forensic Biotechnology	Ahmadu Bello University
	Phytomedicine Research and Development	University of Jos
	Reproductive Health and Innovation	University of Benin, Nigeria
	Materials	African University of Science and Technology
Senegal	Maternal and Infant Health	Cheikh Anta Diop University
	Mathematics, Informatics and Information and Communication Technologies	University of Gaston Berger, St Louis
Togo	Poultry Sciences	University of Lomé

Source: World Bank

Centres of excellence: a problem shared is a problem halved

Most West African scientists currently work in isolation from their peers even within the same country. The World Bank scheme is coherent with *Africa's Science and Technology Consolidated Plan of Action, 2005–2014*, which called for the establishment of regional networks of centres of excellence and for a greater mobility of scientists across the continent.

West Africa is participating in several of these networks. Ouagadougou (Burkina Faso) hosts the African Biosafety Network of Expertise (Box 18.1) and the Senegalese Institute for Agricultural Research in Dakar is one of the four nodes of the pan-African biosciences network (see Box 19.1). In addition, Senegal and Ghana host two of the five African Institutes of Mathematical Sciences (see Box 20.4).

In 2012, the West African Economic and Monetary Union (WAEMU) designated 14 centres of excellence in the region (Table 18.2). This label entitles these institutions to financial support from WAEMU for a two-year period. Within the framework of its *Policy on Science and Technology* (see p. 476), ECOWAS intends to establish several centres of excellence of its own on a competitive basis.

Table 18.2: The WAEMU Centres of Excellence, 2012

	Centre of excellence	City
Burkina Faso	Centre for Research in Biological and Food Science and Nutrition	Ouagadougou
	Higher Institute of Population Sciences	Ouagadougou
	International Centre for Research and Development into Animal Husbandry in Subtropical Zones	Bobo-Dioulasso
	International Institute of Water and Environmental Engineering	Ouagadougou
Côte d'Ivoire	National School of Statistics and Applied Economics	Abidjan
Mali	West African Network of Education Research	Bamako
Niger	Regional Centre for Training and Applications in Agro-meteorology and Operational Hydrology	Niamey
	Regional Specialized Teaching Centre in Agriculture	Niamey
Senegal	African Centre for Higher Management Studies	Dakar
	Multinational Higher School of Telecommunications	Dakar
	School of Veterinary Science and Medicine	Dakar
	Africa Rice Centre	Saint-Louis
	Higher Institute of Management	Dakar
Togo	African School of Architecture and Urban Planning	Lomé

Source: WAEMU

Box 18.1: The African Biosafety Network of Expertise

The African Biosafety Network of Expertise was established in Ouagadougou on 23 February 2010 with the signing of a host agreement between NEPAD and the Government of Burkina Faso. The network serves as a resource for regulators dealing with safety issues related to the introduction and development of genetically modified organisms. In addition to providing regulators with access to policy briefs and other relevant information online in English and French, the network organizes national and subregional workshops on specific topics.

For instance, one-week biosafety courses for African regulators were run by the network in Burkina Faso in November 2013 and in Uganda in July 2014, in partnership with the University of Michigan (USA). Twenty-two regulators from Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda and Zimbabwe took part in the latter course.

In April 2014, the network ran a training workshop in Nigeria at the request of the Federal Ministry of Environment for 44 participants drawn from government ministries, regulatory agencies, universities and research institutions. The aim was to strengthen the regulatory capacity of institutional biosafety committees. This training was considered important to ensure continued regulatory compliance for ongoing confined field trials and multilocation trials for Maruca-resistant cowpea and biofortified sorghum. The workshop was run in partnership with the International Food Policy Research Institute's Program for Biosafety Systems.

From 28 April to 2 May 2014, Togo's Ministry of Environment and Forest Resources organized a stakeholders'

consultative workshop to validate Togo's revised biosafety law. Around 60 participants took part, including government officials, researchers, lawyers, biosafety regulators and civil society representatives; the workshop was chaired by a member of the National Biosafety Committee. The aim of the draft bill was to align Togo's biosafety law signed in January 2009 with international biosafety regulations and best practices, especially the *Nagoya Kuala Lumpur Supplementary Protocol on Liability and Redress* that Togo had signed in September 2011. The validation workshop was a critical step before the new bill could be tabled at the National Assembly for adoption later that year.

In June 2014, the network organized a four-day study tour to South Africa for ten regulators and policy-makers from Burkina Faso, Ethiopia, Kenya, Malawi,

Mozambique and Zimbabwe. The main objective was to allow them to interact directly with their peers and industrial practitioners in South Africa. The study tour was organized under the auspices of the NEPAD Planning and Coordinating Agency, in partnership with the Southern Africa Network for Biosciences (SANBio), see Box 19.1).

The African Biosafety Network of Expertise was conceptualized in *Africa's Science and Technology Consolidated Plan of Action* (2005) and fulfils the recommendation of the High-Level African Panel on Modern Biotechnology, entitled *Freedom to Innovate* (Juma and Serageldin, 2007). The network is funded by the Bill and Melinda Gates Foundation.

Source: www.nepadbiosafety.net



A REGIONAL VISION FOR SCIENCE AND TECHNOLOGY

A roadmap for more effective development

Regional integration can help accelerate development in West Africa. The *Vision 2020* document⁴ adopted by ECOWAS member states in 2011 is consistent with the continent's long-term objective of creating an African Economic Community (Box 18.2). *Vision 2020* aspires to 'create a borderless, prosperous and cohesive region built on good governance and where people have the capacity to access and harness its enormous resources through the creation of opportunities for sustainable development and environmental preservation... We envision, by 2020, an environment in which the private sector will be the primary engine of growth and development' (ECOWAS, 2011b).

Vision 2020 proposes a road map for improving governance, accelerating economic and monetary integration and fostering public-private partnerships. It endorses the planned harmonization of investment laws in West Africa and suggests pursuing 'with vigour' the creation of a regional investment promotion agency. Countries are urged to promote efficient, viable small and medium-sized enterprises (SMEs) and to expose traditional agriculture to modern technology, entrepreneurship and innovation, in order to improve productivity.

The agriculture sector suffers from chronic underinvestment in West Africa. Only Burkina Faso, Mali, Niger and Senegal have so far raised public expenditure to 10% of GDP, the target fixed by the *Maputo Declaration* (2003). Gambia, Ghana and Togo are on the threshold of reaching this target. Nigeria devotes 6% of GDP to agriculture and the remaining West African countries less than 5% (see Table 19.2).

Other underdeveloped areas are the water, sanitation and electricity sectors, which hold potential for public-private partnerships. The situation is most urgent in Benin, Ghana, Guinea and Niger, where less than 10% of the population enjoys improved sanitation. Although people have greater access to clean water than to sanitation, this basic commodity still eludes more than half of the population in most countries. Access to electricity varies widely, from 13% in Burkina Faso to 72% in Ghana (see Table 19.1).

Internet penetration has been excruciatingly slow in West Africa, contrary to mobile phone subscriptions. As of 2013, 5% of the population or less had access to internet in Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Liberia, Mali, Niger, Sierra Leone and Togo. Only Cabo Verde and Nigeria could provide one in three citizens with internet connections (see Table 19.1).

A framework for co-ordinating the region's STI policies

Why has the research sector had so little impact on technological progress in West Africa? Apart from obvious factors like underinvestment, this situation has resulted from the relatively low political commitment to STI on the part of individual countries. There is a lack of:

- national research and innovation strategies or policies with a clear definition of measurable targets and the role to be played by each stakeholder;
- involvement by private companies in the process of defining national research needs, priorities and programmes; and
- institutions devoted to innovation that can make the link between research and development (R&D).

The low impact of science and technology (S&T) in West Africa has also resulted from the differences in education systems, the lack of convergence among research programmes and the low level of exchanges and collaboration between universities and research institutions. The centres of excellence cited earlier should help to foster collaboration and the dissemination of research results, as well as a greater convergence among research programmes. In education, the three-tiered degree system (bachelor's -master's-PhD) has now been generalized to most West African countries. In the case of WAEMU countries, this is largely thanks to the Support to Higher Education, Science and Technology Project, funded by a grant from the African Development Bank. Between 2008 and 2014, WAEMU invested US\$ 36 million in this reform.

The *ECOWAS Policy on Science and Technology* (ECOPOST) is the logical next step. Adopted in 2011, it is an integral part of *Vision 2020*. ECOPOST provides a framework for member states wishing to improve – or elaborate for the first time – their own national policies and action plans for STI. Importantly, ECOPOST includes a mechanism for monitoring and evaluating the policy's implementation, an aspect often overlooked. Nor does it neglect funding. It proposes creating a solidarity fund which would be managed by a directorate within ECOWAS to help countries fund investment in key institutions and improve education and training; the fund would also be used to attract foreign direct investment (FDI). As of early 2015, the fund had not yet been established.

The regional policy advocates the development of a science culture in all sectors of society, including through science popularization, the dissemination of research results in local and international journals, the commercialization of research results, greater technology transfer, intellectual property protection, stronger university-industry ties and the enhancement of traditional knowledge.

4. See the ECOWAS Community Development Programme: www.cdp-pcd.ecowas.int

Box 18.2: An African Economic Community by 2028

The Abuja Treaty (1991) established a calendar for creating an African Economic Community by 2028. The first step was to establish regional economic communities in parts of Africa where these were still lacking. The next target is to establish a free trade area and customs union in each regional economic community by 2017 then across the entire continent by 2019. A continent-wide African Common Market is to become operational in 2023. The last stage will consist in establishing a continent-wide economic and monetary union and parliament by 2028, with a single currency to be managed by the African Central Bank.

The six regional pillars of the future African Economic Community are the following regional communities:

- Economic Community of West African States (ECOWAS): 15 states, population of *circa* 300 million;
- Economic Community of Central African States (ECCAS), 11 states, population of *circa* 121 million;
- Southern African Development Community (SADC), 15 states, population of *circa* 233 million;
- East African Community (EAC), 5 states, population of *circa* 125 million;

- Common Market for Eastern and Southern Africa (COMESA), 20 states, population of *circa* 406 million;
- Intergovernmental Authority on Development (IGAD), 8 states, population of *circa* 188 million.

Some countries belong to more than one economic community, creating overlap (see Annex 1 for the membership of these regional blocs). Kenya, for instance, is a member of COMESA, EAC and IGAD. There are also smaller regional blocs. One example is the West African Economic and Monetary Union grouping Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo.

ECOWAS has launched a common passport to facilitate travel and finance ministers agreed in 2013 to launch a Common External Tariff in 2015 to discourage wide price differentials and smuggling across the region.

In 2000, nine COMESA members formed a free trade area: Djibouti, Egypt, Kenya, Madagascar, Malawi, Mauritius, Sudan, Zambia and Zimbabwe. They were later joined by Burundi and Rwanda (2004), Comoros and Libya (2006) and by the Seychelles in 2009. In 2008, COMESA agreed to expand its free-trade zone to include EAC and SADC members. The COMESA–EAC–SADC Tripartite Free

Trade Agreement was signed on 10 June 2015 in Sharm-El-Sheikh (Egypt).

On 1 July 2010, the five EAC members formed a common market grouping Burundi, Kenya, Rwanda, Tanzania and Uganda. 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. The region is also investing in a standard gauge regional rail, roads, energy and port infrastructure to strengthen links to Mombasa and Dar es Salaam. Intra-EAC trade grew by 22% in 2012 over the previous year. On 30 November 2013, the EAC countries signed a Monetary Union Protocol with the aim of establishing a common currency within 10 years.

Pending the single African currency, 14 countries currently use the West African CFA and Central African CFA currency (in place since 1945), which is indexed on the euro managed by the European Central Bank. The indexation of the CFA on a strong currency favours imports over exports. Five countries currently use the South African Rand: Lesotho, Namibia, South Africa, Swaziland and Zimbabwe.

