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ISSUE BRIEF

Coming to Life: Artificial Intelligence in Africa

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ALEKSANDRA GADZALA

Artificial intelligence (AI), which enables machines to exhibit human-like cognition, is unleashing the next wave of digital disruption. Global investment in AI skyrocketed to somewhere between $20 billion and $30 billion in 2016, with 90 percent of this spent on research and development and deployment, and 10 percent on AI acquisitions.[1] Investment has so far been dominated by digital giants like Google and Baidu, but private investors are also jumping in, fronting an estimated $4-$5 billion in venture capital in 2016, and another $1-$3 billion in private equity.[2] While many uses of AI are still in the experimental phase, commercial applications are already surfacing in a variety of sectors: AI systems filter emails, recommend items for purchase, provide legal advice, and drive cars.

The success of mobile technologies (tech) across Africa is prompting speculation among tech investors about whether AI applications will also take root in African nations. Mobile technologies, after all, have permitted African nations to dramatically increase their communication capabilities while leapfrogging the need for old-fashioned infrastructure. Will AI offer similar benefits?

Unfortunately, except in a handful of countries—namely Kenya, South Africa, Nigeria, Ghana, and Ethiopia—the application of AI is a chimera, not a reality. The critical factors necessary for the technology to take hold are woefully absent across most of the continent, and many African countries remain incapable of requisite reforms in the areas of data collection and data privacy, infrastructure, education, and governance. Without those reforms, there is little chance that most African nations will be able to exploit AI technologies to advance sustainable development and inclusive growth. The specter of automation threatens to leave these countries behind.

But there are a few African countries where the factors needed for the successful adoption of AI technologies are rapidly converging. In these

1 Jacques Bughin et al., "Artificial Intelligence: The Next Digital Frontier?," (paper presented at the 2017 Viva Technology Forum, Paris, France, June 14, 2017), https://www.mckinsey.com/~/media/McKinsey/Industries/Advanced%20Electronics/Our%20Insights/How%20artificial%20intelligence%20can%20deliver%20real%20value%20to%20companies/MGI-Artificial-Intelligence-Discussion-paper.ashx.

2 Jacques Bughin et al., "Artificial Intelligence."

nations, AI initiatives are still mostly small-scale, pilot, or ad hoc—but appear promising and have thus attracted significant backing from global corporations. This issue brief examines the obstacles to AI's broader adoption across the African region and explores the enabling factors underpinning its promise in the handful of African countries where, despite significant challenges, AI ventures are enjoying early success.

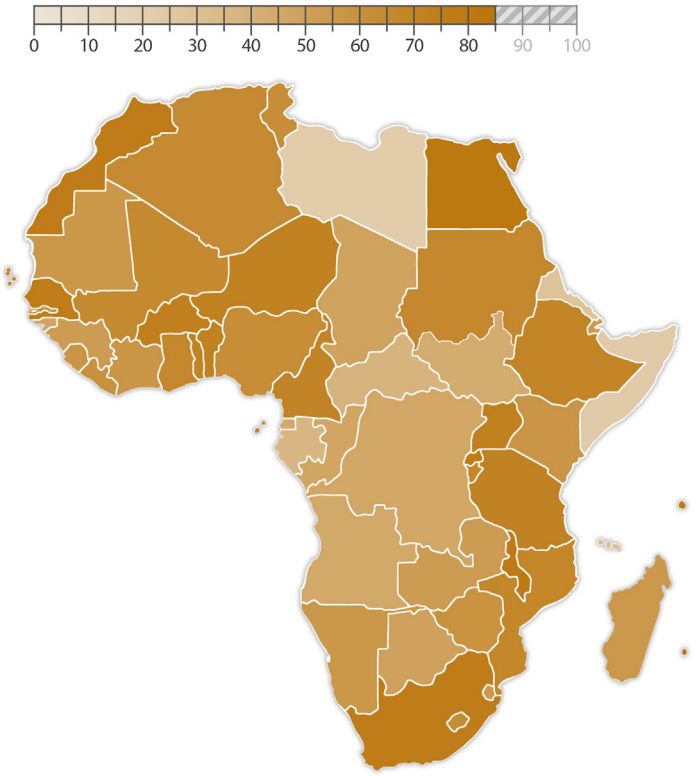
> "Without those reforms, there is little chance that most African nations will be able to exploit AI."

