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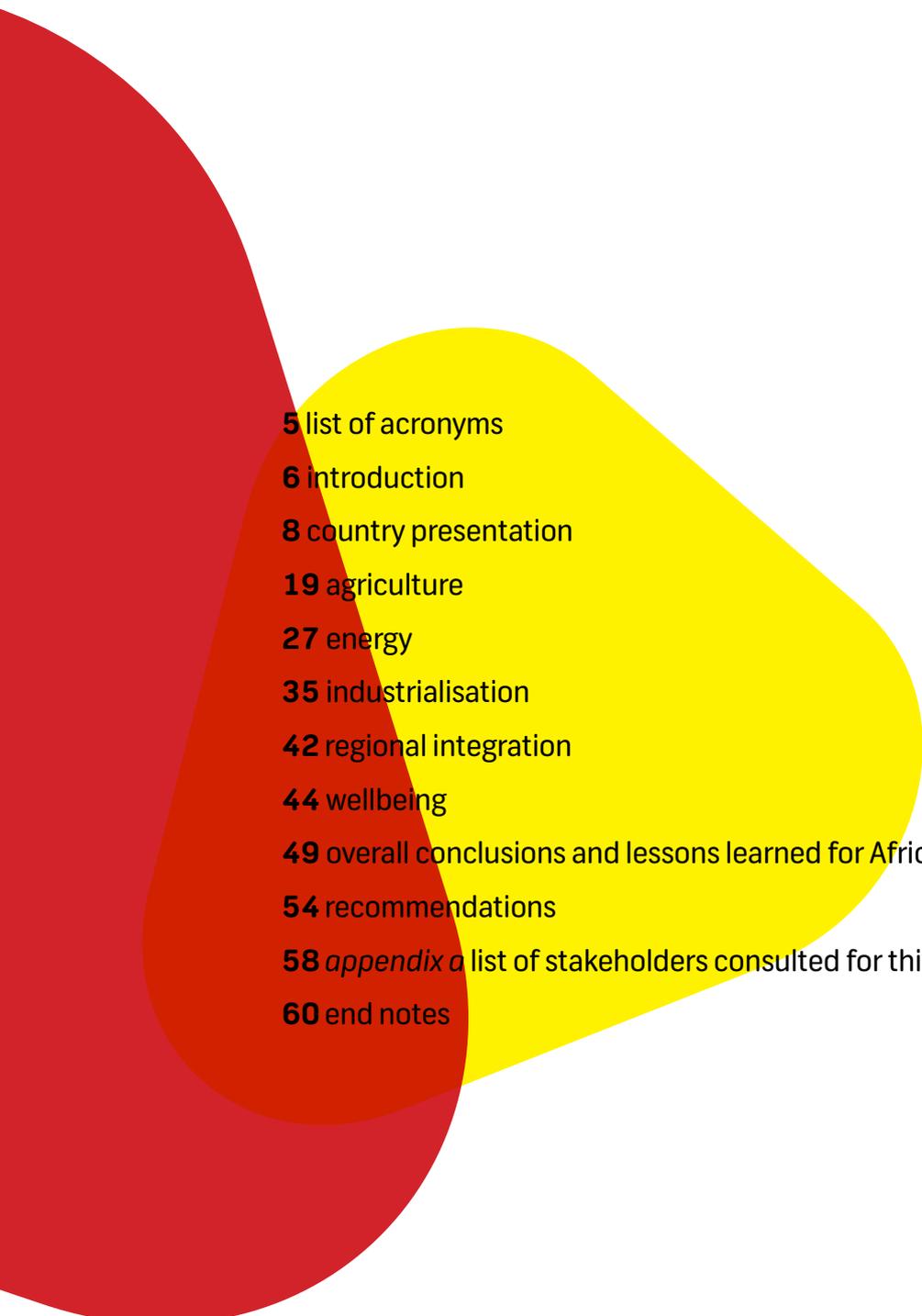
unlocking the potential of the fourth industrial revolution in Africa  
**study report**

**COUNTRY CASE STUDY**  
Nigeria



# tc

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# A

## list of acronyms

<b>4IR</b>	Fourth Industrial Revolution
<b>ABVAD</b>	Afe Babalola University Ado Ekiti
<b>AfDB</b>	African Development Bank
<b>AI</b>	Artificial Intelligence
<b>CPI</b>	Corruption Perception Index
<b>CSCS</b>	Central Securities Clearing System
<b>DAS</b>	Data Acquisition Systems
<b>DER</b>	Distributed Energy Sources
<b>ERGP</b>	Economic Recovery and Growth Plan
<b>ETRI</b>	Electronics and Telecommunications Research Institute
<b>EMR</b>	Energy Management System
<b>ESS</b>	Energy Storage System
<b>EUI</b>	Edo University Iyamho
<b>EV</b>	Electric Vehicles
<b>FGN</b>	Federal Government of Nigeria
<b>LNG</b>	Liquefied natural gas
<b>LTE</b>	Long Term Evolution
<b>GDP</b>	Gross Domestic Product
<b>HDI</b>	Human Development Index
<b>ICT</b>	Information and Communication Technologies
<b>IoT</b>	Internet of Things
<b>IP</b>	Intellectual Property
<b>IT</b>	Information Technology*
<b>ITU</b>	International Telecommunications Union
<b>MAN</b>	Manufacturing Association of Nigeria
<b>MIT</b>	Massachusetts Institute of Technology
<b>MOC</b>	Ministry of Communication
<b>MSMEs</b>	Micro, Small and Medium Enterprises
<b>NAFDAC</b>	National Agency for Food and Drug Administration and Control
<b>NASENI</b>	National Agency for Science and Engineering Infrastructure
<b>NBET</b>	Nigerian Bulk Electricity Trading Plc
<b>NCAP</b>	National Collection of Aerial Photography
<b>NCC</b>	Nigerian Communication Commission
<b>NIA</b>	National Information Society Agency
<b>NIRP</b>	Nigeria Industrial Revolution Plan
<b>NITDA</b>	National Information Technology Development Agency
<b>OECD</b>	Organisation for Economic Cooperation and Development
<b>PEDI</b>	Prototype Engineering Development Ilesa
<b>PSRP</b>	Power Sector Recovery Programme
<b>R&amp;D</b>	Research and Development
<b>REM</b>	Reference Electrification Model
<b>RFID</b>	Radio Frequency Identification
<b>RPAS</b>	Remotely Piloted Aircraft
<b>RSW</b>	ReadySetWork
<b>SME</b>	Small and Medium Sized Enterprise
<b>STEAM</b>	Science, Technology, Engineering, Arts and Mathematics
<b>STEM</b>	Science, Technology, Engineering and Mathematics
<b>US</b>	United States
<b>USAID</b>	United States Agency for International Development
<b>VTL</b>	Verification Technology Limited
<b>WEF</b>	World Economic Forum
<b>WIPO</b>	World Intellectual Property Organization

