THE VIEW FROM THE FRONT LINE

Africa's nations are achieving some success in building their science capacity, but the foundations remain unsteady.

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The forecast for science in Africa has brightened over the past decade. After enduring civil wars and economic crises, many countries have entered a period of rapid growth and leaders are starting to see science and technology as the keys to progress. In 2006, members of the African Union endorsed a target for each nation to spend 1% of its gross domestic product (GDP) on research and development (R&D). And at a summit the following year, heads of state in Africa declared 2007 the year for scientific innovation.

The available data show much progress, but many nations have big gaps to overcome. In May, the African Union released *African Innovation Outlook 2010*, a survey of some of the scientifically most productive sub-Saharan nations. It showed that only three — Malawi, Uganda and South Africa — topped the 1% spending threshold in 2007; most remained far from that mark, even when the support from foreign donors was included. More recent spending totals are not available for most nations, but interviews with scientists and governmental officials across sub-Saharan Africa suggest that funding levels remain low.

Money is just one of many problems, as *Nature* reports in the following profiles of six nations that highlight some of the issues confronting the region. Many labs are poorly equipped, and science students get little practical research training because research centres are often separate from universities. Financial and logistical support for science is typically divided between many ministries with little coordination, and some states rely too much on intermittent foreign funding. Even when research is successful, it is hard to push developments to the marketplace. And poor governance — from corruption to ineffective bureaucracy — stymies progress in many nations.

Despite these hurdles, some African nations can point to notable achievements, in individual institutes and in areas of research. They will need to build on these advances if they are to have any hope of tackling the problems facing Africa today, such as poverty, rampant infectious diseases, the impacts of climate change and the lack of clean water and energy.

The progress described here too easily grinds to a halt when conflicts erupt or governments lose interest in supporting R&D. But science and technology leaders say that they are trying to develop and sustain capacity in the research that can most help their nations to develop. That hope has lured Wole Soboyejo, a professor of mechanical and aerospace engineering at Princeton University in New Jersey, temporarily back to Nigeria, where he grew up. As vice-president in charge of academic research and

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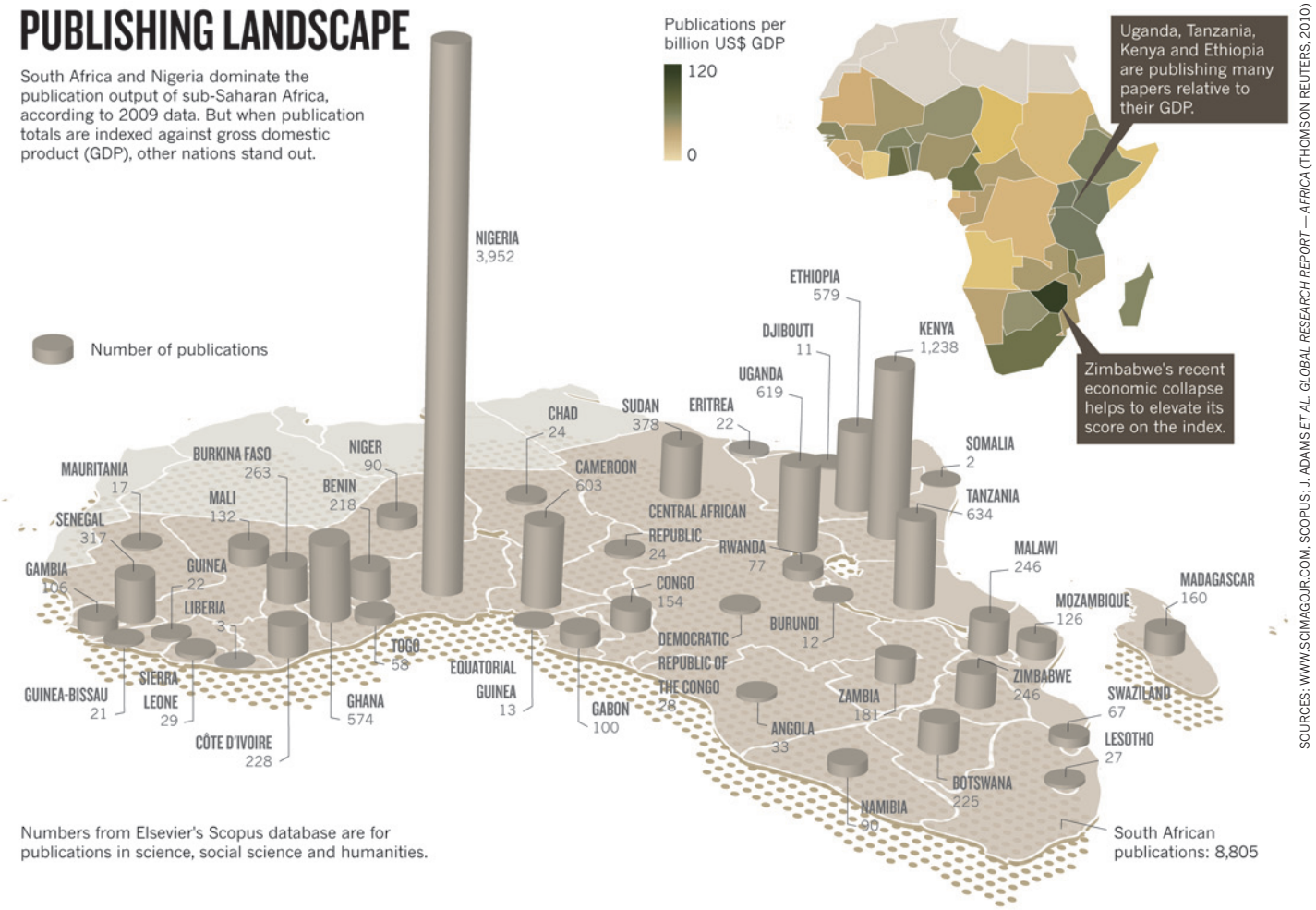