An Uneasy Environment for AI

At its most basic, artificial intelligence uses algorithmic techniques loosely modeled on the human brain to enable machines to discover patterns, generate insights from the data to which they are exposed, and then apply those lessons learned to future decision making and predictions. AI, in the form of virtual assistants like Apple's Siri or Amazon's Alexa, uses algorithms to match single voiceprints against subsequent repetitions of the same phrase to learn and predict natural-language requests. Learning thermostats like Nest, which was acquired by Google in 2014 for $3.2 billion,[3] also use behavioral algorithms to learn individual heating and cooling needs and adjust the temperature in the user's home based on her personal preferences. AI is also now being used in more complex applications including the analysis of large genome sets in an effort to prevent diseases, and the mapping of human mobility patterns to predict and control humanitarian crises.

To perform such functions AI depends on robust digital foundations, which include the availability of large volumes of data—usually referred to as "big data." Machines can analyze this data to learn, make connections, and arrive at decisions. But AI also relies on significant know-how among its human adopters: industry leaders must know how to successfully implement AI into their operations, and consumers must be comfortable with its use (and that includes a reasonable assurance of data privacy). With the exceptions of Kenya, South Africa, Nigeria, Ghana, and Ethiopia—where these factors are rapidly coming together on the back of other enabling factors—most African countries currently struggle to meet any or all of these requirements.

STATISTICAL CAPACITY INDICATOR FOR AFRICAN COUNTRIES IN 2017



Source: The World Bank Databank, Statistical Capacity Indicator, http://datatopics.worldbank.org/statisticalcapacity/SCIdashboard.aspx.

Africa's Data Challenge

The near-ubiquity of mobile phones—nearly one per person[4]—and the growing popularity of social media and messaging applications (apps) across Africa has

3 Aaron Tilley, "Google Acquires Smart Thermostat Maker Nest for $3.2 Billion," *Forbes*, January 13, 2014, https://www.forbes.com/sites/aarontilley/2014/01/13/google-acquires-nest-for-3-2-billion/#544ad9696ee2.

4 *Sub-Saharan Africa: Ericsson Mobility Report*, Ericsson, November 2016, https://www.ericsson.com/assets/local/mobility-report/documents/2016/ericsson-mobility-report-november-2016-rssa.pdf.

Africa and the EU's General Data Protection Regulation (GDPR)

Among the data challenges faced by AI providers in African markets—especially those with cross-border operations—is the lack of a unifying pan-African data protection framework. Data protection efforts differ significantly from country to country, particularly on matters of cross-border data transfers and data breach notification protocols. Here, the European Union's (EU) GDPR may be instructive. The GDPR is automatically enforceable within member states and, unlike the 2014 AU Convention, does not have to be transposed into member state legislation. By unifying the EU's personal data regime, the regulation makes it easier for organizations with a European Union presence to streamline their compliance activities across their EU footprint. Aside from being a good example of data protection legislation, the GDPR presents a timely opportunity for African countries to strengthen their data protection frameworks: any African business that processes the data of EU-based individuals—e-commerce companies, for instance—has to comply with the GDPR.

made data more readily available. Governments, development programs like the World Bank's "Listening to Africa" initiative, and market research companies increasingly rely on mobile phone surveys and user data to collect insights into local populations. Still, even in countries where AI holds promise, the quality, timeliness, and availability of data on critical indicators—data on births and deaths; growth and poverty; taxes and trade; health, schooling, and safety; and land and the environment—and the surrounding necessary data protections are often poor in quality or missing.[5]

Globally, Africa has the lowest average level of statistical capacity. Only half of African countries have carried out more than two comparable household surveys in the past ten years; just 29 percent have published household surveys with education data since 2005;[6] and statistical capacity has, over the last fifteen years, declined more in Africa than in any other region of the world.[7] The weaknesses of the data are expressed in the instability of even headline statistics like economic growth and population size. Nigeria's recent switch to a new base year after a twenty-year delay led to a rebased estimate of gross domestic product (GDP) in 2013 that is approximately 89 percent higher than the earlier estimate for the same year, a figure the *Economist* described as "dodgy."[8] Projections of the country's population—estimated to be the largest in Africa—are also based on census data that the former head of the National Population Commission has called inaccurate.[9]

Lacking or faulty data severely limits the efficacy of AI systems. Discrepancies between on-the-ground realities and data input into AI systems may cause systems to learn incorrectly, yielding erroneous outputs. Skewed input data additionally opens the door for the reproduction and even amplification of human biases and discrimination—an issue that is especially sensitive in countries like Ethiopia and Kenya where long-standing ethnic tensions continue to inform politics and business. Such drawbacks jeopardize the likely benefits to be derived from data sharing, or open access data, which is central to research and development and innovation. When in 2011 Kenya became the first sub-Saharan country to launch a national open data initiative and made public sector information digitally available, it was met with much excitement.[10] The initiative faltered, however, as government ministries were reluctant to release data or the data that were released were poorly structured, outdated, or inconsequential. The initiative was redesigned and relaunched in 2015

5 "Nigeria's GDP: Step Change," *Economist*, April 12, 2014, https://www.economist.com/finance-and-economics/2014/04/12/step-change.