# 1 introduction

this document is one of the five country case studies drafted in the framework of the Study to Unlock the Potential of the Fourth Industrial Revolution (4IR) in Africa.

The overall study aims at i) understanding the preconditions for the adoption of 4IR technologies, challenges and drivers, positive and negative effects; ii) describing the technologies for knowledge dissemination, including domains of application; iii) benchmarking emerging countries; iv) demonstrating applications in Africa; v) in order to conclude on a business case and vi) recommend interventions and vii) design specific ICT components for AfDB projects which will showcase the feasibility of supporting 4IR in Africa.

This case study thus looks in depth at the potential for the adoption of key 4IR applications with diverse geographical, political, economic, technological and social preconditions:

- it reviews the socioeconomic situation of the country and the implications for technological readiness for the 4IR;
- it assesses the potential for the 4IR to be used in the key economic sectors of the country, i.e. the High Five AfDB priority fields, which are agriculture, energy supply, industry manufacturing, regional integration and well-being (including financial inclusion, smart cities, education and healthcare);
- it concludes on the business case for the 4IR in the country;
- it proposes recommendations at the national level;
- it envisions potential AfDB interventions or projects.

Our team collected data by drawing on existing research and public policy documents and by consulting local stakeholders. This was done either on the telephone, online or in person. One field visit per case study country was organised to allow the team to gain a deeper understanding of the local conditions and peculiarities and to be able to identify the most relevant use cases. The field visit occurred on a five-day trip and included face to face meetings with key stakeholders from government, the private sector, researchers and NGOs (about 25 meetings). The document revolves around eight chapters. It has been enriched and finalised following a workshop with stakeholders that was held in early June 2019.

The term AI encompasses so many evolving systems and applications that it is not possible to attach this technology to a specific technological readiness level (TRL). Rather, some AI applications are already at a high TRL, including natural language processing and chatbots, fully self-driving cars (considered to be at a TRL of 7). Other AI systems are still in their infancy, at lower TRLs, such as autonomous surgical robotics, robotic personal assistants and cognitive cybersecurity. At a very low TRL are systems such as real time emotion analytics (Robotics Society Japan, 2015).

# 2

## country presentation

## 2.1 ECONOMIC, SOCIO-DEMOGRAPHIC AND INDUSTRIAL PROFILE

Nigeria is the most populous country in Africa, with an estimated total population of around 198 million in 2017, of which over 70% are to be found in urban areas. The most commonly spoken language is English, but the country is characterised by considerable ethnic, linguistic and religious diversity. The Nigerian population is very young (median age 18.3 years) and growing at 2.5% per year. The country's capital is Abuja, whereas the economic and innovation capital is Lagos, a city of more than 20 million inhabitants, according to various estimates. Around 50% of the population live in urban areas. This means that there is considerable potential in the form of a young workforce in urban areas but currently there seems to be a lack of training and job opportunities. The literacy rate in the whole population was 59.6% in 2015 and Nigerians spend on average only nine years in school (primary to tertiary education, according to an estimation for 2011). The human development index stands at 0.527 and Nigeria is ranked in 152nd position globally. Moreover, the unemployment rate amounted to 16.5% in 2017.

Nigeria's economy is heavily dependent on oil (and consequently its world market price). In 2017 for example, the revenue from petroleum exports accounted for close to 83% of total export revenue. Nigeria's GDP is estimated at \$581.6 billion and real GDP is projected to grow by 2.3% in 2019 and by 2.4% in 2020 as implementation of the Economic Recovery and Growth Plan comes into play. The major industries in Nigeria are crude oil, coal, tin, columbite; rubber products, wood; hides and skins, textiles, cement and other construction materials, food products, footwear, chemicals, fertiliser, printing, ceramics and steel. In the last ten years, economic growth has been driven by agriculture, telecommunications and services, indicating a diversification of the economy. The importance of the telecommunications sector has grown particularly rapidly, with its share of the national GDP rising from 0.6% in 2001 to 9.8% in 2014. Recently, Nigeria has seen the rise of technology start-ups in several technology hubs around the country. Nigerian start-ups attracted approximately \$110 million in venture capital in 2016, making it the largest recipient of venture capital in Africa. Most of this

venture capital came from foreign investors, partially offsetting the lack of readily available local capital.

In general, a large proportion of the Nigerian population is poor and suffering from a lack of infrastructure and adequate healthcare: Over 62% live in extreme poverty and, in 2018, Nigeria ranked 13th in the world for infant mortality and 4th in 2015 for maternal mortality. Additionally, there is a shortage of power supply and, in 2016, only 59.3% of the population had access to electricity. Nevertheless, Nigeria is considered one of the most developed countries in west Africa and boasts the most internet users in Africa.

The table below provides an overview of the relative importance of key sectors in Nigeria's economy, as defined by the OECD. It shows that Nigeria's economy is not actually as dependent on oil revenues as is often surmised. Services and agriculture dominate in terms of added value and agriculture still accounts for a large share of employment.

## 2.2 ICT POLICY OBJECTIVES AND POLICIES SPECIFIC TO 4IR TECHNOLOGIES

In the last 10 years, government has become more open to and supportive of technology but there is a lack of trust between the public and private sector, with the private sector suspecting the government of only moving if they can cash in and thus trying to either work around government or trying to persuade them that it is in their own interest to support these technologies. Broken trust between the public sphere and the technology sector in Nigeria – now going different ways – is hard to overcome.