Source: AfDB et al. (2014); other information compiled by authors

ECOPOST encourages countries *inter alia* to:

- raise gross domestic expenditure on R&D (GERD) to 1% of GDP, as recommended by the African Union a decade ago; currently, it averages 0.3% in West Africa;
- define their own research priorities, so that researchers are working on topics of national interest rather than those proposed by donors;
- create a national S&T fund which would allocate funds to research projects on a competitive basis;
- establish science and innovation prizes;
- define a harmonized regional status for researchers;
- put in place a national fund for local innovators which would also help them protect their intellectual property rights;
- adapt university curricula to local industrial needs;
- develop small research and training units in key industrial fields, such as lasers, fibre optics, biotechnology, composite materials and pharmaceuticals;
- equip research laboratories, including with ICTs;

UNESCO SCIENCE REPORT

- establish science and technology parks and business incubators;
- help companies specializing in electronics to set up business in their country and develop the use of satellites and remote sensing for telecommunications, environmental monitoring, climatology, meteorology, etc.;
- develop a national capacity to manufacture computer hardware and design software;
- facilitate the spread of modern IT infrastructure to foster teaching, training and research;
- incite the private sector to finance research and technology through tax incentives and related measures;
- create networks between universities, research institutions and industry to promote collaboration;
- foster clean, sustainable sources of energy and the development of local construction materials;
- establish national and regional databases on R&D activities.

Countries are also encouraged to work with the ECOWAS Commission to improve data collection. Of the 13 countries which participated in the first phase⁵ of the African Science, Technology and Innovation Indicators Initiative (ASTII), just four from ECOWAS contributed to ASTII's first collection of R&D data for publication in the *African Innovation Outlook* (2011): Ghana, Mali, Nigeria and Senegal (NPCA, 2011).

5. ASTII was launched in 2007 by the African Union's New Partnership for Africa's Development (NEPAD), in order to improve data collection and analysis on R&D.

ECOWAS was barely more visible in the second *African Innovation Outlook*, with just six countries contributing R&D data, out of 19 across the continent: Burkina Faso, Cabo Verde, Ghana, Mali, Senegal and Togo (NPCA, 2014). Nigeria was totally absent and only Ghana and Senegal provided a full set of data for all four performance sectors, which is why they alone feature in Figure 18.5.

Subregional training workshops were organized for countries by ECOWAS in 2013 and 2014 on STI indicators and how to draft research proposals.

ECOWAS has taken other steps recently to tackle the lack of technological impact of the research sector:

- In 2012, the ministers in charge of research adopted the *ECOWAS Research Policy* (ECORP) while meeting in Cotonou;
- In 2011, ECOWAS created the West Africa Institute within a public-private partnership (Box 18.3).

TRENDS IN EDUCATION

Efforts to generalize primary education are paying off

One of West Africa's toughest challenges will be to educate and train young people and develop a highly skilled labour force, particularly in science and engineering. Illiteracy remains a major hurdle to expanding science education: only two out of three young people (62.7%) between the ages of 15 and 24 are literate, with the notable exception of Cabo Verde (98.1%). The proportion of literates is as low as one person in four in Niger (23.5%).

Box 18.3: The West Africa Institute

The West Africa Institute was established in Praia (Cabo Verde) in 2010 to provide the missing link between policy and research in the regional integration process. The institute is a service provider, conducting research for regional and national public institutions, the private sector, civil society and the media. The think tank also organizes political and scientific dialogues between policy-makers, regional institutions and members of civil society.

There are ten research themes: the historical and cultural bases of regional integration; citizenship; governance; regional security; economic challenges

to market integration in West Africa; new ICTs; education; the problem of shared resources (land, water, minerals, coastal and maritime security); funding of NGOs in West Africa; and migration.

The idea for the West Africa Institute emerged from 15 research workshops on the theme of regional integration organized in the ECOWAS member states by UNESCO's Management of Social Transformations programme.

In 2008, the Summit of Heads of State and Government of ECOWAS in Ouagadougou (Burkina Faso) unanimously endorsed the idea to create the West Africa Institute.

In 2009, UNESCO's General Conference established the West Africa Institute as one of its category 2 institutes, which means that it functions under the auspices of UNESCO. A year later, the Government of Cabo Verde passed a law establishing the institute in the capital.

The institute is the fruit of a public-private partnership involving ECOWAS, WAEMU, UNESCO, the pan-African Ecobank and the Government of Cabo Verde.

Source: westafricainstitute.org

The considerable efforts made at the primary level are paying off, with the average enrolment rate having risen from 87.6% to 92.9% between 2004 and 2012 (Table 18.3). According to the *ECOWAS Annual Report (2012)*, enrolment has increased by as much as 20% since 2004 in four countries: Benin, Burkina Faso, Côte d'Ivoire and Niger.

However, in most West African countries, one in three children do not complete the primary cycle. The share is even higher than 50% in Burkina Faso and Niger. In 2012, there were an estimated 17 million children out of school in ECOWAS countries. Although this represents a 3% improvement over the previous decade, this figure pales in comparison to that for sub-Saharan Africa as a whole, where the drop-out rate has fallen by 13%. Cabo Verde and Ghana are the exceptions to the rule, both having a high completion rate (over 90%). Ghana has achieved almost 100% enrolment at primary level, largely thanks to the government's free school meals programme. Five out of six ECOWAS countries reported a higher percentage of qualified primary teachers in 2012 than eight years earlier; especially notable are improvements in Senegal (+15%) and Cabo Verde (+13%).

Table 18.3: Gross enrolment in ECOWAS countries, 2009 and 2012 (%)

Share of population at all levels of education

	Primary (%)		Secondary (%)		Tertiary (%)	
	2009	2012	2009	2012	2009	2012
Benin	114.87	122.77	–	54.16 ⁺¹	9.87	12.37 ¹
Burkina Faso	77.68	84.96	20.30	25.92	3.53	4.56
Cabo Verde	111.06	111.95	85.27	92.74	15.11	20.61
Côte d'Ivoire	79.57	94.22	–	39.08 ⁺¹	9.03	4.46
Gambia	85.15 ⁺¹	85.21	58.84	–	–	–
Ghana	105.53	109.92	58.29	58.19	8.79	12.20
Guinea	84.60	90.83	34.29 ⁺¹	38.13	9.04	9.93
Guinea-Bissau	116.22 ⁺¹	–	–	–	–	–
Liberia	99.64	102.38 ⁺¹	–	45.16 ⁺¹	9.30 ⁺¹	11.64
Mali	89.25	88.48	39.61	44.95 ⁺¹	6.30	7.47
Niger	60.94	71.13	12.12	15.92	1.45	1.75
Nigeria	85.04 ⁺	–	38.90 ⁺	–	–	–
Senegal	84.56	83.79	36.41 ⁺¹	41.00 ⁺¹	8.04	–
Togo	128.23	132.80	43.99 ⁺¹	54.94 ⁺¹	9.12 ⁺¹	10.31

*estimation by UNESCO Institute for Statistics

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

Source: UNESCO Institute for Statistics, May 2015

The challenge now will be to raise the enrolment rate at secondary level from 45.7% in 2011, albeit with marked differences from one country to another: just one in four children from Niger and Burkina Faso attend secondary school, whereas, in Cabo Verde, enrolment has shot up to 92.7% (2012).

To promote girls' education, ECOWAS established the ECOWAS Gender Development Centre in Dakar in 2003. Moreover, ECOWAS provides scholarships for girls from disadvantaged families to enable them to pursue their technical or vocational education. The *ECOWAS Annual Report for 2012* states that the number of girls receiving scholarships in each country had doubled from five to ten or more by 2012 in some countries.

Growing student rolls but universities remain elitist

On average, the gross enrolment rate for tertiary education in West Africa was 9.2% in 2012. Some countries have made impressive progress, such as Cabo Verde between 2009 (15.1%) and 2012 (20.6%). In others, a university education remains elusive: the figures for Niger and Burkina Faso have stagnated at 1.7% and 4.6% of school leavers respectively.

University rolls are rising but this needs placing in a context of strong population⁶ growth. The notable exception is Côte d'Ivoire, where student numbers have been a casualty of the violence and political uncertainty arising from the disputed 2010 election, which prompted the closure of universities and eventually unseated President Gbagbo.

It is difficult to draw conclusions for West Africa as a whole, given the patchy data. The available data nevertheless reveal some interesting trends. For instance, student rolls have surged in recent years in Burkina Faso and Ghana (Table 18.4). Burkina Faso shows the particularity, moreover, of having one of the subregion's highest ratios of PhD students: one in 20 graduates goes on to enroll in a PhD. The number of PhDs in engineering fields remains low: 58 in Burkina Faso and 57 in Ghana in 2012, compared to 36 in Mali and just one in Niger in 2011. Of note is that Ghana is the only country with a critical mass of PhD students in agriculture (132 in 2012), a situation which bodes ill for agricultural development in the subregion. Likewise, Burkina Faso trains a much greater number of PhDs in the field of health than its neighbours; women tend to be most attracted to health sciences: they represent one in three of these PhD candidates in Burkina Faso and Ghana, compared to about one in five in science and engineering (Figure 18.3).

6. The population is growing by more than 3% each year in the Sahelian countries of Mali and Niger and by more than 2.3% in all but Sierra Leone (1.8%) and Cabo Verde (0.95%). See Table 19.1

UNESCO SCIENCE REPORT

Table 18.4: Tertiary enrolment in West Africa, 2007 and 2012 or nearest available year

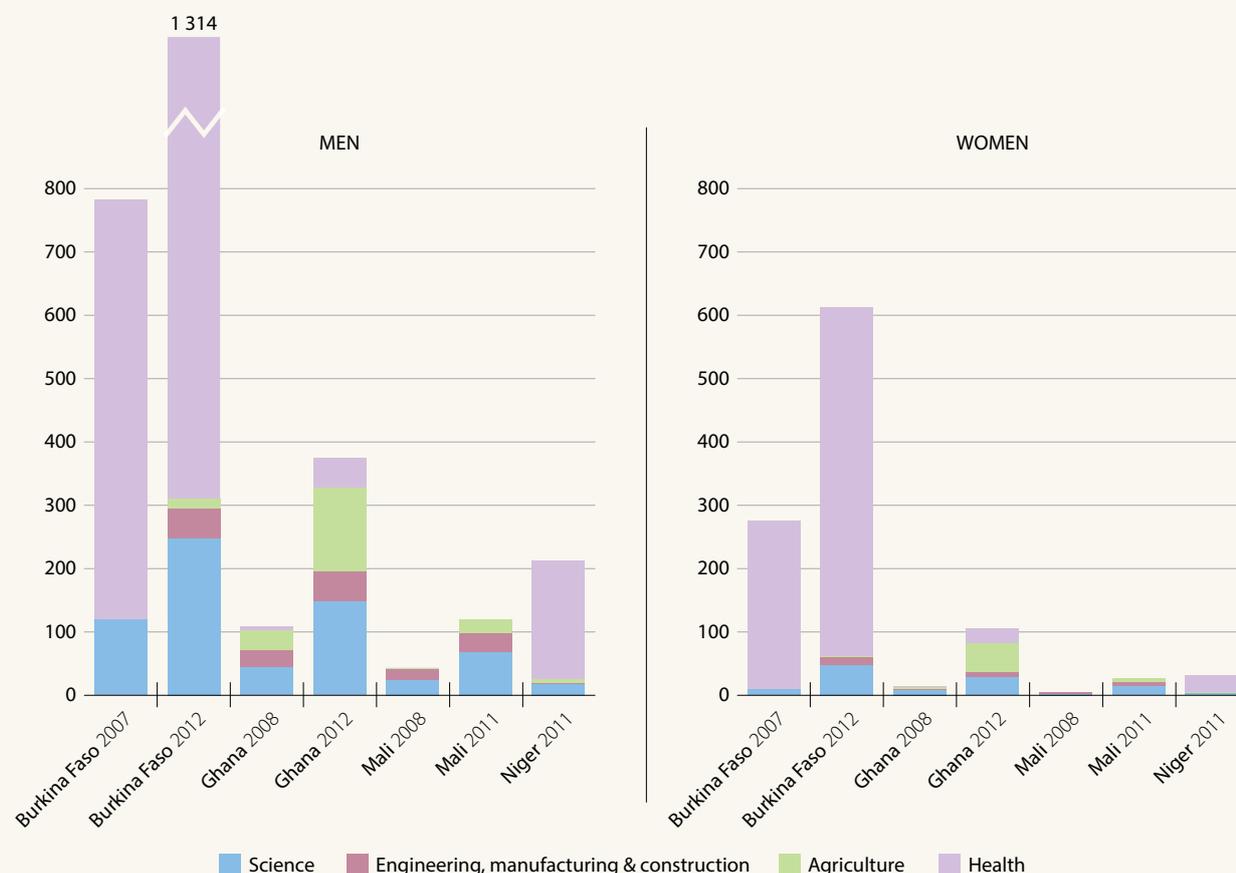
By level and field of study, selected countries