6 Jean-Paul van Belle et al., *The Africa Data Revolution Report 2016: Highlighting Developments in African Data Ecosystems*, United Nations Economic Commission for Africa; United Nations Development Programme; Open Data for Development Foundation; World Wide Web Foundation, 2017, https://www.uneca.org/sites/default/files/uploaded-documents/ACS/africa-data-revolution-report-2016.pdf.

7 Florian Krätke and Bruce Byiers, *The Political Economy of Official Statistics: Implications for the Data Revolution in Sub-Saharan Africa*, PARIS21, December 2014, http://www.paris21.org/sites/default/files/PARIS21-DiscussionPaper5_0.pdf.

8 "Nigeria's GDP."

9 "Why Nobody Knows How Many Nigerians There Are," *Economist*, June 20, 2017, https://www.economist.com/the-economist-explains/2017/06/20/why-nobody-knows-how-many-nigerians-there-are.

10 Claire Provost, "Kenya Opens Its Books in Revolutionary Transparency Drive," *Guardian*, July 13, 2011, https://www.theguardian.com/global-development/poverty-matters/2011/jul/13/kenya-open-data-initiative.

with improvements in quality and an increase in the number of datasets available.

The push for more and better data across Africa is hamstrung by insufficient regulations to protect against data misuse and to ensure personal privacy. The African Union's (AU) Convention on Cybersecurity and Data Protection encourages African governments to recognize the importance of data security and provides a framework for leaders to integrate into their respective legislations. Adopted by the AU in 2014, the Convention has yet to take effect as only ten out of the fifty-four AU member states have ratified it.[11] In Kenya, a data protection law has been making its way through parliament for the last six years; a recent draft was published in June 2018.[12] In Nigeria, personal privacy is *de jure* guaranteed by Section 37 of the constitution. *De facto*, the constitutional promise remains unsupported by comprehensive legislation—a data protection bill introduced in 2010 is still making its way through parliament—leaving citizens exposed to likely data abuses and rights violations. Data privacy groups worry that some governments may have a vested interest in obstructing such regulations in order to access citizen data—or that, if introduced, regulations may curb free speech.

A Missing (Knowledge) Base for Adoption

Concerns over data privacy are met with additional anxieties over automation and potential job losses resulting from the adoption of artificial intelligence solutions. According to the Oxford Martin School at the University of Oxford, 85 percent of Ethiopian jobs are at risk of being replaced by automation. In South Africa, the number is 67 percent and in Nigeria, it is 65 percent.[13] Without a clear understanding of the potential advantages of AI solutions—the potential to improve monitoring and forecasting, optimize operations, develop targeted pricing and marketing solutions, and enhance user experiences, for example—and a workforce able to onboard and take advantage of AI solutions, demand for AI in most African countries is likely to remain low.

Education and skills training remain a critical challenge. The skills base of the continent's workforce is lower than that of any other global region as indicated by the World Economic Forum's (WEF) Human Capital Capacity Index, which reflects the percentage of a region's workforce that has attained tertiary, secondary, and primary education as well as the percentage that has literacy and numeracy skills.[14] Ethiopia is one of the lowest performers on the Index, fourth from the bottom (above only Senegal, Mauritania, and Yemen).[15] Despite the fact that Ethiopian government spending on education nearly doubled between 2000 and 2013,[16] improvements in youth literacy and student enrollment rates have been disappointing. Only one-fifth out of every 1,000 children who starts school advances beyond the eighth grade,[17] and those who do progress learn on average only 40 percent of the material they are expected to master.[18] Nigeria also ranks in the bottom twenty countries of the WEF index, at 114th out of 130 countries. With an estimated 10.5 million children out of school, Nigeria's unenrolled rate is the highest in the world,[19] and its primary and secondary school systems are largely failing.[20] Without significant im-

11 Abdi Latif Dahir, "Africa Isn't Ready to Protect Its Citizens Personal Data Even as EU Champions Digital Privacy," *Quartz Africa*, May 8, 2018, https://qz.com/africa/1271756/africa-isnt-ready-to-protect-its-citizens-personal-data-even-as-eu-champions-digital-privacy.