In June 2012 the Nigerian Ministry of Communication Technology published its first coherent ICT policy. The overall aim of this National ICT Policy was described as "provid(ing) a framework for streamlining the ICT sector, and enhancing its ability to catalyse and sustain socio-economic development critical to Nigeria's vision of becoming a top 20 economy by the year 2020". The national ICT strategy thus refers to the country's overarching 2020 vision (published in 2010) which detailed that research and innovation as well as local manufacturers, capacity and content development in key areas of ICT

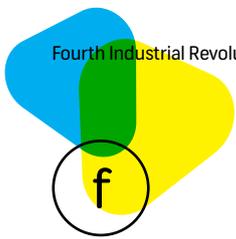
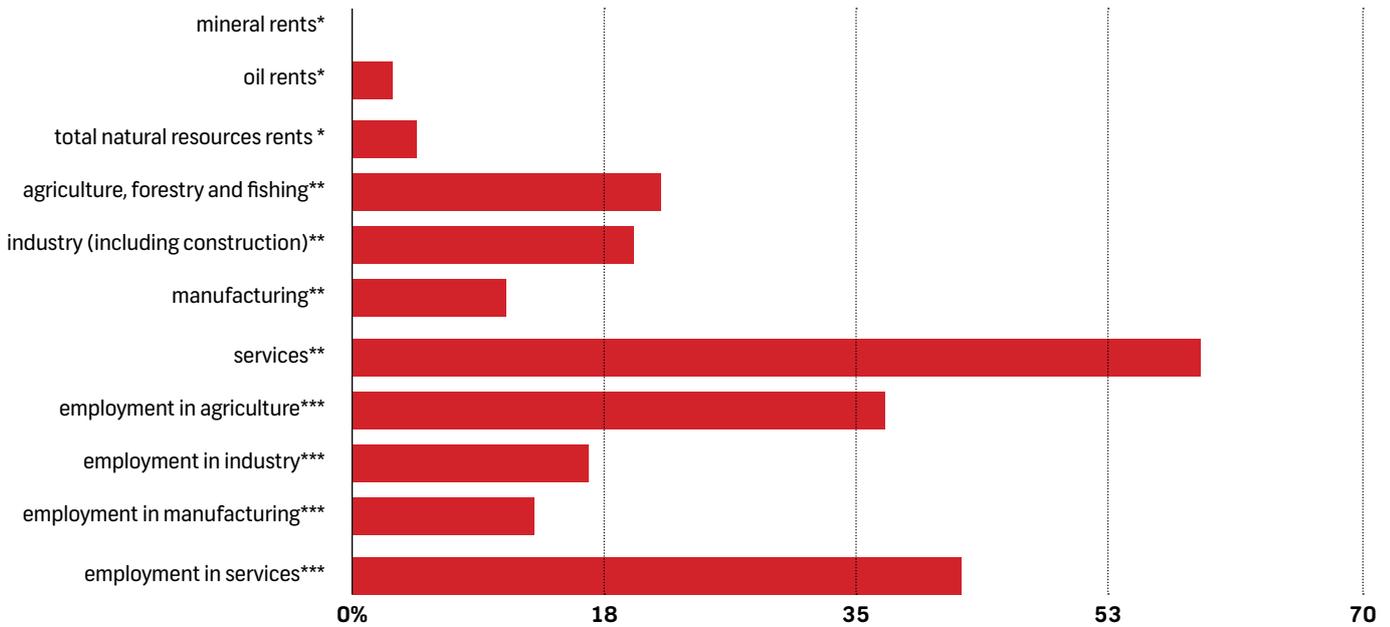


figure 01  
economic indicators Nigeria (2016)



\* (% of GDP), 2016, \*\*value added, (% of GDP), 2016, \*\*\* as% of total, 2016

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OECD Africa's development dynamics statistical database, 2018

would be encouraged. The implementation of this part of the 2020 vision was expected to be mainly driven by the private sector. There was also a National Broadband Plan in 2013, which aimed at promoting pervasive broadband deployment in Nigeria. At least one of the Nigerian States (Enugu) additionally developed its own ICT policy and strategic action plan in 2013. This plan contains eight policy initiatives covering the legal framework, universal access to ICT networks and services such as broadband internet and computers, ICT infrastructure, capacity building regarding ICT skills at all levels of education, promoting local content and the manufacturing of ICT products and services, e-Health, cybersecurity and safety (with a focus on data protection), investment and funding for the ICT sector. In 2017, a major strategy document was published by the Federal Ministry of Communications on behalf of the Federal Government of Nigeria: the Nigeria ICT roadmap

for the timeframe 2017–2020. This document sets out ambitious targets such as creating two million jobs in the ICT sector by 2020. However, it has been criticised for a lack of implementation. In July 2018, the Nigerian Federal government announced that it was planning to formulate a new national ICT policy regarding ICT infrastructure, internet and broadband, local content development and the legal and regulatory framework. This new national ICT policy document has not yet been published.

Nigeria may represent a good test bed for new technologies since it is fairly lightly regulated, with some exceptions (e.g. drones). At the same time, there is little explicit government support although this appears to be changing. For now, there is no national strategy specifically addressing 4IR technologies. However, the Federal Government, notably the Ministry of ICT, are looking at AI, Big Data, IoT and Blockchain.

The government's role is crucial in ensuring that the infrastructure is in place that is needed for 4IR technologies to take off in the country (see also section 1.5 on preconditions). In this regard, the priorities of the Ministry of Communication (MoC) are as follows, as also expressed in the new plan 2019-23:

- invest in the national broadband backbone. Achieve regional integration of broadband infrastructure, including links to Mali, and from there to Europe. The MoC would welcome the AfDB's support in this regard. Another valuable funding source is InfraCo but this is insufficient to provide the whole country with broadband;
- conduct feasibility studies for regional optical fibre backbone across west Africa and invest more in satellite communication;
- construct regional optical fibre backbone and carry out feasibility studies to pave the way for this. Improve 'last mile' fibre links to office premises;
- create a national registry system that digitalises addresses to provide reliable data. In this context, the MoC is seeking advice on how to integrate such data and store it.