SOURCES: WWW.SCIMAGOJR.COM, SCOPUS; J. ADAMS *ET AL. GLOBAL RESEARCH REPORT — AFRICA* (THOMSON REUTERS, 2010)

innovation at the African Institute of Science and Technology (AIST) in Abuja, Soboyejo wants to reverse the brain drain that is robbing Africa of many leading scientists and engineers.

His goal is to train top students from across the continent, then to help establish them back in their home countries, where they can serve as seeds of excellence. "It has the potential to raise the level of the continent as a whole," he says.

NIGERIA: THE HEAVYWEIGHT

Africa's most populous nation wants to catapult itself into the world's top 20 economies by 2020. And science and technology is a central part of the strategy. Nigeria's president, Goodluck Jonathan, has a PhD in zoology, and in the first few weeks after being elected he approved a US$5-million grant to the Nigerian Academy of Science to support its work.

In terms of scientific publications, Nigeria is already a powerhouse of the region, coming in second to South Africa among sub-Saharan nations, according to an analysis of Elsevier's Scopus database. It outpaces South Africa in a few fields, such as food science and agronomy, and it boasts an AIST, which opened in 2008 and is drawing students from around the continent with its emphasis on innovation. But Nigeria publishes far less, relative to its GDP, than many other African nations (see 'Publishing landscape'). And it has fewer researchers, relative to its population size, than countries such as Cameroon, Gabon, Senegal and South Africa.

Scientific leaders say that the problems are systemic: poor science education, lack of equipment in labs, a dearth of funding and little appreciation for the role that science can have in helping the country. "Even though people see all the problems that confront us as a nation," says Oye Ibidapo-Obe, president of the Nigerian Academy of Science, "somehow scientists have not been able to convince the people that the solution lies in their libraries, in their workshops and in their laboratories."

Paul Orhii, director-general of the National Agency for Food and Drug Administration and Control, says that "this is not just the fault of the federal government". He places some of the blame on the private sector, which is not investing in research as much as it does in other nations. Umar Bindir, director-general of the National Office for Technology Acquisition and Promotion, has tried to change that with a programme that gets multinational companies doing business in Nigeria to give back by sharing technology or training.

On the horizon, Nigerians look forward to the imminent launch of a second national Earth-observing satellite, NigeriaSat-2, as well as the experimental NigeriaSat-X — the first satellite built by Nigerian engineers.

UGANDA: GROWING PAINS

In economic terms, Uganda is one of the success stories in sub-Saharan Africa. Its GDP has grown at an average rate of more than 7% between 2000 and 2010 and it weathered the recent economic crisis better than many of its neighbours. Likewise, the country's science sector has grown.

Under long-time president Yoweri Museveni, the country has been boosting its spending on R&D, from $73 million in 2005–06 to $155 million in 2008–09, which is close to 1% of the country's GDP.