12 Duncan Miriri, "Kenya to Publish Draft Data Protection Bill this Month: Minister," Reuters, June 11, 2018, https://www.reuters.com/article/us-kenya-dataprotection/kenya-to-publish-draft-data-protection-bill-this-month-minister-idUSKBN1J71S5.

13 Carl Benedikt Frey et al., *Technology at Work v2.0: The Future Is Not What It Used to Be*, Citi GPS, January 2016, https://www.oxfordmartin.ox.ac.uk/downloads/reports/Citi_GPS_Technology_Work_2.pdf.

14 Ricard Samans et al., "The Global Human Capital Report 2017: Preparing People for the Future of Work" (paper presented at the World Economic Forum, Davos, Switzerland, September 13, 2017)., http://www3.weforum.org/docs/WEF_Global_Human_Capital_Report_2017.pdf.

15 Ricard Samans et al., "The Global Human Capital Report 2017."

16 Dr. Jeffrey Sachs et al., *Global Education Monitoring Report 2016. Education for People and Planet: Creating Sustainable Futures for All*, United Nations Educational, Scientific, and Cultural Organization, September 6, 2016, http://unesdoc.unesco.org/images/0024/002457/245752e.pdf.

17 *Education Sector Development Programme V*, Federal Ministry of Education of the Federal Democratic Republic of Ethiopia, August 2015, http://planipolis.iiep.unesco.org/sites/planipolis/files/ressources/ethiopia_esdp_v.pdf.

18 Tom Gardner and Commentary, "Ethiopia's Remarkable Education Statistics Mask a System in Crisis," *Quartz Africa*, December 28, 2017, https://qz.com/africa/1163797/ethiopias-remarkable-education-statistics-mask-a-system-in-crisis.

19 "Overview: The Situation," United Nations Educational, Scientific, and Cultural Organization, accessed September 5, 2018, https://www.unicef.org/nigeria/overview.html.

20 Feyi Fawehinmi and Commentary, "President Buhari's Slips, Nigeria's 'Lazy' Youth and a Looming Education Crisis," *Quartz Africa*, April 22, 2018, https://qz.com/africa/1258991/nigerias-buhari-unemployed-youth-and-an-education-crisis.

iCog Labs organized Africa's first robot soccer match at Ethiopia's Ministry of Science and Technology in March 2017. *Photo Credit: iCog Labs*

provements, neither Ethiopia nor Nigeria can hope to produce an AI-ready workforce, which must be well-versed in advanced digital skills and data science, and also in complementary disciplines like economics and psychology that become more important as more jobs become automated.

Companies also need employees with the technical skills necessary to understand the business case for AI and to successfully engage suppliers and consumers. This requires the ability to separate the excitement surrounding AI from its actual capabilities in specific, real-world contexts. It includes a pragmatic view of AI's capabilities and limitations, which requires at least a high-level grasp of how AI works and how it differs from other conventional technologies. Even in "developed" markets, few firms have so far deployed AI at scale, as they remain uncertain of either the business case or the likely return on investment.[21] In African countries where data ecosystem and infrastructure are wanting, and the workforce is not yet equipped with the skills necessary to adopt and advance AI solutions, the case for the widespread adoption of the technology is often even less clear.

Where AI Succeeds

Significant hurdles notwithstanding, AI solutions are being successfully deployed at scale in some African countries and especially in Kenya, Nigeria, Ghana, Ethiopia, and South Africa. Most solutions currently target the financial services, agriculture, and healthcare sectors.

South Africa leads the continent in AI adoption with a robust ecosystem that includes numerous technology hubs, research groups, and forums like the AI Summit—which is sponsored by multinational companies including Intel, Salesforce, Amazon, and IBM—and Singularity University's South Africa Summit. There are an estimated one-hundred-plus companies in South Africa that are either integrating AI solutions into their existing operations or that are developing new solutions using AI.[22] Elsewhere, technology giants including IBM, Microsoft, Google, and Facebook are also making in-

21 Jacques Bughin et al., "Artificial Intelligence."
22 Alexander Ferrein and Thomas Meyer, "A Brief Overview of Artificial Intelligence in South Africa," *AI Magazine*, 2012, 99-101.

roads. Google's next AI research lab—its first in Africa—will open in Accra, Ghana, later in 2018. IBM operates AI-oriented research labs in Kenya and South Africa. In Kenya, IBM's $100 million initiative, "Project Lucy," an extension of the company's supercomputer "Watson," is working to address development challenges including healthcare, financial inclusion, water and sanitation, human mobility, and agriculture. Facebook opened its first African technology hub in Lagos earlier in 2018. Among the available training programs is a year-long AI Research Residency Program with the company's AI Research Group.