	Total			Science			Engineering, manufacturing and construction			Agriculture			Health		
	Post-secondary	1st & 2nd degree	PHD	Post-secondary	1st & 2nd degree	PHD	Post-secondary	1st & 2nd degree	PHD	Post-secondary	1st & 2nd degree	PHD	Post-secondary	1st & 2nd degree	PHD
Burkina Faso, 2007	7 964	24 259	1 236	735	3 693	128	284	–	0	100	219	2	203	1 892	928
Burkina Faso, 2012	16 801	49 688	2 405	1 307	8 730	296	2 119	303	58	50	67	17	0	2 147	1 554
Côte d'Ivoire, 2012	57 541	23 008	269	12 946			7 817			1 039			1 724		
Ghana, 2008	64 993	124 999	281	6 534	18 356	52	7 290	9 091	29	263	6 794	32	946	4 744	6
Ghana, 2012	89 734	204 743	867	3 281	24 072	176	8 306	14 183	57	1 001	7 424	132	3 830	10 144	69
Mali, 2009	10 937	65 603	127	88	6 512	69	0	950	9	602	408	2	1 214	5 202	4
Mali, 2011	10 541	76 769	343	25	1 458	82	137	1 550	36	662	0	23	2 024	3 956	0
Niger, 2009	3 252	12 429	311	258	1 327	30	–	–	–	–	315	4	871	1 814	–
Niger, 2011	3 365	14 678	285	139	1 825	21	240	56	1	0	479	6	1 330	2 072	213

Source: UNESCO Institute for Statistics, January 2015

Figure 18.3: West African PhD students enrolled in S&T fields by gender, 2007 and 2012 or closest year

Selected countries



Source: UNESCO Institute for Statistics, January 2015

TRENDS IN R&D

Most countries still far from 1% target

ECOWAS countries still have a long way to go to reach the AU's target of devoting 1% of GDP to GERD. Mali comes closest (0.66%), followed by Senegal (Figure 18.4). The strong economic growth experienced by the subregion in recent years does, of course, make it harder to improve the GERD/GDP ratio, since GDP keeps rising. Although the government is the main source of GERD, foreign sources contribute a sizeable chunk in Ghana (31%), Senegal (41%) and Burkina Faso (60%). Gambia receives nearly half of its GERD from private non-profit sources (see Table 19.5).

GERD tends to be spent mainly in either the government or university sectors, depending on the country, although only Ghana and Senegal have provided data for all four performing sectors. These data reveal that the share of GERD performed by the business enterprise sector in these two countries is negligible (Figure 18.5). This will need to change if the region is to raise its investment in R&D.

A lack of researchers, in general, and women, in particular

It would be hazardous to extrapolate to the entire subregion without recent data for more than seven countries but the available data do suggest a shortage of qualified personnel. Only Senegal stands out, with 361 full-time equivalent (FTE) researchers per million population in 2010 (Table 18.5). Despite policies promoting gender equality, women's participation in R&D remains low. Cabo Verde, Senegal and Nigeria have some of the best ratios: around one in three (Cabo Verde) and one in four researchers. Concerning the sector of employment, the surprise comes from Mali, where half (49%) of researchers were working in the business enterprise sector in 2010 (Table 18.5).

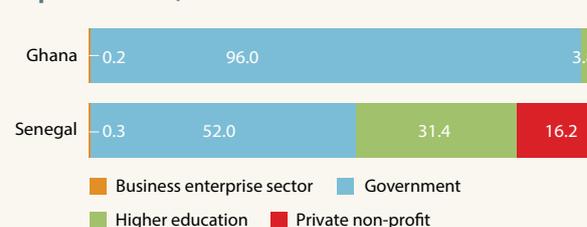
Figure 18.4: GERD/GDP ratio in West Africa, 2011 or closest year (%)

Selected countries



Source: UNESCO Institute for Statistics, January 2015

Figure 18.5: GERD in Ghana and Senegal by sector of performance, 2010



Note: Complete data for each sector are unavailable for other West African countries.

Source: UNESCO Institute for Statistics, January 2015

Table 18.5: Researchers (FTE) in West Africa, 2012 or closest year

	Total			By sector of employment (% of total)			By field of science and share of women											
	Numbers	Per million population	Women (%)	Business sector (%)	Government (%)	Higher education (%)	Natural Sciences	Women (%)	Engineering	Women (%)	Med & Health Sciences	Women (%)	Agricultural Sciences	Women (%)	Social Sciences	Women (%)	Humanities	Women (%)
Burkina Faso, 2010	742	48	21.6	–	–	–	98	12.2	121	12.8	344	27.4	64	13.7	26	15.5	49	30.4
Cabo Verde, 2011	25	51	36.0	0.0	100.0	0.0	5	60.0	8	12.5	0.0	–	0.0	–	6	50.0	6	33.3
Ghana, 2010	941	39	17.3	1.0	38.3	59.9	164	17.5	120	7.7	135	19.3	183	14.1	197	18.6	118	26.8
Mali, 2010	443	32	14.1	49.0	34.0	16.9	–	–	–	–	–	–	–	–	–	–	–	–
Nigeria, 2007	5 677	39	23.4	0.0	19.6	80.4	–	–	–	–	–	–	–	–	–	–	–	–
Senegal, 2010	4 679	361	24.8	0.1	4.1	95.0	841	16.9	99	14.1	898	31.7	110	27.9	2 326	27.2	296	17.1
Togo, 2012	242	36	9.4	–	22.1	77.9	32	7.1	13	7.8	40	8.3	63	3.8	5	14.1	88	14.1

Note: The sum of the breakdown by field of science may not correspond to the total because of fields not elsewhere classified.

Source: UNESCO Institute for Statistics, January 2015

A modest publication record, little intraregional collaboration

When it comes to scientific publications, West Africa has not progressed as quickly as the rest of the continent since 2005 (Figure 18.6). Output remains low, with only Gambia and Cabo Verde publishing more than 30 articles per million population. In the coming years, the country to watch may be Ghana, where the number of articles almost tripled to 579 between 2005 and 2014.

From 2008 to 2014, the top three partners for ECOWAS authors came from the USA, France and the UK, in that order. South Africa, Burkina Faso and Senegal are the main African partners of ECOWAS countries. South Africa has established bilateral agreements with Ghana, Mali and Nigeria to boost co-operation in science and technology (see Table 20.6).

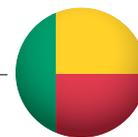
A report by the African Observatory of Science, Technology and Innovation on scientific production in the African Union between 2005 and 2010 indicates that only 4.1% of scientific papers published by Africans involved co-authors from the same continent in 2005–2007 and 4.3% in 2008–2010 (AOSTI, 2014).

Judging from the publication record, ECOWAS research focuses on medical and biological sciences, even if Nigeria did publish 1 250 research articles on agriculture between 2008 and 2014. Agricultural research takes a back seat in most ECOWAS countries, despite being a priority. This is hardly surprising, given the small number of PhDs in agriculture emerging from the universities of most West African countries and the generally low level of investment in agriculture. Research in mathematics, astronomy and computer science is negligible, even among the subregion's leaders, Nigeria and Ghana (Figure 18.6).

In the great majority of ECOWAS countries, more than eight out of ten scientific articles catalogued in the Web of Science between 2008 and 2014 had foreign partners. In the case of Cabo Verde, Guinea-Bissau and Liberia, this was even the case for the totality of articles, although it must be said that these three countries have a low output. There are two exceptions to the rule: in Côte d'Ivoire, three-quarters of articles (73%) had foreign co-authors between 2008 and 2014 and, in Nigeria, just over one-third (37%). In comparison, the average for members of the Organisation for Economic Co-operation and Development (OECD) is 29%. As for G20 countries, they publish just under 25% of articles with foreign partners on average. The average for sub-Saharan Africa is 63%.

COUNTRY PROFILES

BENIN



A need to match R&D with development needs

In Benin, the Ministry of Higher Education and Scientific Research is responsible for implementing science policy. The National Directorate of Scientific and Technological Research handles planning and co-ordination, whereas the National Council for Scientific and Technical Research and National Academy of Sciences, Arts and Letters each play an advisory role.

Financial support comes from Benin's National Fund for Scientific Research and Technological Innovation. The Benin Agency for the Promotion of Research Results and Technological Innovation carries out technology transfer through the development and dissemination of research results.

The regulatory framework has evolved since 2006 when the country's first science policy was prepared. This has since been updated and complemented by new texts on science and innovation (the year of adoption is between brackets):

- A manual for monitoring and evaluating research structures and organizations (2013);
- A manual on how to select research programmes and projects and apply to the National Fund for Scientific Research and Technological Innovation (2013) for competitive grants;
- A draft act for funding scientific research and innovation and a draft code of ethics for scientific research and innovation were both submitted to the Supreme Court in 2014;
- A strategic plan for scientific research and innovation (under development in 2015).

Equally important are Benin's efforts to integrate science into existing policy documents:

- *Benin Development Strategies 2025: Benin 2025 Alafia* (2000);
- *Growth Strategies for Poverty Reduction 2011–2016* (2011);
- Phase 3 of the *Ten-year Development Plan for the Education Sector*, covering 2013–2015;
- *Development Plan for Higher Education and Scientific Research 2013–2017* (2014).

The priority areas for scientific research are health, education, construction and building materials, transportation and trade, culture, tourism and handicrafts, cotton/textiles, food, energy and climate change.

The main research structures are the Centre for Scientific and Technical Research, National Institute of Agricultural Research, National Institute for Training and Research in Education, Office of Geological and Mining Research and the Centre for Entomological Research. The University of Abomey-Calavi also deserves mention for having been selected by the World Bank as a centre of excellence in applied mathematics (Table 18.1).

The main challenges facing R&D in Benin are the:

- unfavourable organizational framework for R&D: weak governance, a lack of co-operation between research structures and the absence of an official document on the status of researchers;
- inadequate use of human resources and the lack of any motivational policy for researchers; and the
- mismatch between R&D and development needs.

BURKINA FASO



S&T have become a development priority

Since 2011, Burkina Faso has clearly made S&T a development priority. The first sign was the creation of the Ministry of Scientific Research and Innovation in January 2011. Up until then, management of STI had fallen under the Department of Secondary and Higher Education and Scientific Research. Within this ministry, the Directorate General for Research and Sector Statistics is responsible for planning. A separate body, the Directorate General of Scientific Research, Technology and Innovation, co-ordinates research. This is a departure from the pattern in many other West African countries where a single body fulfils both functions.

In 2012, Burkina Faso adopted a *National Policy for Scientific and Technical Research*, the strategic objectives of which are to develop R&D and the application and commercialization of research results. The policy also makes provisions for strengthening the ministry's strategic and operational capacities.

One of the key priorities is to improve food security and self-sufficiency by boosting capacity in agricultural and environmental sciences. The creation of a centre of excellence at the International Institute of Water and Environmental Engineering (2iE) in Ouagadougou within a World Bank project (Table 18.1) provides essential funding for capacity-building in these priority areas. Burkina Faso also hosts the African Biosafety Network of Expertise (Box 18.1).

A dual priority is to promote innovative, effective and accessible health systems; the growing number of doctoral candidates in medicine and related fields is a step in the right direction (Figure 18.3). The government wishes to develop,

in parallel, applied sciences and technology and social and human sciences. To complement the national research policy, the government has prepared a *National Strategy to Popularize Technologies, Inventions and Innovations* (2012) and a *National Innovation Strategy* (2014).

Other policies also incorporate science and technology, such as that on *Secondary and Higher Education and Scientific Research* (2010), the *National Policy on Food and Nutrition Security* (2014) and the National Programme for the Rural Sector (2011).