And in 2006, the country won $30 million in low-interest loans as part of the World Bank's Millennium Science Initiative (MSI). That five-year project, implemented by the Uganda National Council for Science and Technology (UNCST), paid for the training of 102 scientists and engineers at the master's and doctorate levels. Among the research projects funded by the MSI programme is one at Med Biotech Laboratories in Kampala to develop a malaria vaccine that has undergone successful testing in baboons, says Thomas Egwang, the director of the non-profit lab.

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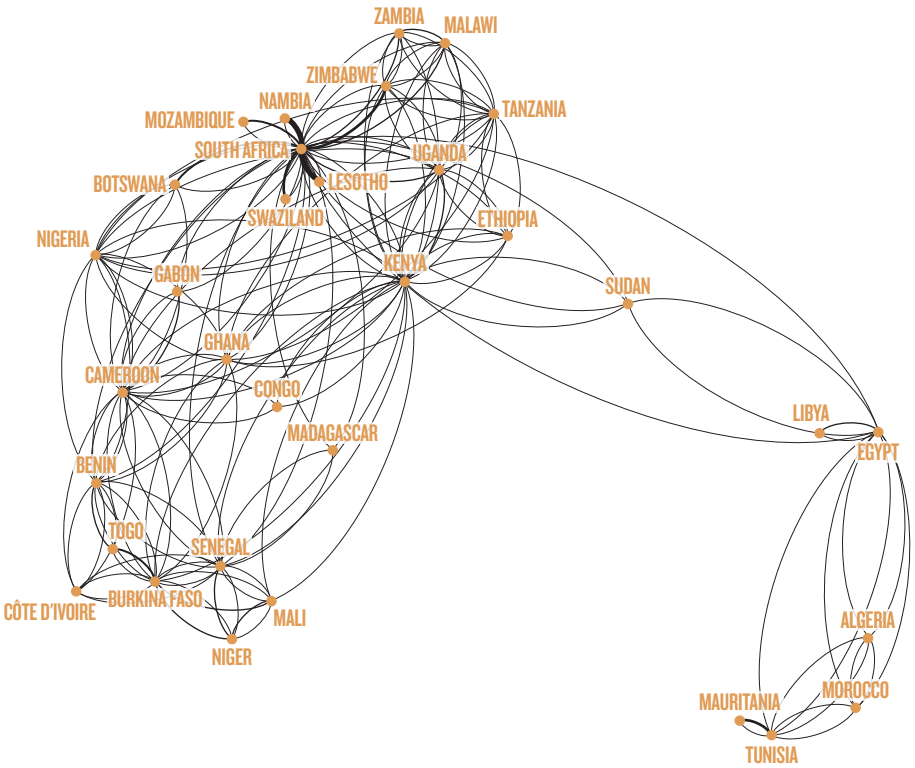
COUNTRY CONNECTIONS

South Africa and Kenya are major hubs for collaborations between African scientists. The thickness of lines between two countries represents the fraction of publications that involve authors from both.



SOURCE: *KNOWLEDGE, NETWORKS AND NATIONS* (R. SOC., 2011)

Uganda also invests substantially in agricultural science; it is one of the few sub-Saharan nations to spend more than 1% of its agricultural GDP on R&D in this sector. That funding helped the National Agricultural Research Laboratories at Kawanda to develop bananas enriched with vitamin A and iron that are now being tested, as well as genetically modified bananas resistant to the banana wilt disease.

But behind these highlights lie major concerns. Uganda has one of the lowest densities of researchers among the most scientifically advanced nations in sub-Saharan Africa: just 25 researchers per million inhabitants.

The country is trying to reduce its dependence on foreign donors, so it decided not to request additional loans through the World Bank when the MSI money runs out this year. The government promised to continue funding the MSI grants itself, but it did not allocate money for them in its recent budget.

Although research activities are growing in the country, observers say that the educational system is lagging. Only 6 of the 27 universities in Uganda offer science-related programmes; and even at those few universities, only one in five students pursues a degree in science.

Another problem that the country faces is that it has no science ministry, despite the government's promises last year to establish one. "They should create a ministry for us," says Peter Ndemere, executive secretary of the UNCST. "You need somebody in cabinet to defend your budget."

KENYA: IN SEARCH OF TALENT

Kenyan science is a study in contrasts. Among sub-Saharan nations, it ranks third — behind South Africa and Nigeria — in its output of scientific papers published in international journals, and its publishing outranks that of economic heavyweight Nigeria in fields such as environment, ecology and immunology. It is also a hub of collaborations on the continent (see 'Country connections'). But Kenya's research output has grown more slowly than most other sub-Saharan nations. In the recent African Union survey, Kenya scored last in terms of the increase in the numbers of published research papers, normalized for population size.