Smaller, somewhat less coordinated efforts are also surfacing. iCog Labs is a privately operated AI research lab in Addis Ababa, Ethiopia. iCog Labs launched in 2013 with $50,000 and four programmers,[23] including the founder and chief executive officer of SinguarityNET, a global AI marketplace, and chief scientist of Hanson Robotics, the Hong Kong-based engineering and robotics company famed for its development of the interactive humanoid robot, "Sophia." The venture provides a variety of AI research and development services for Ethiopian and international customers and educates young Ethiopians in computer coding, hardware, and entrepreneurship. Many of iCog Labs' domestic pursuits align with the government's development priorities, especially in the areas of education and agriculture. Like many emergent AI and technology ventures across the African region, iCog Labs reflects a forward-looking vision for the continent with an ever-more blurred line between public and private sector-led development solutions.

In Nigeria, a chatbot called Kudi AI is integrated into Facebook's Messenger app, and facilitates mobile banking and payment services to users who may not have access to, or may be unfamiliar with, browser-based online banking but are comfortable with text-based messaging.[24] With over 5,000 users since its launch in 2017,[25] Kudi, which receives seed funding from the Silicon Valley incubator Y-Combinator, is among a growing number of AI-powered apps designed to extend financial services to underserved populations. In like manner, MomConnect, a chatbot initiated by South Africa's National Department of Health, connects an estimated 1.8 million expectant mothers with pre-and post-natal services. Registered women are able to "chat" with the app and receive healthcare advice relevant to their pregnancy.[26] Delivering services is a big opportunity for AI in African markets—this includes social as well as commercial services. IBM launched its Watson Workspace, a messaging app designed to streamline corporate workflow, in Nigeria in August 2018. The app has been adopted by Descasio, Nigeria's leading cloud services provider, to enhance its email services and improve employee collaboration.[27]

> "AI ventures can succeed in select African markets when key enabling factors are in place."

The apparent success of these and other AI ventures in select African markets occurs in spite of numerous data, regulatory, and workforce challenges. Various factors conspire to facilitate this success, but several are especially key for fostering favorable AI environments in African countries.

Existing Digital Foundations

Early adopters of AI in developed economies tend to be companies that are advanced in their digital transformations and have the right assets in place in order to be able to effectively deploy the technology.[28] In African markets where AI is taking root, digital foundations in the form of widespread mobile phone penetration and established mobile technology solutions are also in place. Such foundations ensure a baseline

23 Thomas Lewton, "Futurists in Ethiopia are Betting on Artificial Intelligence to Drive Development," *Quartz Africa*, June 13, 2018, https://qz.com/africa/1301231/ethiopias-futurists-want-artificial-intelligence-to-drive-the-countrys-development.

24 "Frequently Asked Questions," Kudi, accessed September 5, 2018, https://kudi.ai/faq.html.

25 "Nigeria's Kudimoney.com Applies for Banking License to Launch Country's Online-Only Bank of the Future," *TechMoran*, May 5, 2017, https://techmoran.com/nigerias-kudimoney-com-applies-banking-license-launch-countrys-online-bank-future.

26 Toby Shapshak, "South African Messaging Wonder MomConnect Launches on WhatsApp," *Forbes*, December 4, 2017, https://www.forbes.com/sites/tobyshapshak/2017/12/04/african-messaging-wonder-momconnect-launches-on-whatsapp/#109c4ac27c3b.

27 Jumoke Akiyode-Lawanson, "IBM Introduces AI-Powered Solution in Nigeria," *Business Day*, August 21, 2018, https://www.businessdayonline.com/companies/technology/article/ibm-introduces-ai-powered-solution-nigeria.

28 Bughin et al., "Artificial Intelligence."

A Kenyan farmer uses the precision farming app UjuziKilimo. *Photo Credit: UjuziKilimo.*

of technological infrastructure—sufficient mobile and Internet connectivity—and consumer awareness and acceptance of technology-driven solutions on which AI providers can build trust and discover new avenues for consumer engagement.