In 2013, Burkina Faso passed the Science, Technology and Innovation Act establishing three mechanisms for financing research and innovation, a clear indication of high-level commitment. These mechanisms are the National Fund for Education and Research, the National Fund for Research and Innovation for Development and the Forum of Scientific Research and Technological Innovation⁷. The creation of national funds for R&D is one of the recommendations of ECOPOST.

The other most important actors are the National Centre for Scientific and Technological Research, Institute for Environment and Agricultural Research, National Agency for Biodiversity, National Council for Phylogenetic Resources Management and the Technical Secretariat for Atomic Energy. Responsibility for technology transfer and the popularization of research results falls to the National Agency for the Promotion of Research Results and the National Centre for Scientific and Technological Research.

Burkina Faso faces a number of challenges in developing R&D:

- a small pool of researchers: 48 per million population in 2010;
- a lack of research funding,
- outdated research facilities,
- poor access to information and internet: 4.4% of the population in 2013;
- an insufficient utilization of research results; and
- brain drain.

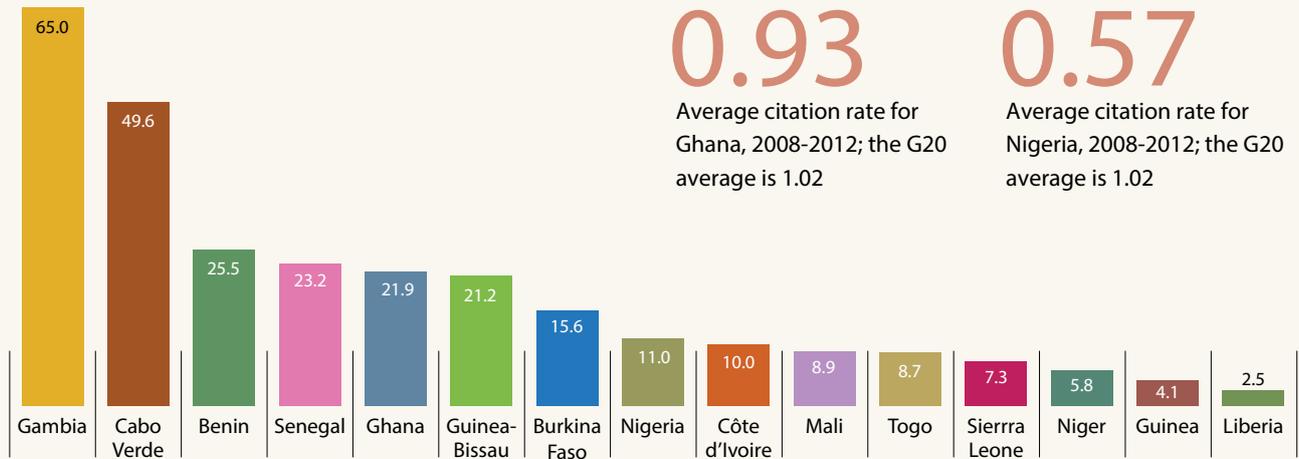
Before he passed away in December 2013, Nelson Mandela, a champion of education, lent his name to two graduate universities entrusted with the mission of producing a new generation of Africa-focused researchers, the African Institutes of Science and Technology in Tanzania and Nigeria. A third is planned for Burkina Faso.

7. Funding comes from the national budget and various annual subsidies: 0.2% of tax revenue, 1% of mining revenue and 1% of the revenue from operating mobile phone licenses. The funds also benefit from royalties on sales from the results of research and the patent license agreement concerning inventions funded by the public purse.

Figure 18.6: Scientific publication trends in West Africa, 2005–2014

Scientists from Gambia and Cabo Verde publish most in international journals

Per million inhabitants, 2014



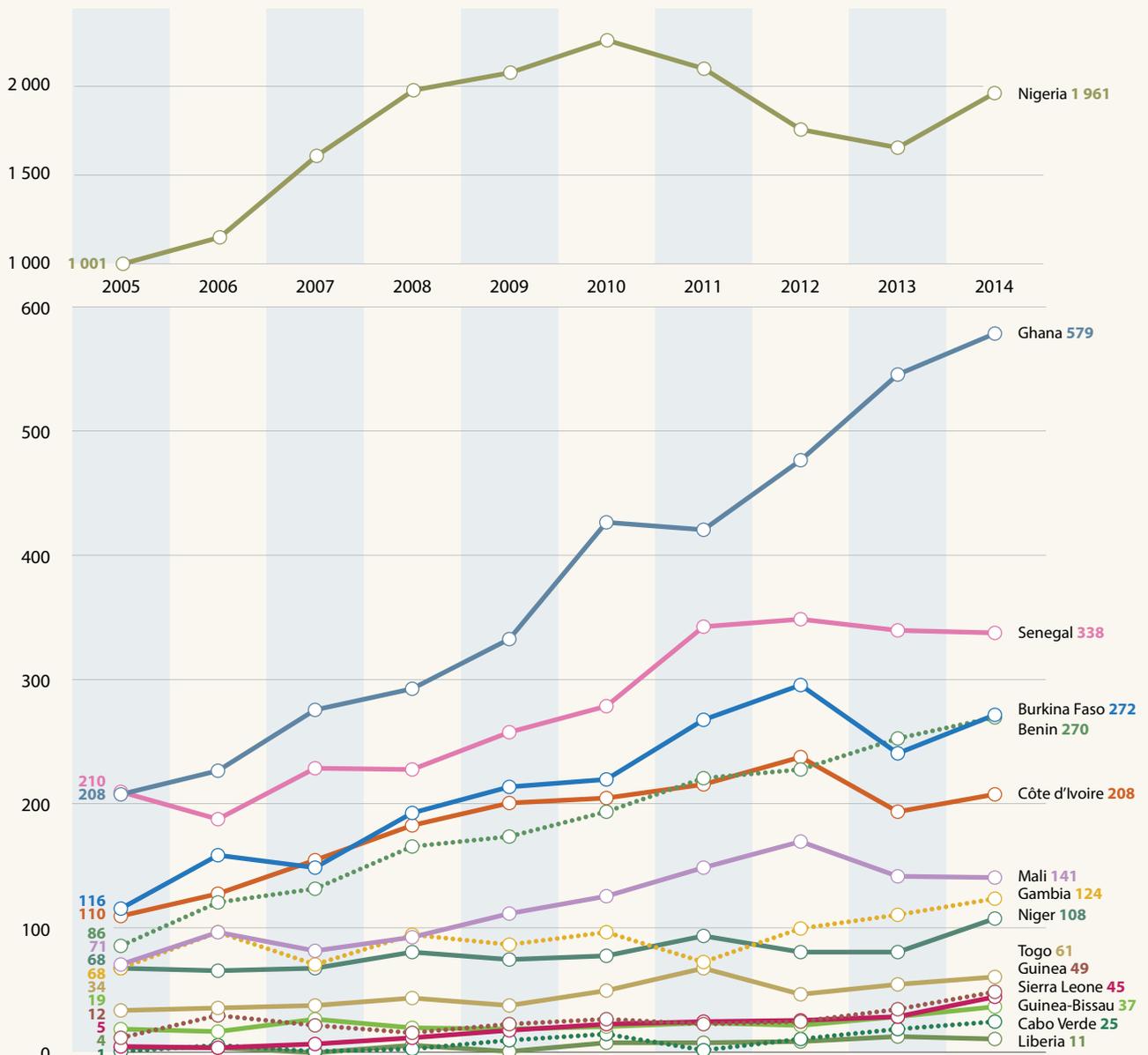
0.93

Average citation rate for Ghana, 2008-2012; the G20 average is 1.02

0.57

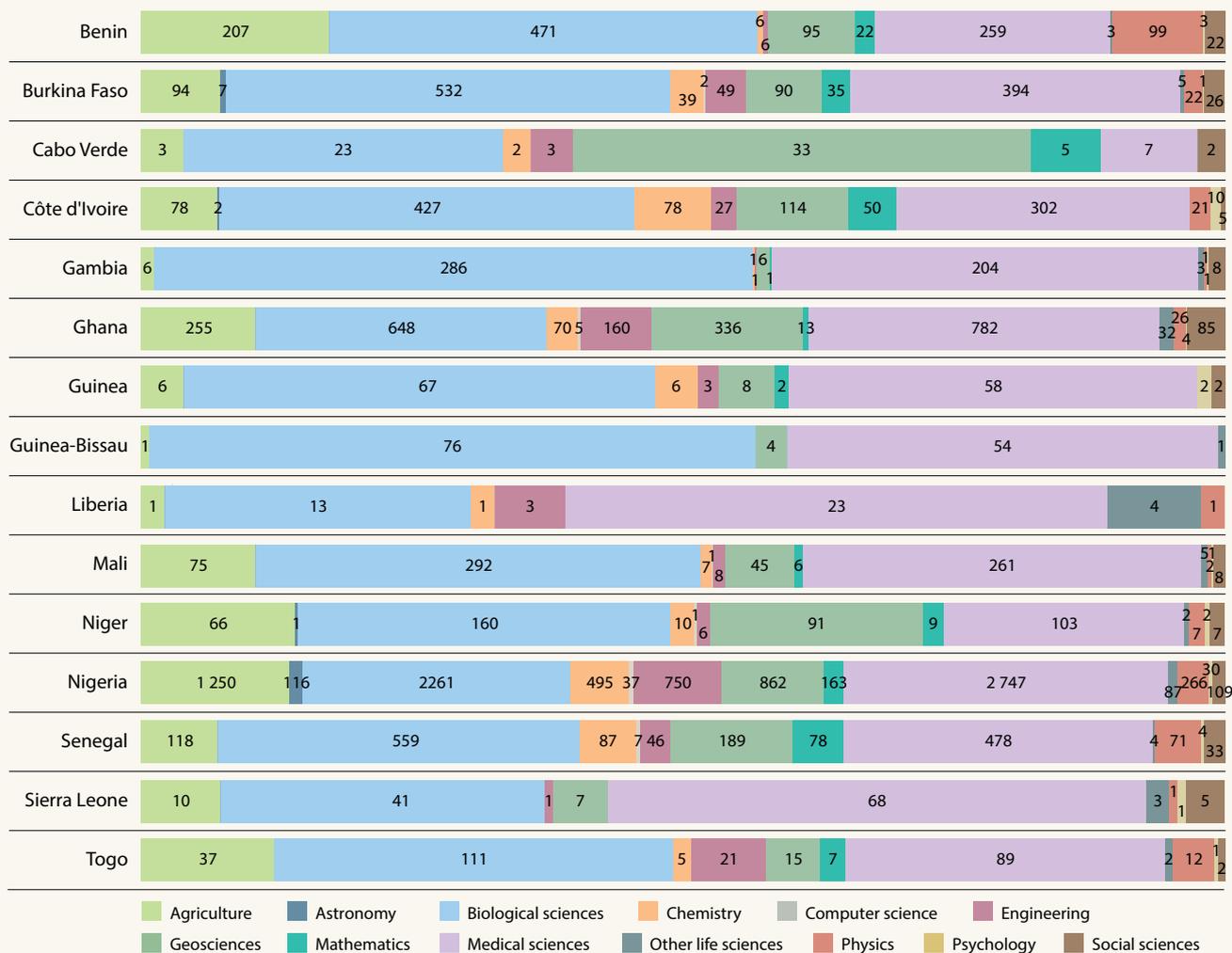
Average citation rate for Nigeria, 2008-2012; the G20 average is 1.02

Ghana now has the second-biggest volume of output after Nigeria



West African scientists publish much more in health than in agriculture

Cumulative totals by field, 2008–2014



Note: Totals exclude unclassified articles.