Most of the scientific work in Kenya is centred in government-owned research institutes that have extensive international collaborations. Among the most renowned is the Kenya Medical Research Institute (KEMRI), which has centres around the country and does basic research as well as developing drugs, vaccines and products such as diagnostic kits for HIV — an important service because Kenya lacks a thriving private sector for commercialization of research. KEMRI has a budget of $37.5 million, with 45% coming from its international collaborators, including the Wellcome Trust, a London-based medical research charity.

Other centres also stand out, such as the Kenya Agricultural Research Institute, headquartered in Nairobi, which has an international reputation for its work on crops and agricultural diseases. And the Kenya Marine and Fisheries Research Institute, headquartered in Mombasa, has a programme focused on mangrove research that is considered the best in sub-Saharan Africa.

By contrast, the universities suffer from lack of infrastructure and money. The government and donors have focused on boosting primary and secondary education, but have neglected universities, say observers.

The government invested only $3.6 million in 2010 on university-based research, according to Shaukat Abdulrazak, secretary of the National Council for Science and Technology. And there is a shortage of professors to serve a student population that grew from 90,000 in 2004 to more than 120,000 in 2008.

TANZANIA: EYEING INDEPENDENCE

Tanzania is overshadowed by neighbouring Kenya in most things — trade, political influence and traditionally also in science and technology. But in recent years, its government has taken steps towards strengthening homegrown research and cutting dependence on foreign funding.

At $234 million, or 0.48% of its GDP, Tanzania's research spending in 2007 was on a par with Kenya's as a proportion of GDP, according to the African Union's survey. But 38% of its R&D funding comes from abroad — as opposed to 18% in Kenya. This means that research funding is precarious for the country's academics.

Despite this, the country has pockets of long-established research excellence. The Ifakara Health Institute (IHI), a jewel of Tanzanian science, grew out of a partnership with the Swiss Tropical Institute and remains almost entirely funded by foreign partners. Researchers there have studied malaria in central Tanzania since the 1950s, and in 2009 it became the first institution in Africa to start clinical trials of RTS,S, a promising malaria vaccine.

The IHI's prominent malaria research is one reason why Tanzania scores as one of Africa's top five countries in terms of immunology publications, according to *Global Research Report — Africa* published by Thomson Reuters in April 2010. The country also ranks highly in social sciences and environmental science. However, agricultural research — the field in which more than half of the country's researchers work — does not excel.

In 2010, the country's president Jakaya Kikwete announced a financial boost for science. Funding for the Commission for Science and Technology (COSTECH), which gives out research grants, increased thirty-fold last year to $20 million. This funding will support 200 new PhD and master's students, agricultural research and technology transfer projects.

Hassan Mshinda, COSTECH's director, expects another increase this year. "The money has started to flow," he says.

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But the funding increase is throwing up a new problem for him: making sure the money ends up in the right hands. That means putting funding applications up for rigorous peer review, which has not happened in the past to Tanzania's public R&D funding. Some of the spending is going towards training reviewers and setting up quality-control mechanisms.

"We want to build a culture of competitive and peer-reviewed research," Mshinda says.

SENEGAL: AGEING EXPERTISE

At first glance, Senegal seems to be doing well in science. With 661 researchers per million inhabitants (see graph), the country is second to South Africa in researcher density, according to the African Union report. The people who work in R&D are also highly qualified compared with the African average: more than one-quarter have a PhD.

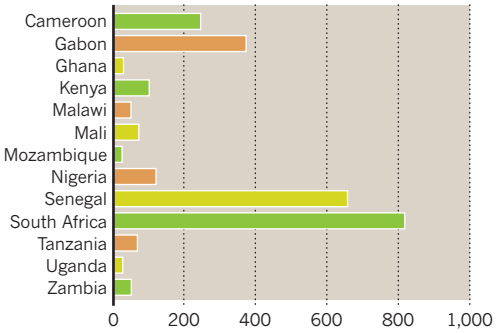
However, Senegal's scientists are getting old. More than half of its agricultural researchers were over 50 years old in 2007, in part because there was a slump in spending for higher education and research in the late 1980s and early 1990s. As agriculture is one of the areas in which the Senegalese government wants to invest, the country's scientific development depends on training and retaining enough early and mid-career scientists.