Mobile phone penetration in Kenya, for example, is 94 percent;[29] almost a quarter of the country's households have an Internet connection—among the highest in the developing world. In a population of about 48 million, there are at least seven million Kenyan Facebook accounts and another ten million on WhatsApp.[30] MPesa, the country's mobile money transfer platform, today has the highest number of mobile money transactions in the world—equal to almost one-third of Kenya's GDP.[31] Such an environment makes it easier for AI providers to merge their solutions with existing ones. AI apps like UjuziKilimo, for instance, a precision farming app that uses machine learning and data analytics to help Kenyan farmers optimize their irrigation practices, relies on established SMS technology for its interface.[32] In Nigeria, where mobile phone penetration is 84 percent[33] and technology start-ups attract on average $73,000 in investment,[34] ventures pursuing the AI market also leverage existing mobile solutions. Ubenwa, a Nigerian startup working to detect birth asphyxia, uses inbuilt smartphone microphones and speech recognition algorithms to identify the condition based on the amplitude and frequency of an infant's cry.[35]

AI companies in African markets with robust digital foundations are able to capitalize on earlier waves

29 *Third Quarter Sector Statistics Report for the Financial Year 2017/2018 (1st January – 31st March 2018)*, Communications Authority of Kenya, July 2018, http://www.ca.go.ke/images/downloads/STATISTICS/Sector%20Statistics%20Report%20Q3%202017-18.pdf.

30 Nanjala Nyabola, "Kenya's Technology Evolved. Its Political Problems Stayed the Same," *MIT Technology Review*, August 22, 2018, https://www.technologyreview.com/s/611833/kenyas-technology-evolved-its-political-problems-stayed-the-same.

31 Nyanjala, "Kenya's."

32 "UjuziKilimo: Farm Specific and Actionable Advice by SMS," UjuziKilimo, accessed September 5, 2018, http://www.ujuzikilimo.com/sms.html.

33 Adeyemi Adepetun, "Nigeria's Mobile Phone Penetration Hits 84 Per Cent," *Guardian Nigeria*, March 16, 2018, https://guardian.ng/business-services/nigerias-mobile-phone-penetration-hits-84-per-cent.

34 Matthew Green, "Nigeria's Booming Start-up Scene Draws Foreign Investment," *Financial Times*, November 6, 2017, https://www.ft.com/content/ffb3b3f8-a511-11e7-8d56-98a09be71849.

35 "Overview," Ubenwa, accessed September 5, 2018, http://ubenwa.com/index.html#overview.

of technological innovation and to leverage existing technology providers as early adopters—chatbots for financial technology (fintech) platforms, for instance. They also have at their disposal consumers who are generally familiar with and open to innovative tech-driven solutions.

Government Support

AI holds promise in countries where governments have made technology a national priority and are taking concerted measures to stimulate innovation and to improve data protection, research, and development. Kenya, Ghana, South Africa, Ethiopia, and Nigeria are the nations in which the efforts are most aggressive and advanced—and not surprisingly, they are the nations in which AI technologies are beginning to pay off.

The Kenyan Ministry of Information, Communication, and Technology (ICT), for example, has established an eleven-person "Blockchain and Artificial Intelligence Taskforce," to explore how the technologies can best be used to advance the country's development. With a three-month tenure, the team is to propose a fifteen-year roadmap with key milestones in 2027 and 2037.[36] In Nigeria, the government has similarly approved the establishment of an agency on robotics and AI for the southeast region. Generally regarded for its energy industry, the Nigerian southeast has long been one of the country's most entrepreneurial areas. Over the last eight years, and with little fanfare, tech hubs and start-up communities have been burgeoning in areas outside of Lagos—Enugu, Abuja, Ibadan, Port Harcourt—diversifying Nigeria's innovation landscape.[37] The new AI agency is a nod to this reality. It is also a likely effort to attract financing, as well as an encouraging sign that other building blocks necessary for AI to develop and scale are likely to follow.

A growing number of African governments are beginning to realize that they cannot on their own fulfill their development goals: commercial technology solutions will play a bigger role in fixing issues previously entrusted to government bureaucrats and aid agencies. Governments are also beginning to realize that for such solutions to prevail, critical regulatory and infrastructure bottlenecks must be eliminated or improved. Leaders in Ghana and South Africa have enacted comprehensive data protection legislation—two of only eleven sub-Saharan countries to have done so thus far.[38] Ghana's 2012 Data Protection Act regulates how personal information is acquired, stored, and disclosed. The Protection of Personal Information Act, signed into law in South Africa in 2013, similarly introduces an overarching framework for processing personal information and sets up a supervisory function to ensure legislative compliance. Like Kenya, Ghana is one of the few African countries with an open data initiative. In order for technological innovations to be successful in the long term, progress and innovation in government policies is also necessary.