A wide range of scientific partners, including in Africa

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

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Benin	France (529)	Belgium (206)	USA (155)	UK (133)	Netherlands (125)
Burkina Faso	France (676)	USA (261)	UK (254)	Belgium (198)	Germany (156)
Cabo Verde	Portugal (42)	Spain (23)	UK (15)	USA (11)	Germany (8)
Côte d'Ivoire	France (610)	USA (183)	Switzerland (162)	UK (109)	Burkina Faso (93)
Gambia	UK (473)	USA (216)	Belgium (92)	Netherlands (69)	Kenya (67)
Ghana	USA (830)	UK (636)	Germany (291)	South Africa (260)	Netherlands (256)
Guinea	France (71)	UK (38)	USA (31)	China (27)	Senegal (26)
Guinea-Bissau	Denmark (112)	Sweden (50)	Gambia /UK (40)	–	USA (24)
Liberia	USA (36)	UK (12)	France (11)	Ghana (6)	Canada (5)
Mali	USA (358)	France (281)	UK (155)	Burkina Faso (120)	Senegal (97)
Niger	France (238)	USA (145)	Nigeria (82)	UK (77)	Senegal (71)
Nigeria	USA (1309)	South Africa (953)	UK (914)	Germany (434)	China (329)
Senegal	France (1009)	USA (403)	UK (186)	Burkina Faso (154)	Belgium (139)
Sierra Leone	USA (87)	UK (41)	Nigeria (20)	China/Germany (16)	–
Togo	France (146)	Benin (57)	USA (50)	Burkina Faso (47)	Côte d'Ivoire (31)

Source: Thomson Reuters' Web of Science, Science Citation Index Expanded, data treatment by Science–Metrix, November 2014

CABO VERDE



A model for civil rights and development

Cabo Verde remains a model for political rights and civil liberties in Africa, according to a country study by the African Development Bank in 2014. Thanks to its sustained economic performance, this isolated and fragmented territory with a dry Sahelian climate and scarce natural resources acceded to the World Bank's middle-income category in 2011. In order to maintain the momentum, the government has devised its third *Growth and Poverty Strategy Paper* covering the period 2012–2016. Expanding the coverage of health service delivery and human capital development have been designated priority areas, in order to ensure inclusive growth, with an emphasis on technical and vocational training. In recent years, Cabo Verde has invested more than 5% of GDP in education. This strategy has paid off. The literacy rate is now the highest in West Africa (98%), with 93% of young people being enrolled in secondary school and one in five in tertiary education (Table 18.3).

Plans to strengthen research

Research spending, on the other hand, remains among the lowest in West Africa, at 0.07% of GDP in 2011. The Ministry of Higher Education, Science and Culture plans to strengthen the research and academic sectors by placing emphasis on greater mobility, through exchange programmes and international co-operation agreements. As part of this strategy, Cabo Verde is participating in the Ibero-American academic mobility programme that expects to mobilize 200 000 academics between 2015 and 2020.

ICTs at the heart of development plans

Cabo Verde Telecom linked all the islands by fibre optic cable in 2000. In December 2010, it joined the West African Cable System project⁸ to provide residents with an alternative access route to high-speed internet. Thanks to this, internet penetration more than doubled between 2008 and 2013 to 37.5% of the population. As the cost remains high, the government provides centres where people can surf the internet free of charge.

The government now plans to build a 'cyber-island' which would develop and offer ICT services, including software development, computer maintenance and back office operations. Approved in 2013, the Praia Technology Park is a step in this direction; financed by the African Development Bank, it is expected to be operational by 2018.

The government launched the Mundu Novu project in 2009 to modernize education. The project is introducing the concept of interactive education into teaching and

mainstreaming informatics into curricula at different levels. Some 150 000 computers are being distributed⁹ to public schools. By early 2015, the Mundu Novu education plan had equipped 18 schools and training centres with internet access, installed the Wimax antenna network across the country, produced teaching kits on ICTs for 433 classrooms in 29 pilot schools (94% of all classrooms), given university students access to digital libraries and introduced courses in information technology, in addition to implementing an Integrated Management and Monitoring System for university students.

CÔTE D'IVOIRE



A plan to consolidate peace and promote inclusive growth

With the political crisis now over, the incoming government of President Alassane Ouattara has vowed to restore the country to its former leading role in sub-Saharan Africa. The *National Development Plan for 2012–2015* has two primary objectives: to achieve double-digit growth by 2014 and to turn Côte d'Ivoire into an upper middle-income country by 2020. A second national development plan is under preparation for 2016–2020.

The budget for the *National Development Plan* is broken down into five strategic areas: greater wealth creation and social equity (63.8%, see Figure 18.7), provision of quality social services for vulnerable populations, particularly women and children (14.6%), good governance and the restoration of peace and security (9.6%), a healthy environment (9.4%) and the repositioning of Côte d'Ivoire on the regional and international scenes (1.8%).

Key targets of the *Plan* requiring recourse to S&T include:

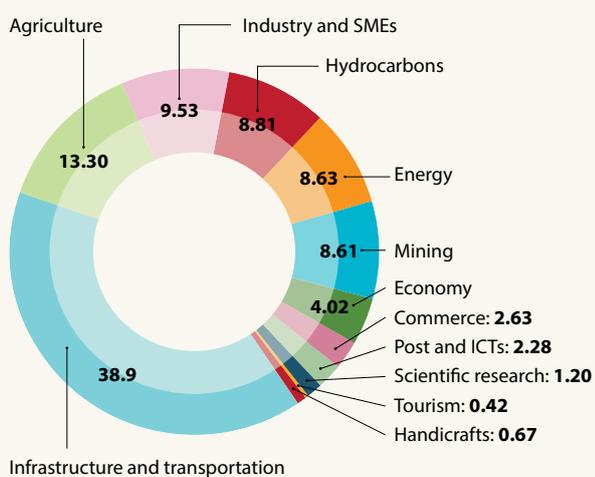
- rehabilitation of the railway linking Abidjan to Burkina Faso's border, rehabilitation and extension of the ports of Abidjan and San Pédro, creation of a new airline company (infrastructure and transport);
- increasing the productivity of yam, banana plantain and manioc by at least 15% (agriculture);
- creation of two transformation units for iron and manganese and one for gold refining (mining);
- construction of the Soubré dam, electrification of 200 rural communities each year (energy);
- establishment and equipping of three technopoles to promote innovation, transformation of 50% of raw materials into value-added goods (industry and SMEs);

9. Microsoft has given the official government agency working on Mundu Novu, Operational Information Society Nucleus, a 90% discount on the operating systems being installed in schools, through an agreement signed in August 2010.

8. See: www.fosisgrid.org/africa/cape-verde

- expansion of the country's fibre optic¹⁰ network, introduction of an e-education programme, establishment of cybercentres in every municipality (post and ICTs);
- construction and equipping of 25 000 classrooms, construction of four universities and a university village, rehabilitation of several existing universities (education);
- rehabilitation of hospitals and clinics, free health care for children under the age of five, free childbirth care and free emergency care (health);
- construction of latrines in rural areas, rehabilitation of sewage systems in Abidjan and Yamoussoukro (sanitation);
- connection of 30 000 low-income families each year to subsidized piped water (drinking water);
- rehabilitation of the lagoon and Cocody Bay in Abidjan and construction of a technopole to treat and recycle industrial and dangerous waste (environment).

Figure 18.7: **Priority sectors of Côte d'Ivoire's National Development Plan to 2015**
Within budget devoted to greater wealth creation and social equity (%)



Source: Ministry of Planning and Development (2012) *National Development Plan, 2012–2015*

Infrastructure is a top priority

The share of the *Plan* devoted to scientific research remains modest (Figure 18.7). Twenty-four national research programmes group public and private research and training institutions around a common research theme. These programmes correspond to eight priority sectors for 2012–2015, namely: health, raw materials, agriculture, culture, environment, governance, mining and energy; and technology.

According to the Ministry of Higher Education and Research, Côte d'Ivoire devotes about 0.13% of GDP to GERD.

Apart from low investment, other challenges include inadequate scientific equipment, the fragmentation of research organizations and a failure to exploit and protect research results.

Côte d'Ivoire does not yet have a dedicated STI policy. Related policies are implemented by the Ministry of Higher Education and Scientific Research. The main planning body is the Directorate General of Scientific Research and Technological Innovation and its technical directorate. For its part, the Higher Council for Scientific Research and Technological Development serves as a forum for consultation and dialogue with stakeholders and research partners.

Research and innovation are promoted and funded by the National Agricultural Investment Programme (est. 2010), the Policy Support Programme for Scientific Research (est. 2007), the Interprofessional Fund for Agricultural Research and Advice (est. 2002), the National Fund for Scientific and Technological Research (yet to be established) and the Ivorian Fund for the Development of National Enterprises (est. 1999).

The following structures foster innovation and technology transfer: the Department for the Promotion of Research and Technological Innovation, the Ivorian Organization for Intellectual Property and Promotion and the Centre for the Demonstration of Technologies. To this list should be added the Ivorian Society of Tropical Technology. Set up in 1979, this government centre promotes agro-industrial innovation and provides training in the preservation and transformation of crops (manioc, banana plantain, cashew nut, coconut, etc.) into value-added goods such as soap and cocoa butter.

Other key structures include the Pasteur Institute, Centre for Oceanological Research, National Centre for Agronomic Research, National Institute of Public Health, Centre for Ecological Research and the Centre for Economic and Social Research.

GAMBIA



A desire to link training with STI development

Gambia's *Programme for Accelerated Growth and Employment*, covering the period 2012–2015, drives its own vision of attaining middle-income status. One of the smallest countries in West Africa, with a per capita GDP of PPP\$ 1 666, Gambia is conscious of the need for a robust STI capacity to address its pressing development challenges. Just 14% of the population has access to internet, for instance, and only three in four Gambians have access to a clean water supply.

10. Just 2.4% of Ivoirians had internet access in 2012.

The establishment of the Ministry of Higher Education, Research, Science and Technology in 2007 signals the country's desire to link the training of skilled personnel with STI development. Other encouraging signs are the president's decision to make 2012 the Year of Science, Technology and Innovation, the efforts to establish the first-ever national academy of sciences in Gambia and the adoption of the *National Science, Technology and Innovation Policy 2013–2022*, prepared with UNESCO's assistance.

This policy aims specifically to foster entrepreneurship among youth and women, in order to enhance their employability. It also aims to modernize both agriculture (peanuts and derivatives, fish, cotton lint, palm kernels) and national industries (tourism, beverages, agricultural machinery assembly, woodworking, metalworking, clothing) to create quality products and services.

A number of institutions provide research and training, the main ones being the University of Gambia, the National Agricultural Research Institute, the Centre for Innovation against Malaria, the Public Health Research and Development Centre, the Medical Research Council and the International Trypanotolerance Centre.

Low tertiary enrolment, little R&D

Development indicators for Gambia are fairly encouraging for a small country with limited resources. Public expenditure on education has quadrupled since 2004 to 4.1% of GDP. Of this, just 7% (0.3% of GDP) is invested in tertiary education. Although nine out of ten children attend primary school, enrolment rates have not progressed at either the primary or secondary levels since 2009, suggesting that the government may be focusing on improving the quality of primary and secondary education (Table 18.3). Tertiary enrolment remains extremely low, at just 3% of the 18–25 age cohort, even though it has risen in recent years.

Just 0.13% of GDP is spent on R&D (2011). Gambia does have the particularity, though, of having an active private non-profit sector, which performs nearly half of R&D¹¹ according to available data – although it should be noted that the business enterprise sector has not been surveyed. On the whole, however, STI in Gambia is characterized by inadequate infrastructure and insufficient skills and institutional capacity to realize its science and innovation goals, combined with a lack of funding. The *National Science, Technology and Innovation Policy* is intended to address these constraints.

11. This may be at least partly due to the fact that the Medical Research Council in Gambia, a unit of the UK's council of the same name, is classified as a private non-profit institution.

GHANA



A desire to create a science culture

The *Ghana Shared Growth and Development Agenda 2014–2017* contextualizes the sector-specific policies for agriculture, industry, health and education defined by the *National Science, Technology and Innovation Policy*¹² (2010). The main objectives of this policy are to use STI to reduce poverty, increase the international competitiveness of enterprises and promote sustainable environmental management and industrial growth. The long-term goals of the policy are to create a science and technology culture oriented towards problem-solving.