The Nigerian government is also planning a geolocation mapping exercise to provide the data needed for autonomous vehicles to drive on Nigerian roads one day, according to the MoC.

The Nigerian Communication Commission (NCC) plays a key role in making sure that the preconditions in terms of infrastructure are in place and that spectrums for mobile networks are given to providers that are able to actually implement change. The Commission has initiated several programmes to help stimulate demand and to accelerate the take-up of ICT tools and services necessary for the take-up of the 4IR in Nigeria:

**A State Accelerated Broadband Initiative** aims to achieve nationwide connectivity. This is a capital-intensive undertaking implemented in a Public Private Partnership (PPP) format licensing private sector providers to deploy infrastructure with government subsidies.

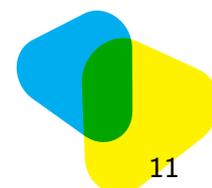
**A Wire Nigeria Project** helps install fibre infrastructure around the country. It creates a pathway for telecommunications providers to connect the country by licensing infrastructure companies. The project follows an open access model whereby fibre that is rolled out can be used by different providers. The ideal combination, in view of the NCC, is to combine underground fibre for key areas with 'last mile' wireless connections through spectrum - bypassing the stage where the whole country is connected via fibre. Fibre connections are also needed for the mobile towers providing 4G and 5G connectivity.

**A Digital Bridge Institute** provides training, skilling and creates manpower for telecommunications providers. The main campus is situated in the capital, Abuja, but there are also campuses in Lagos and Kano and the institute is expanding. It is recognised by the ITU (International Telecommunications Union) as a centre of excellence and takes in students from all over Africa.

An example of a comprehensive initiative supporting 4IR-related skills development in Nigeria is **Data Science Nigeria**, which is supported by **MTN Nigeria**. Data Science Nigeria provides training and education on data science and analytics. The courses cover, inter alia, Big Data, Machine Learning and AI applications, drawing on locally relevant solutions with high impact on the economy, for example in the healthcare sector. The initiative is implemented in partnership with Nigerian universities to benefit students. The courses aim to integrate knowledge that is currently developed and taught in silos.

The initiative also contributes to regional integration by inviting students from other African countries to participate, e.g. in boot camps, presenting best practices as to how to apply 4IR technologies in practice. The local centres also make drones available at no cost to students to experiment with new technological innovations.

[The ultimate goal is to build an ecosystem around AI research and innovation in Nigeria in support of applications related to the United Nation's Sustainable Development Goals.](#)



There are also plans by the Federal Government to use Blockchain for a national census of the country's population to help with national development planning. In combination with AI, this could help the government accurately monitor population developments, according to the MoC.

In a country as federalised as Nigeria, a lot of activities are also carried out at the regional level. The State of Lagos has launched some ambitious initiatives in support of the 4IR:

- Lagos Innovates is a State initiative supporting the growth of the regional tech start-up ecosystem and provides access to high quality workspaces and infrastructure, learning, early stage investment capital and investor and peer networks;
- Lagos has launched a smart city initiative aimed at leveraging ICT and increasing connectivity to improve urban life, drawing on the IoT, AI and other solutions. In pursuit of this ambition, Lagos State is cooperating with Dubai to share knowledge and learning to increase public and private investment in the city of Lagos. A focus will be on how to use technology to improve waste collection and traffic management. Inspired by the Lagos example, the Federal Government is now working on a national policy on smart cities;
- Code Lagos is an initiative that aims, by 2020, to train one million Lagos citizens on coding to bridge the skills mismatch between university graduates and the needs of corporates. This is seen as a step to preparing the workforce for a tech-enabled economy. As part of the initiative, more than 1,000 trainers in 659 schools have already been trained. The initiative is implemented as a Public Private Partnership and is linked to the Lagos State Employment Trust Fund that, inter alia, funds the training of local people to promote entrepreneurship. Currently, the future of the initiative is uncertain due to the change in government in Lagos State following recent elections;
- RSW (ReadySetWork) is an employability and entrepreneurship programme aimed at preparing final year students for immediate entry into the workforce as employees and employers of labour by equipping them with market-aligned knowledge, soft skills,

business tools and a mindset reorientation to the world of work. By October 2018, the programme had already reached 150,000 students.

### 2.3 LEVEL OF READINESS OF THE COUNTRY FOR THE 4IR

The six Worldwide Governance indicators by the World Bank provide information on governance in close to 200 countries. In the following section, these six indicators are presented for the year 2017.

For that year, Nigeria was given a score of -0.34 for voice and accountability on a scale from -2.5. to +2.5, where higher values are equivalent to a more positive judgment. Nigeria was given a rank of 34.98 among the countries in the world where 0 is the lowest and 100 the highest. These scales and ranks are also used for the other five indicators. Regarding government effectiveness, Nigeria was given a score of -0.96 and ranked at 16.35. For political stability and absence of violence/terrorism, Nigeria scored -1.94 and was ranked at 5.24. Regulatory quality in Nigeria was given a score of -0.89 and ranked at 16.83. Regarding rule of law, Nigeria reached a score of -0.87 and a rank of 18.75. Control of corruption in Nigeria was assigned a score of -1.07 and a rank of 12.5.

Overall, it is clear that Nigeria has rather low scores on the six indicators. The ranks show that these scores are also low in comparison to other countries. The scores and ranks given for the six indicators are all similar, except for voice and accountability, where Nigeria received rather positive ratings and political stability and absence of violence/terrorism, where the country scored especially poorly.

There are several other more or less well-known indicators by governmental and non-governmental organisations measuring governance in various forms. The Worldwide Governance indicators are among the most comprehensive because they are aggregates of other data sources.