EZ-Farm: Using AI to Improve Food Security in Kenya

EZ-Farm is an IBM project designed to help Kenyan farmers better manage water resources for irrigation and monitor crop health. The remote monitoring solution relies on sensors placed at farms to capture data on water tank levels, soil moisture, and rates of photosynthesis. The data is securely streamed to the cloud, where machine learning systems measure how the plants are doing and then transmit the insights to the farmer on her mobile phone. The agriculture sector is one in which AI solutions are being deployed at scale in Kenya and other select African markets.

A Culture of Research and Innovation

Among the reasons behind Google's decision to locate its AI research lab in Ghana is the country's "strong ecosystem of local universities"[39] and expanding network of technology hubs. Ghana has twenty-four tech hubs[40]—the most in sub-Saharan Africa after

36 Rachael Odhiambo, "Kenya Launches Blockchain and Artificial Intelligence Taskforce," *BitcoinAfrica*, March 1, 2018, https://bitcoinafrica.io/2018/03/01/kenyablockchain-and-artificial-intelligence-taskforce.

37 Paul Adepoju, "Why Nigeria's Newest Start-ups are Sprouting Outside the Megacity of Lagos," *Quartz Africa*, September 21, 2015, https://qz.com/africa/506450/why-nigerias-newest-start-ups-are-sprouting-outside-the-megacity-of-lagos.

38 The eleven countries are Angola, Benin, Burkina Faso, Gabon, Ghana, Côte d'Ivoire, Lesotho, Madagascar, Mali, Senegal, and South Africa.

39 "Google AI in Ghana," *Google Africa Blog*, June 13, 2018, https://africa.googleblog.com/2018/06/google-ai-in-ghana.html.

40 Abdi Latif Dahir, "Africa's Newest Startup Hubs are Expanding Beyond Its Legacy Tech Markets," *Quartz Africa*, March 21, 2018, https://qz.com/africa/1234168/africas-newest-tech-hubs-are-in-senegal-ghana-cote-divoire-zimbabwe-uganda.

South Africa (59), Nigeria (55), and Kenya (30)—ten public universities, and several private institutions, many of which maintain partnerships with universities around the world. For example, the Ghana Technology University College, which was founded in 2005 by Ghana Telecom, the national telecommunications company, has scholarly links to schools in the United States, Kenya, Germany, Denmark, South Korea, and the United Kingdom. It offers various degree programs, including a Master of Science in "Entrepreneurship and Technology."[41]

Universities and tech hubs are key channels through which African countries can acquire, domesticate, and diffuse new technologies in the economy. Even more importantly, they are critical for identifying emerging technologies that can serve as a platform for producing new products and services to address local challenges. At the "Artificial Intelligence and Robotics Center of Excellence" at Addis Ababa Science and Technology University, researchers are developing AI-powered solutions for Ethiopia's agriculture sector—flying insect robots, for instance, to assist with crop surveillance.[42] Despite the country's overall poor education, efforts are being made to develop science and technology skills. Ethiopia has over thirty official universities and around 130 polytechnics, most of which emphasize technology,[43] and many of which have collaborations with the country's emergent tech hubs—Bluemoon, IceAddis, and Sheba Valley. Similar collaborations between South African universities and technology hubs haven proven to be strong drivers of AI innovation. The LaunchLab at Stellenbosch University, for example, successfully incubates student-led start-ups in areas including blockchain, fintech, 3D printing, and AI. Other notable South African AI initiatives include the Centre for Artificial Intelligence Research (CAIR), a joint initiative of the School of Mathematics, Statistics, and Computer Science at the University of KwaZulu-Natal and the Council for Industrial Research; the Computational Intelligence Research Group at the University of Pretoria; Robotics and Agents Lab at the University of Cape Town; and the Mobile Intelligence Autonomous Systems, which develops autonomous navigation systems.[44]

Sandboxing for AI Innovation

Regulatory sandboxes—controlled innovation environments that facilitate cooperation between policy makers, regulators, and innovators—are increasingly being used by governments around the world to observe the implications of fintech initiatives in their country and develop suitable regulations. A similar "sandboxing" concept can be applied for AI solutions and data protection legislation. For example, the United Kingdom's Financial Conduct Authority (FCA) has, since 2016, made available a regulatory sandbox for technology firms to identify appropriate consumer protection safeguards that should be built into their products and services.[1] Similar efforts would go a long way in facilitating more applicable and robust data protection measures in African countries.