Ghana has one of West Africa's most developed national innovation systems. There is a Council for Scientific and Industrial Research, established in 1958, with 13 specialized institutes for research on crops, animals, food, water and industry. The export of cocoa contributed over 40% of the country's foreign exchange earnings up until the 1980s and still contributes about 20%. The Cocoa Research Institute of Ghana plays an important role in developing the cocoa industry, through research into crop breeding, agronomy, pest management and extension services, among others. Other scientific institutions include the Ghana Atomic Energy Commission, the Centre for Scientific Research into Plant Medicine and the Noguchi Memorial Institute for Medical Research at the University of Ghana.

Ghana has only a small pool of researchers (39 per million population in 2010) but they are increasingly publishing in international journals. Ghana's scientific publication record almost tripled between 2005 and 2014 (Figure 18.6). This performance is all the more noteworthy in that Ghana devoted just 0.38% of GDP to GERD in 2010 (see Table 19.5).

Greater investment needed to stimulate R&D

Between 2004 and 2011, Ghana invested 6.3% of GDP in education, on average, and between one-fifth and one-quarter of this in higher education. The number of students enrolled in degree courses shot up from 82 000 to 205 000 (12% of the age cohort) between 2006 and 2012 and the number of PhD candidates from 123 to 867 (see Table 19.4).

The investment in education has not lived up to expectations, as it has not acted as a stimulus for R&D. This is because science and engineering are accorded insufficient status in Ghana. Government scientists and academics (who perform 96% of GERD) receive an inadequate budget and private sector opportunities are rare. In the 2000s, successive governments made efforts to enhance the infrastructure for modern business

12. This policy followed a review of Ghana's national innovation system by UNCTAD, the World Bank and Ghana's Science and Technology Policy Research Institute.

development. They fostered business incubators for ICTs, industrial parks for textiles and garments and smaller experimental incubators within research institutes like the Food Research Institute. These are all located in the Accra-Tema metropolis where they are too inaccessible for the thousands of entrepreneurs living outside the capital who need these facilities to develop their businesses.

Despite insufficient investment, some universities maintain high standards, such as the University of Ghana (1948), the country's oldest, and Kwame Nkrumah University of Science and Technology (KNUST, 1951). Both have been selected for the World Bank's African Centres of Excellence project (Table 18.1). KNUST has developed a reputation for excellence in engineering, medicine, pharmacy, basic sciences and applied sciences. In 2014, the government established a centre of excellence in petroleum engineering at KNUST with the World Bank which will serve as a hub for developing Africa's capacity in the oil and gas value chain. In all, seven public universities conduct extensive R&D.¹³

Within the World Bank project, the West Africa Centre for Crop Improvement at the University of Ghana is receiving US\$ 8 million for research and the training of crop breeders at PhD and MSc levels over 2014–2019, as well as for the provision of other services. The West Africa Centre on the Cell Biology of Infectious Pathogens within the University of Ghana and KNUST's Regional Water and Environmental Sanitation Centre are receiving similar support (Table 18.1).

GUINEA



Middle-income status by 2035

Following the death of President Lansana Conte in 2008, Guinea experienced a severe political crisis until the election of the current President Alpha Conde in November 2010. This challenging political transition plunged the country into an economic recession in 2009 (-0.3% growth), prompting the government to extend its *Poverty Reduction Strategy* to 2012.

The ambition of the new authorities is to transform Guinea into a middle-income economy within 25 years. This ambition will be articulated in *Guinea 2035*, which was under preparation in 2015. The government intends to promote:

- the collection of economic intelligence, in order to anticipate changes in the national and international

economic environments and to identify opportunities for access to new markets through innovation and creativity. Over the period 2013–2015, economic intelligence poles are being established for the administration (public services) and private sector (employers);

- clean industries;
- security of intellectual and economic property;
- management and exploitation of knowledge and information, in the priority areas of science and industrial, technological and medical production processes.

Key reforms in higher education and research

The government has made it a priority to achieve universal primary education by 2015, in line with the Millennium Development Goals. The roadmap for achieving this ambition is the government's *Programme for the Education Sector 2008–2015*, adopted in 2007. By 2009, 85% of children were attending primary school but this share had barely progressed by 2012, no doubt owing to the political unrest in 2008 and 2009. The share of secondary pupils rose from 34% to 38% between 2008 and 2012 (Table 18.3). Guinea's education effort accounted for 2.5% of GDP in 2012, one of the lowest proportions in West Africa.

One-third of education expenditure goes on higher education. One in 10 Guineans aged between 18 and 25 years is enrolled at university, one of the highest rates in West Africa. Important reforms are under way in Guinea to improve university governance and the financing of institutions of higher learning and scientific research, to create an advanced (doctoral) graduate school, implement a system of quality assurance and develop relevant professional networks in higher education.

The government is also promoting access to ICTs and their use in teaching, scientific research and administration. Guinea currently has one of the lowest rates of internet penetration in Africa, at just 1.5% (2012).

A need to review the legal framework for R&D

The development of R&D is governed by the Guidance Law for Scientific and Technical Research. This law has not been updated since its adoption on 4 July 2005, nor implemented or reviewed.

The Ministry of Higher Education and Scientific Research is the main body responsible for policies related to higher education and scientific research. Within the ministry, the National Directorate for Scientific and Technical Research (DNRST) is responsible for the implementation of the policy and research institutions that constitute the executive component. The DNRST is also responsible for designing, developing and coordinating the monitoring and evaluation of national policy.

¹³ In addition, there are ten polytechnics, one in each of Ghana's ten administrative regions and 23 institutes for vocational and technical training. The evolving policy on polytechnics is to transform these into technical universities.

In addition to the Ministry of Higher Education and Scientific Research, there is a Higher Council of Scientific and Technical Research. This consultative body related to on matters has national S&T policy; it consists of representatives of ministries, the scientific community and users of the products of research.

R&D funding comes from two sources: the state, through the national development budget, allocates grants to research institutions, documentation centres and universities; and international co-operation. In recent years, R&D in Guinea has received financial assistance from France, via its Aid Fund for Co-operation and the Priority Solidarity Fund, as well as from Japan, Belgium, Canada, the World Bank, UNDP, UNESCO, the Islamic Educational, Scientific and Cultural Organization and others.

GUINEA-BISSAU



Political troubles have undermined the economy

Once hailed as a model for African development, Guinea-Bissau has suffered a civil war (1998–1999), followed by several coups d'état, the latest in April 2012. Political instability has undermined the economy, making it one of the poorest countries in the world.

Guinea-Bissau is dependent on primary crops – mainly cashew nuts for its foreign exchange – and subsistence agriculture. There are other resources that could be exploited and processed, such as fish, timber, phosphates, bauxite, clay, granite, limestone and petroleum deposits.

Guinea-Bissau's long-term vision is encapsulated in *Guinea-Bissau 2025 Djitu ten* (1996). The government's vision is articulated in the first *National Strategy for Poverty Reduction* covering the period 2008–2010 and its successor covering 2011–2015. The title of the latter reflects the strategy's overarching goals, *Reducing Poverty by Strengthening the State, Accelerating Growth and Achieving the Millennium Development Goals*.

Higher education policy currently under review

Like most WAEMU countries which share a common currency (the CFA), Guinea-Bissau has made considerable efforts in the past five years to improve its higher education system. These efforts have been supported by Guinea-Bissau's partners and especially by WAEMU through its Support to Higher Education, Science and Technology Project and its assistance in developing Guinea-Bissau's higher education policy in 2011. This policy is currently under review, in consultation with key stakeholders, particularly private-sector employers, socio-professional organizations, policy-makers and civil society.

Thus, like other WAEMU countries, Guinea-Bissau has held national consultations on the future of higher education and scientific research. In March 2014, the Ministry of Education organized a national dialogue on this topic on the theme of What Future for Higher Education and Scientific Research in Guinea-Bissau in the Short, Medium and Long Term? The consultation brought together a wide range of national and foreign stakeholders. The recommendations emanating from this consultation, combined with the election of President José Mario Vaz in May 2014 and the consequential removal of the sanctions imposed by the African Union after the coup d'état in 2012, should enable Guinea-Bissau to take this reform agenda forward.

LIBERIA



Strong economic growth has not spilled over into the STI sector

Liberia is a country recovering from a quarter of a century of civil war. Although it has turned the page of strife since the election of President Ellen Johnson Sirleaf in 2005, the economy remains in ruins and, since early 2014, has been struggling with the crippling effects of the Ebola epidemic. With GDP per capita of just PPP\$ 878 in 2013, Liberia remains one of the poorest countries in Africa.

The country does have considerable natural assets, including the largest rainforest in West Africa. Its economy is based on rubber, timber, cocoa, coffee, iron ore, gold, diamonds, oil and gas. Between 2007 and 2013, the economy grew by 11% on average. Even though this economic recovery is commendable, it has not spilled over into the STI sector.

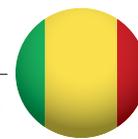
Low public spending on agriculture and education

Nor has public spending risen in such key sectors as agriculture (less than 5% of GDP) and education (2.38% of GDP), where just 0.10% of GDP goes to higher education. Although Liberia has achieved universal primary education, less than half of pupils attend secondary school. In addition, university enrolment has stagnated: almost the exact same number of students (33 000) were enrolled in degree courses in both 2000 and 2012. At the other extreme, Liberia shares the distinction with Sierra Leone of devoting more of GDP to health (15%) than any other country in sub-Saharan Africa.

An emphasis on better governance

Liberia has set its sights on becoming a middle-income country by 2030, in its *National Vision: Liberia Rising 2030*¹⁴ (Republic of Liberia, 2012). The first priority will be to create the conditions for socio-economic growth, through better governance

¹⁴ *Liberia Rising 2030* follows on the heels of *Lifting Liberia*, the country's poverty reduction strategy for 2008–2011.



MALI

A policy but no long-term plan for research

In 2009, the Ministry of Secondary and Higher Education and Scientific Research developed a *National Policy for Higher Education and Scientific Research* (MoSHESR, 2009). It has three main objectives:

- to strengthen the social and economic utility of higher education and research;
- to regulate the flow of students enrolled in higher education, in order to establish the best possible compromise between the needs of the labour market, social demand and the available means; and
- to optimize available resources by directing the lion's share towards teaching and research, while making better use of the private sector's potential role, in order to limit social spending.

Despite the guidance offered by this science policy, no strategic plan for developing long-term scientific research has yet been formally adopted, nor any document defining the human, material and financial resources needed to mobilize and implement such a policy. The United Nations' Economic Commission for Africa did support a study in 2009–2011 on developing a national STI policy and an accompanying implementation plan but this process was perturbed by the military coup in 2011 which preceded the Touareg rebellion in the north. In the absence of these elements, departments or individuals within education and research structures continue to initiate research projects themselves or, in some cases, the initiative is taken by donors, an only too familiar pattern in Africa.

From one university to five

Until 2011, Mali had a single university, established in 1996. Nearly 80 000 students enrolled in the 2010–2011 academic year, 343 of whom were PhD candidates (Table 18.4). In order to accommodate the burgeoning student numbers, the government decided to divide the University of Bamako into four separate entities in 2011, each with its own institute of technology: the University of Science, Techniques and Technologies in Bamako; University of Arts and Humanities in Bamako; University of Social Sciences and Management in Bamako; and the University of Law and Political Sciences in Bamako.

In parallel, the University of Segou was approved by decree in 2009 and welcomed its first cohort of 368 students in January 2012, according to the Malian journal *L'Essor*. The Faculty of Agriculture and Veterinary Medicine was the first to open, followed by the Faculty of Social Sciences, the Faculty of Health Sciences and the Faculty of Science and Engineering. It is planned to set up a vocational training centre on campus.

practices such as respect for the rule of law, infrastructure development, a more business-friendly environment, free basic education and more trained teachers, investment in technical and vocational education and higher education. *Liberia Rising* cites a World Bank Doing Business survey (2012) in which 59% of Liberian firms identified lack of electricity and 39% lack of transportation as a major constraint.

With the entire infrastructure for energy generation and distribution having been destroyed by the war, it is planned to make greater use of renewable energy and to install affordable power services, with 'more access to fuel that does not contribute to deforestation.' Being able to supply electricity to most of the economy is considered 'essential' for achieving middle-income status. Emphasis is being placed on ensuring greater inclusiveness, as 'instability and conflict remain the primary risk to long-term wealth creation in Liberia... The challenge will be to turn away from the traditional practice of concentrating wealth and power in the elite and in Monrovia (the capital).'