Specifically, for the African continent there is an index, the Ibrahim Index of African Governance, by the Mo Ibrahim Foundation, which provides four indicators on governance. These indicators are safety & rule of law, participation & human rights, sustainable economic opportunity and

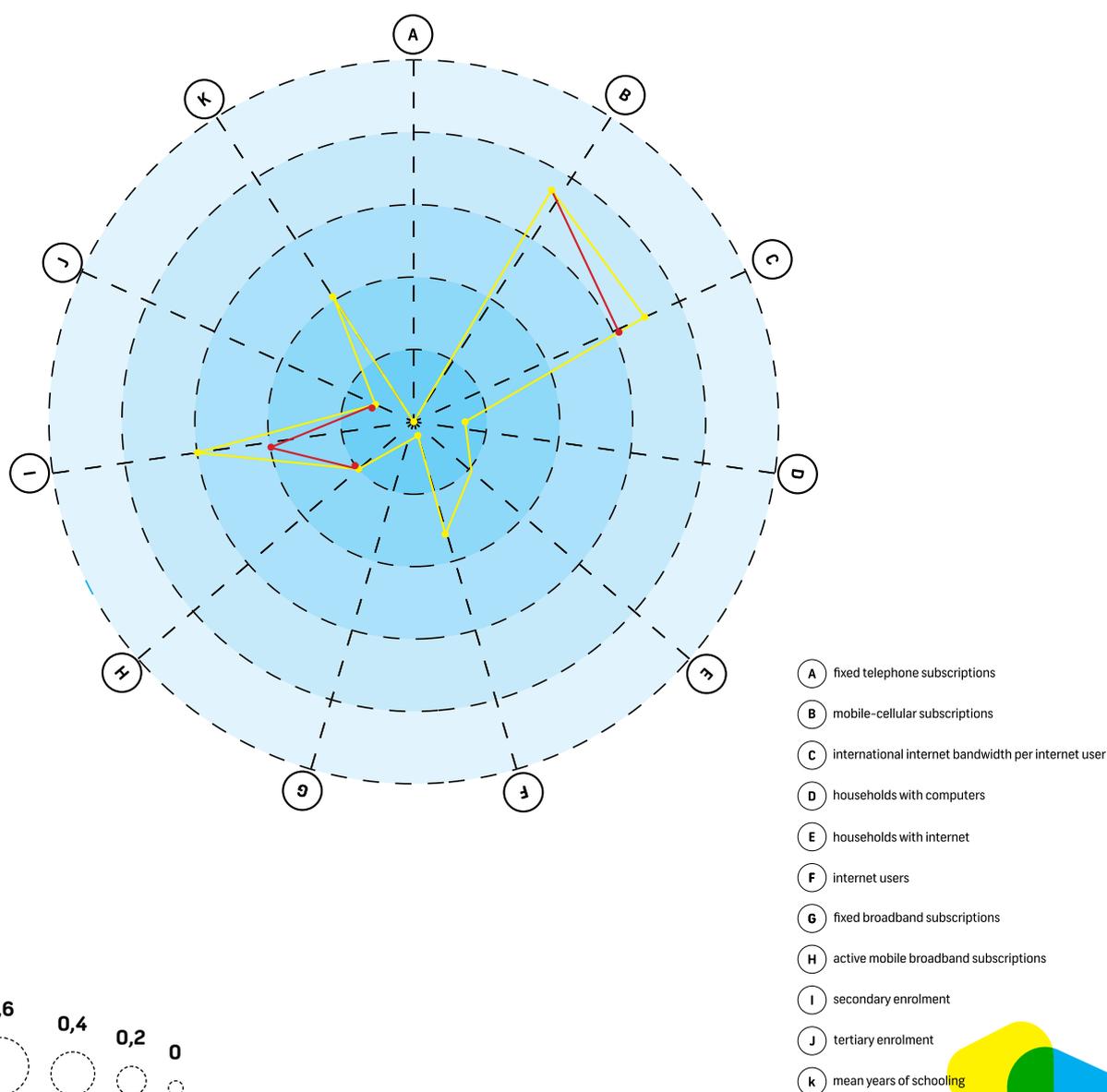
human development. These indicators are presented as scores where 0 represents the worst score on the African continent and 100 the best, which allows for regional comparison. Nigeria receives a score of 46.4 for safety & rule of law, 53.2 for participation & human rights, 43.5 for sustainable economic opportunity and 48.7 for human development. This shows that, compared to its African peer group, Nigeria receives medium scores.

Nigeria was ranked in 143rd position in the ITU's IDI development index in 2018, with an estimated 25.67% of their population using the internet. A few general policy implementation indicators for ICT connectivity for Nigeria are shown in the figure below.

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## figure 02

Nigeria's ranking in the ITU's ICT development index



## GLOBAL INNOVATION INDEX 2018

Nigeria scores 22.37 (scale 0–100) and is ranked 118th out of 126 countries.

Nigeria is ranked last of 100 countries in the Readiness for the Future of Production report by the World Economic Forum/A.T.Kearney. This sheds light on Nigeria's strengths and weaknesses in terms of technology and innovation, human capital, trade and investment, institutional framework, sustainable resources and demand environment. The only indicators of this index on which Nigeria scores above average are cybersecurity commitment, venture capital deal volume, hiring and firing practices, the low prevalence of non-tariff barriers, greenfield investments, the use of alternative energy, the CO2 intensity level, baseline water stress and market size. On all other indicators, of which there are more than 20, Nigeria has low scores and is often close to the bottom. This shows that there is still a long way to go for Nigeria as regards creating an enabling environment for the 4IR. Based on this report, Nigeria's ability to innovate is very low, with very low rates (mostly below 3 on a scale of 10) on state of cluster development, company investment in emerging technology, companies embracing disruptive ideas, multi-stakeholder collaboration, R&D expenditure, scientific and technical publications and, worse still, patent applications.

The stakeholder feedback revealed that there are three main preconditions for the take-up and take-off of 4IR technologies in Nigeria, and these are the same across all the sectors that the AfDB focuses on. They are stable power supply, reliable and fast internet connectivity (both through fibre mobile connections to the 'last mile') and human capital. Formation of human capital as a precondition for the 4IR is in turn affected by the previous two preconditions, most importantly by availability of the internet, so the three main preconditions affect each other. Another issue of importance is regulation. Each of these preconditions is considered in more detail below.