[1] "Regulatory Sandbox," Financial Conduct Authority, accessed September 5, 2018, https://www.fca.org.uk/firms/regulatory-sandbox. goatsandsoda/2016/03/04/469070891/mad-max-is-mad-about-namibia-but-some-namibians-are-mad-at-the-crew.

Connecting universities with tech hubs promotes innovation in AI and other disruptive technologies by bringing together teaching, research, product development, and commercialization—functions that are often kept separate. The value in this approach is that it creates full value chains for specific AI solutions and connects key stakeholders through continuous interaction.

Global Support

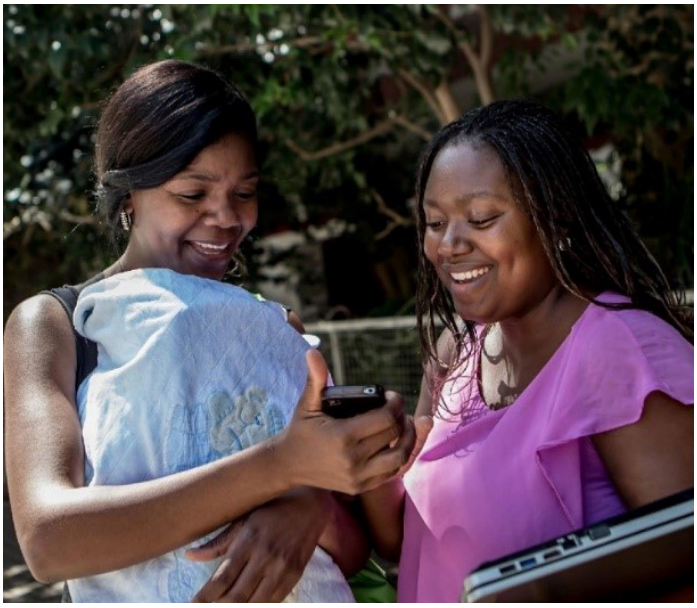
Most successful AI ventures in Africa are supported by global partnerships that facilitate either financing or know-how—or both. iCog Labs is backed by SingularityNET, two American AI firms, and Humanity+, an international organization focused on the ethical use of emerging technologies to advance human development. The technology behind Kudi AI

41 "MSc Business Entrepreneurship and Technology," Ghana Technology University College, accessed September 5, 2018, http://site.gtuc.edu.gh/msc-business-entrepreneurship-and-technology.

42 "The Artificial Intelligence & Robotics Center of Excellence," Addis Ababa Science & Technology University, accessed September 5, 2018, http://www.aastu.edu.et/research-and-technology-transfer-vpresident/the-artificial-intelligence-robotics-center-of-excellence.

43 Christina Galbraith, "Artificial Intelligence Catches Fire in Ethiopia," *Huffington Post*, August 26, 2015, https://www.huffingtonpost.com/techonomy/artificial-intelligence-c_b_8043974.html.

44 Alexander Ferrein and Thomas Meyer, "A Brief Overview."



MomConnect is a chatbot offering maternal health information to around 1.8 million pregnant women in South Africa. *Photo Credit: United Nations Foundation.*

is developed in Silicon Valley and deployed in Nigeria; UjuziKilimo is supported by a range of global organizations including the American venture capital firm, VillageCapital; MomConnect, an initiative of the South African government, has over twenty global and South African partners including US multinational Johnson & Johnson, which provides funding. A significant portion of the $560 million in venture capital financing to tech hubs across Africa comes from US and European investors[45] who rightly recognize the transformative potential of AI and other technologies across the region.

Conclusion

For now, opportunities for AI in Africa remain confined to a handful of countries where critical factors for success are quickly coming together to bypass outstanding challenges and bottlenecks. These factors are converging more gradually—or not at all—in other African countries. Despite enthusiasm about AI being able to help African countries "leapfrog" their economic development, progress in certain areas—in data availability and privacy; in skills and training; in digital infrastructure—first has to happen before AI can be meaningfully mastered and deployed. In the absence of such efforts, only a select group of African countries will likely advance toward sustainable development and inclusive growth while the rest will, as feared, be left behind.

Aleksandra Gadzala is a senior fellow in the Africa Center.

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1030 15th Street, NW, 12th Floor,
Washington, DC 20005

(202) 463-7226, www.AtlanticCouncil.org