It is expected that financing for the *National Vision* will come essentially from large mining companies – including those currently prospecting offshore for oil and gas – and from development partners. In 2012, FDI contributed 78% of GDP, by far the largest share in sub-Saharan Africa (Republic of Liberia, 2012).

Liberia has not yet published an STI policy but it does have a national industrial policy, *Industry for Liberia's Future* (2011), a *National Environmental Protection Policy* (2003), a *National Biosafety Framework* (2004) and a *National Health Policy* (2007).

An S&T college for the University of Liberia

In higher education, the main development has been the commissioning of the T.J.R. Faulkner College of Science and Technology in 2012 at the University of Liberia. The latter was founded in 1862 and already had two colleges, the College of Agriculture and Forestry and the College of Medicine. Other universities also have science and engineering faculties. Liberia also has specialized institutions such as the Liberia Institute for Biomedical Research and the Central Agriculture Research Institute.

The National Commission on Higher Education is responsible for developing STI. There is also a Renewable Energy Agency, a Forestry Development Authority and an Environmental Protection Agency. Currently, the Ministry of Education holds responsibility for science education and research, through its Division for Science and Technology Education. There are calls, however, for the establishment of a Ministry of Research, Science and Technology.

Since 2009, the UNESCO Office in Bamako has been implementing a project to help university professors adopt the three-tier degree cycle (bachelor's– master's –PhD). UNESCO collaborated with the University of Bamako and the National Directorate of Higher Education in organizing a mission to Dakar in April 2013 for about 20 university professors, so that they could study doctoral schools and quality assurance mechanisms in Senegal with a view to emulating these in Mali. UNESCO also ran a number of national and international workshops, including one on the use of ICTs to improve education and research. The University of Bamako has since joined the African Network of Scientific and Technological Institutions, hosted by the UNESCO Nairobi office.

NIGER



The country's first STI policy

In Niger, several ministries are involved in designing S&T policy but the Ministry of Higher Education, Scientific Research and Innovation is the principal player. The *National Policy on Science, Technology and Innovation* was approved in 2013 and was awaiting adoption by parliament in 2015. In parallel, UNESCO is helping Niger develop a strategic implementation plan.

In March 2013, Niger participated in a subregional workshop¹⁵ in Dakar co-organized by UNESCO's Global Observatory of STI Policy Instruments (GO→SPIN) programme and AOSTI. The workshop was the first step in mapping research and innovation in Niger.

In 2010, Niger created a Support Fund for Scientific Research and Technological Innovation (FARSIT). With an annual budget of CFA 360 million (€ 548 000), FARSIT aims to support research projects of socio-economic relevance; strengthen the capacity of institutions, teams and laboratories to conduct R&D; encourage creativity and technological innovation; and improve research training.

A first long-term plan for all levels of education

University enrolment rates in Niger are among the lowest in Africa, at just 175 students per 10 000 population (Table 18.3). Developing a viable higher education system of quality thus remains a major challenge for a country where half the population is less than 15 years of age. In 2010, three new universities were founded: the University of Maradi, the University of Zinder and the University of Tahoua.

In 2014, the government adopted a *Programme for the Education and Training Sector, 2014–2024*. This is Niger's first

¹⁵ The workshop was attended by high-level experts, government officials, researchers, statisticians and parliamentary commission staff from Burkina Faso, Burundi, Côte d'Ivoire, Gabon, Niger and Senegal.

long-term planning document for education as a whole, from the pre-primary to tertiary levels. The previous plan in 2001 focused solely on basic education, encompassing pre-school, primary school, adult literacy and non-formal education.

NIGERIA



The National Fund for STI approved

Nigeria plans to use its *Vision 20:2020: Economic Transformation Blueprint* (2009) to place it among the top 20 economies¹⁶ in the world by 2020, with annual per capita income of at least US\$ 4 000. *Vision 20:2020* integrates STI into the development of key economic sectors and is built on three pillars, namely: optimizing the nation's key sources of economic growth; guaranteeing the productivity and well-being of Nigerians; and fostering sustainable development.

One of the nine strategic targets of *Vision 20:2020* was initially to set up a US\$ 5 billion endowment fund to finance the establishment of a National Science Foundation. This fund was pledged by former President Olusegun Obasanjo (1999–2007) towards the end of his mandate and has not materialized. Progress towards other targets is hard to evaluate for lack of data, examples being the target of investing a share of GDP in R&D comparable to that of the 20 leading economies or that of increasing numbers of R&D personnel.

In 2011, the Federal Executive Council approved the allocation of 1% of GDP to set up a National Science, Technology and Innovation Fund. This strategy features in the *Science, Technology and Innovation Policy* approved by the Federal Executive Council in 2011, which recommends putting in place reliable funding arrangements to ensure that R&D focuses on national priorities. Four years later, this fund has not yet materialized.

A policy shift towards innovation

The policy also recommended a shift in research focus from basic research to innovation. In his foreword, the Federal Minister of Science and Technology¹⁷ observed that 'one notable feature of this policy is the emphasis on innovation, which has become a tool for fast-tracking sustainable development.' President Goodluck Jonathan put it this way: 'we are going to run our economy based on S&T because nowhere in this world can you move the economy without S&T...for the next four years, we will emphasize S&T so much

¹⁶ For details of Nigeria 20:2020, see the *UNESCO Science Report 2010: the Current Status of Science around the World*, p. 309.

¹⁷ The Federal Ministry of Science and Technology is supported by the National Council on Science and Technology, the National Assembly Committees on Science and Technology and the National Centre for Technology Management. Nigeria being a federal republic, there are also relays in the state ministries and assemblies.

Box 18.4: Taxing business to upgrade tertiary education in Nigeria

One of the strategies outlined in Nigeria's *Science, Technology and Innovation Policy* (2011) is for funding frameworks to be set up with various partners.

One such framework is the TETFund. It was established under the Tertiary Education Trust Fund Act of 2011 to serve as the agency responsible

for managing and disbursing tax funds to public tertiary institutions. It is also responsible for monitoring the utilization of funds.

Under the fund, a 2% education tax is imposed on the assessable profits of all registered companies in Nigeria. TETFund then disburses 50% of the money to

universities, 25% to polytechnics and 25% to teachers' colleges. Grants are provided for the purchase of essential physical infrastructure for teaching and learning, research and publication and academic staff training and development.

Source: www.tetfund.gov.ng

because we have no choice.' The aim is to transform Nigerians into 'science and technology thinking entities.'

The policy also recommended founding a National Research and Innovation Council. This was effectively established in February 2014. Membership includes the federal ministers of science and technology; education; information and communications technology; and environment.

The emphasis in STI is on space science and technology, biotechnology and renewable energy technologies. Although Nigeria has had a National Biotechnology Development Agency since 2001, the National Biosafety Management Agency Bill lingered in parliament for years; the bill was finally passed in 2011 but was still awaiting presidential consent in early 2015.

In 2012, an International Centre for Biotechnology was established under the auspices of UNESCO at the University of Nigeria in Nsukka. The institute provides high-level training (including at subregional level), education and research, particularly in areas related to food security, conservation of harvested crops, gene banking and tropical diseases.

Some key goals of the *Science, Technology and Innovation Policy* are to:

- develop an endogenous capability in launching and exploiting Nigeria's own satellites (it already has three) for telecommunications and research;
- run advanced field trials of genetically modified crops designed to increase agricultural productivity and food security (see also Box 18.1);
- promote solar technology systems as dependable back-ups to the national grid and to address energy needs in marginalized communities;
- promote the design and use of local construction materials and a 'green construction culture' through the development of 'green homes' and 'green cement';

- establish or develop technology transfer offices to improve intellectual property protection and thereby encourage industrial R&D;
- build the Sheda Science and Technology Complex (SHESTCO) in Abuja within the Silicon Valley Project, which is developing a high-tech capability in ICTs, materials science, solar and new technologies, along with skills in engineering and maintenance. In a visit to the complex in October 2014, the Federal Minister of Science and Technology, Dr Abdu Bulama, pledged to 'do everything under our mandate to ensure Silicon Valley becomes a reality. Hence, we are partnering with UNESCO, Poland and other international bodies to fast-track the process.'

The success of Nigeria's ambitious programme will rest on its strategy for developing human resources (Box 18.4). Nigeria currently has 40 federal universities, 39 state universities and 50 private universities, according to the Nigeria Universities Commission. There are also 66 polytechnics, 52 monotechnics and about 75 research institutes.

Despite this, federal spending on R&D in 2007 represented only about 0.22% of GDP, according to the UNESCO Institute for Statistics, and over 96% of this was provided by the government. These statistics should improve as implementation of the *Science, Technology and Innovation Policy* progresses.

Economic diversification an urgent necessity

The president has implemented two schemes to support the economy since 2010:

- With power outages costing the Nigerian economy billions of dollars each year, the president launched a *Roadmap for Power Sector Reform* in 2010. Central to this scheme has been the privatization of the state electricity provider, the Power Holding Company of Nigeria, which has been broken up into 15 different companies.

- In October 2011, the president launched the Youth Enterprise with Innovation in Nigeria (You Win)¹⁸ grant scheme to generate jobs. By 2015, some 3 600 aspiring entrepreneurs between 18 and 45 years had received up to 10 million naira each (US\$ 56 000) to help them launch or expand their business, mitigate start-up risks or set up spin-offs from existing businesses. A fledgling ICT business and dental clinic figure among the recipients.

One of the goals of Vision 20:2020 is to diversify the economy, yet, by 2015, oil and gas still accounted for 35% of Nigeria's economic output and 90% of its exports, according to OPEC. With the Brent crude price having more than halved to about US\$ 50 since mid-2014, Nigeria has devalued the naira and announced plans to cut public spending by 6% in 2015. More than ever, economic diversification is an urgent necessity.

SENEGAL

A focus on higher education reform

In 2012, Senegal adopted a *National Strategy for Economic and Social Development for 2013–2017*, based on the vision of its *Senegal Emerging Plan*, Senegal's development plan for becoming an upper middle-income country by 2035. Both documents consider higher education and research as a springboard to socio-economic development and thus a priority for reform.

In early 2013, a national dialogue was held on the future of higher education. It produced 78 recommendations that the Ministry of Higher Education and Research has since translated into an action plan entitled *Priority Programme Reform and the Development Plan for Higher Education and Research, 2013–2017* (PDESR). This action plan was adopted in stages by the Presidential Council on Higher Education and Research through 11 presidential decisions taken by the Head of State, including a funding commitment of US\$ 600 million over five years.

In its first year of implementation, PDESR created three new public universities: the University of Sine Saloum of Kaolack in central Senegal, specializing in agriculture, the Second University of Dakar, situated 30 km from Dakar and specializing in basic sciences, and the Virtual University of Senegal. Within the plan, a network of vocational training institutes and upgraded laboratories has been developed with the introduction of high bandwidth to connect public universities with one another.

A lot remains to be done, however. There is little synergy in R&D, which suffers from a low budget and inadequate

equipment, a low status for researchers and a lack of university–industry linkages. Research results are also insufficiently applied, owing to weak oversight and relatively low scientific output (Figure 18.6).

New governing bodies and an astronomical observatory

The creation of a National Council of Higher Education, Research, Innovation, Science and Technology in 2015 should allow Senegal to meet some of these challenges. It will act as a consultative committee to the Minister of Higher Education and Research and as a monitoring body. The ongoing construction of Senegal's first planetarium and mini-astronomical observatory could also be a sign of a growing science culture.

A law passed in December 2014 should also help to galvanize research. The law creates a governing board for universities. Half of board members must be external to the university, such as from the private sector.

Another new development has been the creation of the Directorate-General for Research in 2014. Placed under the Ministry of Higher Education and Research, it is responsible for planning and co-ordinating research at the national level, especially that conducted by universities and academic research institutes. The ministry relies on the National Agency for Applied Scientific Research, the National Academy of Science and Technology of Senegal and the Senegalese Agency for Intellectual Property and Technological Innovation to promote Senegalese research.