### Power supply

As things stand in 2016, only 61% of the population have access to electricity, mostly from natural gas, hydropower

and solar energy (putting Nigeria in 114th place out of 140 countries in the World Economic Forum's competitiveness index) but, due to the unreliable supply, 80% of those with connections also use an alternative source supply. Another estimate puts the access rate in the total population at 45%, with 55% of urban and only 36% of rural residents having access to power. Many rural areas are not connected to the electricity grid.

There are projects trying to address power supply in Nigeria, notably USAID, which is currently co-funding the establishment of mini grids using solar energy and involving rural communities. The project aims to tackle a range of challenges in increasing power supply, including macroeconomic forces, lack of creditworthy utilities and lack of strong regulation by reducing electricity losses in cooperation with utilities, providing transaction advisory services and building a partnership with the National Association of Regulatory Utility Commissioners.

Power is essential not only to connect people to the internet, which in turn is a prerequisite for 4IR technologies but also to run data centres and servers that can ensure the smooth flow of data and information around the country. To provide rural areas with electricity rather than connecting these areas to the grid, Nigeria has the opportunity to make a leap forwards to a stage where decentralised mini grids drawing on renewable energy, notably solar, provide a stable power supply.

One response to the lack of ubiquitous power supply is for entrepreneurs and innovators to cluster in coworking spaces that have generators to provide continuous power supply even in case of frequent power outages. Electricity is expensive and so it is more economical to pool electricity and internet connections in one space for a larger group of people.

### Internet connectivity

As regards internet connectivity, stakeholders affirm that it is not possible to make the leap straight to mobile networks but rather a combination of investment in fibre broadband and 'last mile' mobile connectivity is required. In view of the Federal Ministry of Communications, the AfDB could

support the deployment of such infrastructure, especially in rural areas where there is a market failure in that there is no incentive for the private sector to invest in connectivity in such areas even though large parts of the population live there. At the same time, broadband solutions for rural areas need to be affordable.

Below are a few indicators on the World Economic Forum's competitiveness index, placing Nigeria near the bottom of the rankings:

- mobile broadband subscriptions: 19.9% of the population (ranked 126th out of 140 countries);
- fixed broadband internet subscriptions: 0.06% of the population (ranked 136th out of 140);
- fibre internet subscriptions: 0% of the population (ranked 105th out of 140);
- internet users: 25.7% of the population (ranked 107th out of 140).

The Nigerian Federal Government is already investing in internet connectivity where it previously focused on investments in roads and electricity. A major issue in this regard concerns 'last mile' connectivity. Even though many undersea cables from Europe terminate in Lagos, parts of the city are not properly connected to broadband networks. Fibre-to-home is limited in Nigeria, also due to the government having the right of way to use (and sell) access to the cables. Since selling this right of way provides significant government revenue, access remains restricted.

Nevertheless, there have been some improvements. The country recently exceeded its own target of connecting 30% of the population to broadband, reaching 33% in early 2019, representing 65 million citizens. A new target of 70% has been set by the Federal Government for 2024.

Another important aspect of connectivity is the availability of data centres that allow vast amounts of data to be stored and processed rapidly. Only with the help of such data centres, which need to be connected to high-speed internet connections and distributed across the country, can Big Data and AI realistically take off in Nigeria. The evidence is that the country is catching up when it comes

to data centre infrastructure but still has a way to go before it reaches sufficient capacity for the wider adoption of the latest technology related to data analytics.

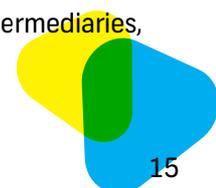
Nigeria also has a plan in place to roll out the next generation of mobile networks, 5G, across the country.

### **Human capital**

Perhaps the most important precondition for rapid 4IR take-up and reaping the associated rewards is a well-educated and motivated workforce with the right skills. Nigeria has already made significant progress in this regard but more needs to be done. According to the World Economic Forum, Nigeria is ranked 3.3 on a scale of 1-7 (121st out of 140 countries) in terms of the existence of digital skills in the population. In rural areas, more basic issues trump the lack of digital skills as many people are illiterate.

The take-up of the 4IR is made more difficult by a mismatch of skills and a 'brain drain' of highly-skilled people to other countries is holding the country back. Where in the past many medical staff left for Europe and the US, it is now the software developers and coders that are joining start-ups around the world. In this context, it is problematic that platforms such as Upwork that connect freelance developers to businesses around the world are not operating fully in Nigeria as these would allow skilled people to make a living without leaving the country, ensuring that the skills and the benefits of education are captured in Nigeria rather than outside. However, there are also local platforms such as Andela that connect decentralised engineering and software developer teams and that may (inadvertently) contribute to the brain drain by connecting local talent with international business. There may be a role for the AfDB in supporting projects that connect Nigerian developers to international business through platforms such as Upwork.

At university level, there is a need for more specialised Master's degrees in 4IR fields such as AI and Machine Learning. It is also crucial to connect university students and graduates better to the most innovative businesses in the private sector. Tech hubs and centres of excellence have an important role to play in this regard as intermediaries,



providing start-ups with visibility and access to know-how and investors. One article put the list of such hubs around Nigeria at just under 40 while another counts 55 tech hubs, the second highest number in Africa. Technology hubs are key to bringing the innovation ecosystem together. There is a need, according to one stakeholder, for mentorship and more advisory services (legal, business) provided by hubs to help innovative entrepreneurs prototype and execute their ideas. The AfDB can support technology enablers and the ecosystem of technology hubs and start-up incubators.

Research labs, another transmission mechanism between scientific knowledge and business innovation, are currently underdeveloped in Nigeria. The key objective of technology hubs and research centres should be to help develop practical solutions drawing on the 4IR that would allow sectors such as farming to be upgraded through automation but without replacing humans by developing pilot projects and demonstrating added value through use cases.

### **Regulation & government support**

A strong regulatory framework creates the legal certainty needed for investors to be confident enough in the Nigerian economy to invest in innovation. Appropriate regulation of data and infrastructure providers such as telecommunications firms was also highlighted by stakeholders as crucial to creating the right enabling environment in Nigeria for 4IR technologies. Some entrepreneurs expressed a concern that Africans would be exploited by foreign entities through unregulated use of their private data and one stakeholder cited the European General Data Protection Regulation as a source of inspiration as to how to prevent this from happening. There are also concerns about inconsistency around certain regulations related to customs, taxes, and financial regulation. In the energy sector, one stakeholder suggested that restrictions around licensing exist on the amount of energy that anyone other than the main energy suppliers can generate, potentially imposing a barrier on the scaling up of off-grid solar energy solutions.