Historical ties with France have left a strong legacy in mathematics and physical sciences. In September, Senegal will officially open an African Institute for Mathematical Sciences in Mbour on the coast south of the capital Dakar. The institute is based on a model pioneered in Cape Town, South Africa (see page 567), and is the second in a network of such institutions that is planned across the continent.

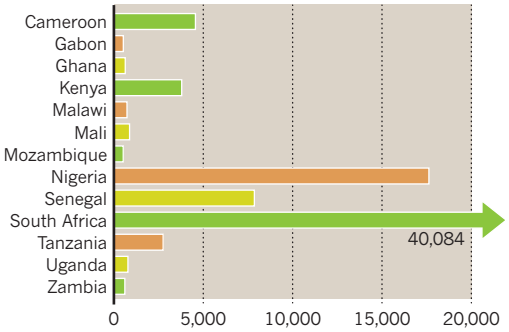
Like researchers in Tanzania, Senegal's receive more than 38% of their funding from abroad. And when foreign grants end, there is scarce national funding to sustain long-term research projects.

But the government's interest in science is growing. In October 2010, it vowed to boost funding in three areas of science: renewable energy, reducing soil salinity and seed development. The priority areas are matched with the country's biggest challenges: frequent power cuts are a bane of Senegal's citizens and businesses. Decades of drought have resulted in expanding areas with salty soils that don't support crops. And the World Food Programme estimates that 46% of households in Senegal are vulnerable to food shortages, with 20% considered highly vulnerable. The country is also creating a National Centre for Scientific and Technological Research to coordinate government policy across the ministries that deal with science.

RESEARCHERS PER MILLION INHABITANTS



NUMBER OF RESEARCHERS



SOURCE: *AFRICAN INNOVATION OUTLOOK 2010* (AU–NEPAD, 2010)

RWANDA: WIRED FOR SCIENCE

President Paul Kagame has frequently declared science to be a key part of Rwanda's development. In 2006, he established a ministry of scientific research and the following year he vowed to vastly increase the country's spending on the promotion of science, with a goal of reaching 3% of its GDP by 2012.

Since the 1994 genocide and civil war, Rwanda has rebuilt many of its institutions and has chalked up some notable successes in areas linked to science, such as reducing the prevalence of malaria and HIV/AIDS. And the country just finished laying 2,300 kilometres of fibre-optic cable to expand Internet access.

In its 2011–12 budget, released this month, the Rwandan government again announced plans to increase R&D spending, with a focus on constructing and equipping science laboratories and on health and agriculture research. Rwanda's officials are seeking to improve its capacity in part by partnering with other nations to promote skills, training and knowledge exchanges between scientists.

But researchers in Rwanda say the spending levels remain too low. According to information provided by various government agencies, Rwanda will spend just over $12 million on scientific research activities in the new budget.

The lack of support for research is causing science graduates to choose other professions. "Poverty is still an issue for the majority of graduates in science, and looking for jobs in other careers is the only option for them when money is short," says Hermogene Nsengimana, vice-dean of the faculty of science at the National University of Rwanda.

Rwanda's science output falls well short of its ambitions. It ranks 27th out of 43 sub-Saharan nations in publications, two places behind Namibia, which has just one-fifth the population. But Rwandan officials hope that the investments that they have made in rebuilding the country's infrastructure will eventually pay off.

AFRICA ON THE RISE

Despite the many problems confronting scientists in sub-Saharan Africa, there are signs that they are starting to build momentum. After a period of relatively slow growth during the 1990s and early 2000s, the output of publications is now rising rapidly. In 1996, sub-Saharan researchers produced roughly 0.8% of the total papers in the Scopus database. By 2009, that fraction had reached about 1%.

Part of this trend can be explained by increasing collaborations among researchers in Africa and the developed world. KEMRI in Kenya, for example, has seen its output grow by 45% in the last 5 years, with an increasing number of papers coauthored by researchers at institutions such as the London School of Hygiene and Tropical Medicine and the Centers for Disease Control and Prevention in Atlanta, Georgia. Other African institutes are seeing growth in collaborations with rapidly developing countries such as China (see page 560) and Brazil. Expanding access to the Internet across sub-Saharan Africa is one factor behind these intercontinental ties. But they also reflect the growing ambitions of Africa's own researchers. ■

"POVERTY IS STILL AN ISSUE FOR THE MAJORITY OF GRADUATES IN SCIENCE."

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