Some national research institutions fall under the authority of other ministries, such as the Institute for Food Technology (Ministry of Mines and Industry), the Senegalese Institute for Agricultural Research and the National Institute for Soil Science (Ministry of Agriculture).

The Ministry of Higher Education and Research runs an extension programme called Centres for Research and Experimentation to promote technology transfer. These centres popularize innovative research that improves social welfare.

Several research funds, including one targeting women

The public sector uses a variety of instruments to fund research:

- the Impulse Fund for Scientific and Technical Research, set up in 1973 and transformed in 2015 into the National Fund for Research and Innovation;
- the Project for Supporting and Promoting Female Teachers and Researchers in Senegal (2013), which only funds women applicants;

18. See: www.youwin.org.ng

- the National Fund for Agricultural and Food Research, set up in 1999, which funds research and the commercialization of results for users; and
- the Fund for Scientific and Technical Publications, set up in the 1980s.

SIERRA LEONE



Inclusive, green and middle-income by 2035

Sierra Leone also aspires to become 'an inclusive, green middle-income country by 2035', in the words of the country's *Agenda for Prosperity: the Road to Middle Income Status, 2013–2018*.¹⁹ Current GDP per capita may be only US\$ 809 per year but the fact that GDP progressed by 20.1% in 2013 gives cause for hope of realizing this goal. Sierra Leone has, of course, been struggling with the Ebola epidemic. Some 95 health workers have died, a sad reminder of the country's inadequate health facilities: there is just one doctor for 50 000 people.

Among the *Agenda for Prosperity's* objectives to 2035, those which will depend upon science and technology include:

- a health care and delivery system within a 10-km radius of every village;
- modern infrastructure with reliable energy supplies;
- world-standard ICTs (just 1.7% of the population had internet access in 2013);
- private-sector led growth creating value-added products;
- an effective environmental management system in place that protects biodiversity and is capable of pre-empting environmental disasters;
- becoming a model in responsible and efficient natural resource exploitation.

In 2006, the Ministry of Education, Science and Technology engaged a participatory process for the drafting of the *Sierra Leone Education Sector Plan: a Road to a Better Future* (2007–2015). The *Plan* emphasizes human resource development, starting with the bottom of the pyramid. Despite this laudable intention, public expenditure on education only increased from 2.6% to 2.9% of GDP between 2007 and 2012. The share devoted to tertiary education likewise rose little: from 19% to 22% of total expenditure on education (0.7% of GDP in 2012). In the *Plan*, the ministry projected that student enrolment in public universities would rise to about 15 000 by 2015 and to 9 750 in private and distance institutions offering vocational training, including for teachers (MoEdST, 2007).

19. This document follows on from *Agenda for Change, 2007–2012*.

Fourah Bay College, founded in 1827, is the oldest Western-type university in West Africa. Currently, it is part of the University of Sierra Leone, the country's only university boasting a Faculty of Engineering and a Faculty of Pure and Applied Sciences.

TOGO



A first STI policy

In July 2014, Togo took a major step by developing its first *National Policy for Science, Technology and Innovation* and the action plan for its implementation. In addition, a Presidential Council on the Future of Higher Education and Research was established, following a national consultation. Togo has identified such a wide range of priority research areas that they encompass almost all scientific fields: agriculture, medicine, natural sciences, humanities, social sciences and engineering and technology.

The Ministry of Higher Education and Research is responsible for implementing science policy, in tandem with the Directorate for Scientific and Technical Research, which is in charge of co-ordination and planning.

Togo does not have a biotechnology policy but it does have a framework for biosafety. In April 2014, the Ministry of Environment and Forest Resources organized a consultative workshop to align Togo's revised biosafety law with international biosafety regulations and best practices (Box 18.1).

Togo's main research centres are the Universities of Lomé and Kara, together with the Institute for Agronomic Research, which manages an extension service. To date, though, the country has neither a structure for promoting research and technology transfer, nor any funding to drive it.

The country faces a host of other challenges, including poorly equipped – or even totally unequipped – laboratories, an unattractive working environment for scientists and a lack of information.

CONCLUSION

Research networks need sustainable funding

The overall development goal for ECOWAS countries is to attain lower or upper middle-income status. This ambition permeates their respective development plans and policies. Even for those countries which have moved into the middle-income bracket, there is the fundamental challenge of diversifying the economy and ensuring that wealth creation impacts positively on the lives of all citizens. Development entails building roads and hospitals, expanding railways, installing telecommunications,

developing a reliable, responsible energy network, improving agricultural productivity, producing value-added goods, improving sanitation systems and so on. Any one of these areas needs science or engineering, or both.

Countries have made a big effort in recent years to expand their university and research networks. These institutions must not remain empty shells. They must be nurtured, staffed with competent people who have the means to dispense quality education and conduct creative research that is responsive to socio-economic problems and market needs. That necessitates sustainable investment. In this regard, Nigeria's tax on businesses for use in upgrading universities serves as an interesting funding model that could be replicated in other West African countries which host multinationals.

ECOWAS countries are formulating beautifully crafted policies and programmes but these must also be implemented, funded and monitored, so that progress can be measured and future plans adapted to the shifting reality. New scientific programmes are emerging that are well-designed and well-funded, like the African Centres of Excellence (Table 18.1). Hopefully, these programmes will create a momentum that will have a lasting impact on these countries and the wider subregion.

In our view, there are five main challenges for the years to come. West African governments need to:

- invest more in science and engineering education, in order to develop the skilled labour force necessary to become a middle-income country within 20 years; the number of engineers and agricultural researchers is particularly low in most countries;
- establish viable national S&T policies, in other words, policies that are accompanied by an implementation plan that foresees an evaluation of implementation and a relevant funding mechanism for research and the commercialization of results;
- make a greater effort to reach the national target of devoting 1% of GDP to R&D, if they are serious about becoming middle-income countries within 20 years; greater government investment would have the advantage of allowing researchers to work on topics of national interest rather than those proposed by donors;
- encourage the business sector to participate more actively in R&D, in order to stimulate demand for knowledge production and technological development, while reducing budgetary pressure on governments, which tend to bear the greatest funding burden for R&D, along with donors; in this context, governments which have not yet done so should put in place national funds to help local innovators protect their intellectual property rights, as recommended by ECOPOST; other measures could include

making provision for representatives of the private sector to sit on the governing boards of universities and research institutes, as Senegal has done (see p. 494), tax incentives to support business innovation, the creation of science and technology parks and business incubators to encourage start-ups and public-private partnerships and research grants to support collaborative research between the government, industry and academia in priority areas;

- foster exchanges and intraregional collaboration among West African researchers, while maintaining partnerships beyond the subregion, in order to ensure the quality and impact of scientific production; the African Centres of Excellence project and the WAEMU centres of excellence offer a golden opportunity for researchers across the region to 'put their heads together' to solve common development problems and respond to market needs.

KEY TARGETS FOR SUB-SAHARAN AFRICA

- Raise GERD to 1% of GDP in all ECOWAS countries;
- Raise the share of public expenditure on agriculture to 10% of GDP in all ECOWAS countries;
- Establish a national fund in each ECOWAS country to help local innovators protect their intellectual property;
- Establish a free trade area and customs union in each regional economic community by 2017 and across the entire continent by 2019;
- A continent-wide African Common Market to be operational by 2023;
- Put in place a continent-wide economic and monetary union by 2028, with a parliament and single currency to be managed by the African Central Bank.

REFERENCES

- AfDB, OECD and UNDP (2014) *African Economic Outlook 2014*. African Development Bank, Organisation of Economic Cooperation and Development and United Nations Development Programme.
- AOSTI (2014) *Assessment of Scientific Production in the African Union, 2005–2010*. African Observatory of Science, Technology and Innovation: Malabo, 84 pp.
- ECOWAS (2011a) *ECOWAS Policy for Science and Technology: ECOPOST*. Economic Community for West African States.
- ECOWAS (2011b) *ECOWAS Vision 2020: Towards a Democratic and Prosperous Society*. Economic Community for West African States.

- Essayie, F. and B. Buclet (2013) *Synthèse : Atelier-rencontre sur l'efficacité de la R&D au niveau des politiques et pratiques institutionnelles en Afrique francophone*, 8–9 octobre 2013, Dakar. Organisation of Economic Cooperation and Development.
- Gaillard, J. (2010) *Etat des lieux du système national de recherche scientifique et technique au Bénin*. Science Policy Studies Series. UNESCO : Trieste, 73 pp.
- ISSER (2014) *The State of the Ghanaian Economy in 2013*. Institute of Statistical, Social and Economic Research. University of Ghana: Legon.
- Juma, C. and I. Serageldin (2007) *Freedom to Innovate: Biotechnology in Africa's Development*. Report of High-level Panel on Modern Biotechnology.
- MoEdST (2007) *Education Sector Plan – A Road Map to a Better Future, 2007–2015*. Ministry of Education, Science and Technology of Sierra Leone: Freetown.
- MoEnST (2010) *National Science, Technology and Innovation Policy*. Ministry of Environment, Science and Technology of Ghana: Accra.
- MoESC (2007) *Description du programme sectoriel de l'éducation 2008–2015*. Ministry of Education and Scientific Research of Guinea-Bissau: Conakry.
See: <http://planipolis.iiep.unesco.org>
- MoHER (2013a) *Décisions présidentielles relatives à l'enseignement supérieur et à la recherche*. Ministry of Higher Education and Research of Senegal: Dakar, 7 pp.
- MoHER (2013b) *Plan de développement de l'enseignement supérieur et de la recherche, 2013–2017*. Ministry of Higher Education and Research of Senegal: Dakar, 31 pp.
- MoHERST (2013) *National Science, Technology and Innovation Policy*. Ministry of Higher Education, Research, Science and Technology of Gambia: Banjul.
- MoSHESR (2009) *Document de politique nationale de l'enseignement supérieur et de la recherche scientifique*. Ministry of Secondary and Higher Education and Scientific Research of Mali: Bamako.
See <http://planipolis.iiep.unesco.org>
- MRSI (2012) *Politique nationale de recherche scientifique et technique*. Ministry of Research, Science and Innovation of Burkina Faso: Ougadougou.
- Nair–Bedouelle, S; Schaaper, M. and J. Shabani (2012) *Challenges, Constraints and the State of Science, Technology and Innovation Policy in African Countries*. UNESCO: Paris.
- NPCA (2014) *African Innovation Outlook 2014*. Planning and Coordinating Agency of the New Partnership for Africa's Development: Pretoria, 208 pp.
- NPCA (2011) *African Innovation Outlook 2011*. Planning and Coordinating Agency of the New Partnership for Africa's Development: Pretoria.
- Oye Ibidapo, O. (2012) *Review of the Nigerian National System of Innovation*. Federal Ministry of Science and Tehchnology of Nigeria: Abuja.
- Republic of Liberia (2012) *Agenda for Transformation: Steps Towards Liberia Rising 2030*. Monrovia.
- University World News (2014) Effective research funding could accelerate growth. *Journal of Global News on Higher Education*. February, Issue no. 306.
- Van Lill, M. and J. Gaillard (2014) *Science-granting Councils in sub-Saharan Africa. Country report: Côte d'Ivoire*. University of Stellenbosch (South Africa).

George Owusu Essegbey (b. 1959: Ghana) holds a PhD in Development Studies from the University of Cape Coast in Ghana. Since 2007, he has been Director of the Science and Technology Policy Research Institute of the Council for Scientific and Industrial Research Institute in Ghana. His research focus encompasses technology development and transfer, new technologies, agriculture, industry and environment.

Nouhou Diaby (b. 1974: Senegal) received his PhD in Geoscience and Environment from the University of Lausanne (Switzerland). He is currently working in Dakar as technical advisor to the Ministry of Higher Education and Research. In parallel, he teaches at Ziguinchor University and at the Institute of Science and the Environment at Cheikh Anta Diop University. Since 2013, he has been the focal point in Senegal for UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN).

Almamy Konte (b. 1959: Senegal) received his PhD in Physics from Cheikh Anta Diop University in Dakar. He works on innovation policy at the African Observatory of Science, Technology and Innovation in Malabo (Equatorial Guinea). He has over ten years of research and teaching experience in his field of expertise.