In general, stakeholders advocated pragmatic regulation that creates the space for the private sector to experiment with new technological solutions. One institution that appears to strike the right balance between regulation and flexibility, according to several private sector stakeholders consulted, is the Central Bank of Nigeria, whose approach is to provide FinTech start-ups with the breathing space to try out new things whilst closely monitoring any emerging developments.

Some regulation is considered by private sector stakeholders to place a barrier to technological innovation. Notably, where more than one regulator needs to approve the use of new technologies such as drones, this can slow down innovation. The Nigerian Communication Commission tries to mediate between different regulators to remedy this.

The ease of doing business in Nigeria is also reduced by bureaucracy (Nigeria is ranked 146th out of 190 in the 2019 Ease of Doing Business Index). Rather than waiting for the public sector to accelerate 4IR take-up, the private sector in Nigeria tends to move first and provides incentives for the government to buy into newly developed private sector solutions. On the upside, several private sector stakeholders consulted stated they see the government providing them with the space to innovate, even if the government is not proactively supporting this. For start-ups specifically, one stakeholder suggested that the government could be supportive by allocating a certain share of public procurement to start-ups to ensure that there is a market for their innovative solutions. Whilst this may be problematic in terms of market distortion, a more viable solution could be for the Nigerian government to enter into Public Private Partnerships, with start-ups providing solutions to governance problems – following the public procurement for innovation concept also used in Europe.

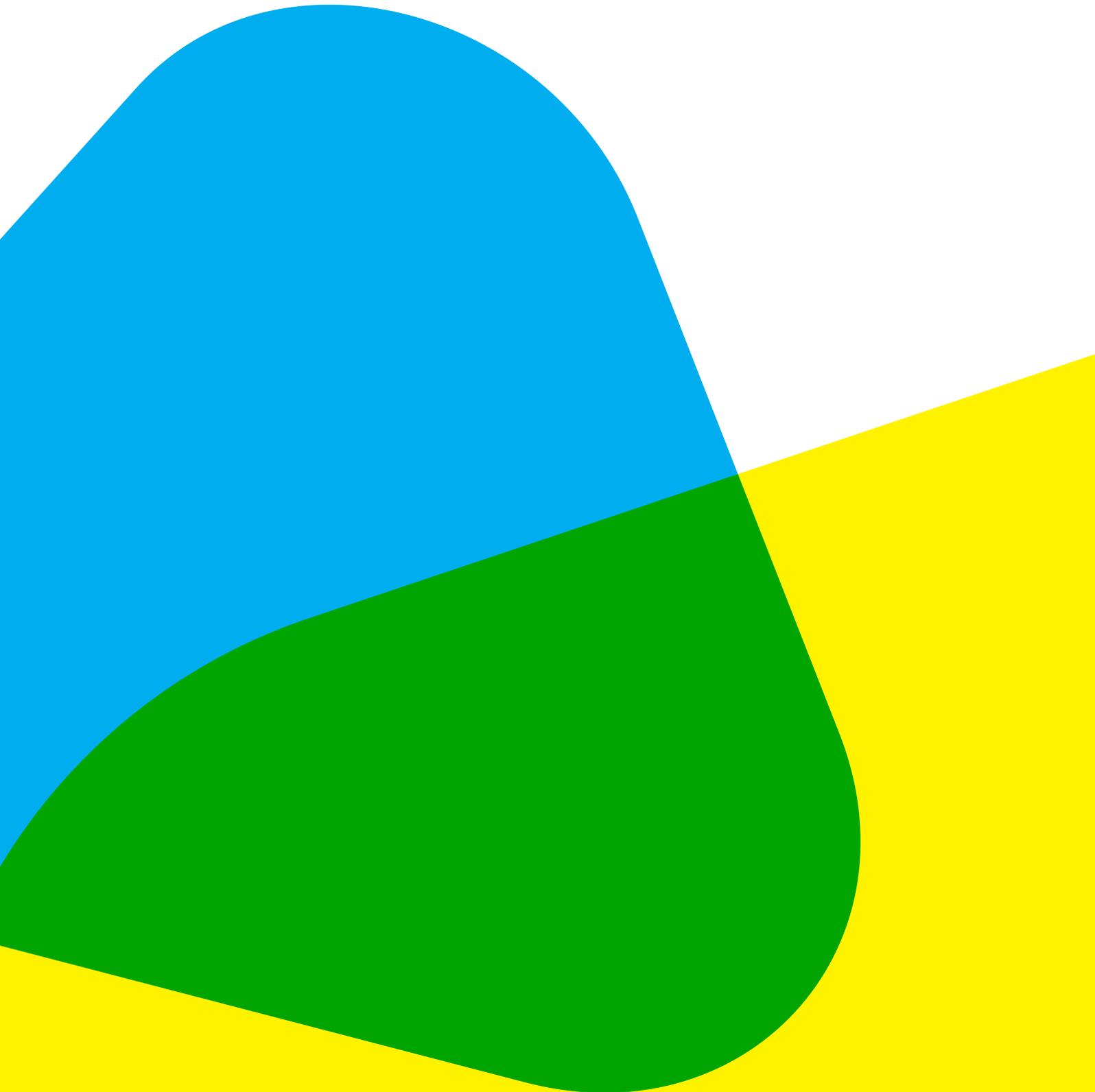
As regards 4IR take-up within government, the National Information Technology Development Agency (NITDA) has subjected a Nigeria entrepreneurship and innovation vision to public consultation in 2018, which aims to strengthen the Nigerian technology entrepreneurship ecosystem.

To elaborate, there are three sections addressing digital infrastructure: education reform, skills development and R&D as well as supporting the ecosystem for innovative entrepreneurship. The final document is not publicly available but there is a document on its implementation framework which puts great emphasis on supporting technology start-ups and hubs in Nigeria with the help of stakeholders such as universities, development partners, investors and other Nigerian public and private bodies.

Finally, continuity of government is also an issue in terms of support for the 4IR. As things stand, whenever there is a change in government (be it at the federal or state level), the parameters for technological innovators are reset. This is also due to the fact that administration is highly dependent on government and can therefore not provide more stability in terms of the regulatory environment for business managers.

The WEF has two indicators positioning Nigeria in the lower ranks of countries with regard to its regulatory environment:

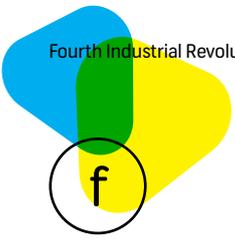
- Intellectual property protection: 3.1 on a scale of 1-7 (ranked 129th out of 140);
- e-participation index (use of online services to facilitate the provision of information by governments to citizens): 0.48 on a scale 0-1 (ranked 104th out of 140).



3

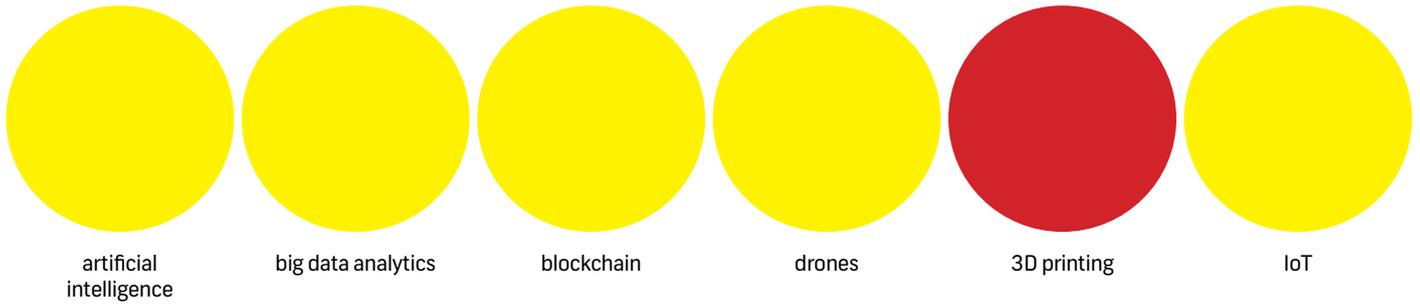
agriculture



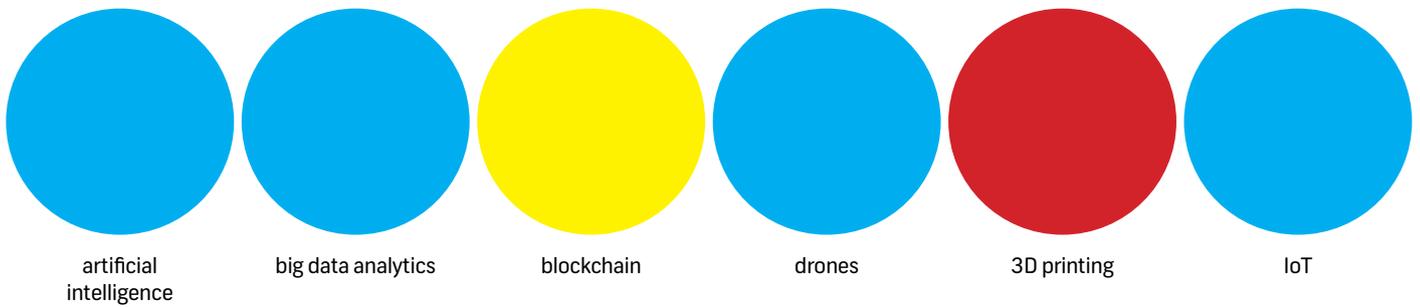


# figure A

current level of utilization of technologies



potential for applications



### LEGEND

**red**, not many / few examples; **yellow**, nascent / some examples; **blue**, good potential / numerous examples

### 3.1 PRESENTATION

In 2017, agriculture accounted for over 40% of Nigeria's GDP and employed over 70% of the labour force, with about 32% being women. Agricultural exports have been increasing since the 1980s and stood at \$1.825 billion in 2012. The main agricultural products are cocoa, peanuts, cotton, palm oil, corn, rice, sorghum, millet, cassava (manioc, tapioca), yams, rubber; cattle, sheep, goats, pigs; timber; fish. Agriculture only makes up a small part of export receipts, totalling 4% of total trade in 2016. The agricultural productivity index (which measures the relative level of aggregate volume of agricultural production for each year by comparison with the base period of 2004-2006) of Nigeria has not increased much – from 215 to 143, still showing that much has not been done to increase productivity in Nigeria. Nigerian agriculture mostly consists of subsistence farming, with a low level of mechanisation. This means that technology adoption is currently low too.

In 2016, the Nigerian Federal Ministry of Agriculture & Rural Development announced its agricultural promotion policy for 2016-2020. The previous policy (2011-2016) had focused on rebuilding the farming sector and the current policy continues to pursue this aim. Major issues to be resolved include the large amount of food imports because of the inability to meet local demand through domestic food production and the low levels of foreign exchange obtained by exports due to the low quality of domestic produce. The current policy focuses on increasing productivity and has identified some priority products for domestic consumption and for export. The policy also contains aspects of rural development, such as investments in rural roads and measures to reduce the crime rate in rural areas. The overarching vision is to create a whole agribusiness ecosystem.

The Nigerian government is working on using the opportunities of the 4th Industrial Revolution. A Growth Enhancement Support Scheme has been implemented by the Nigerian Federal Ministry of Agriculture and Rural Development to stabilise the market for fertilisers and to give resource-constrained farmers better access to agricultural inputs. The programme is implemented by Cellulant, a company which describes itself as the

“premier African digital payment platform”. According to the company, by April 2019 the Growth Enhancement Support Scheme has been used to give out more than one billion dollars in subsidy payments to more than 17 million farmers. Cutting-edge solutions are often invented by the corporate sector as showcased above. Collaboration between the public and the private sector can thus be a fruitful endeavour. For instance, in Nigeria there are subsidies provided in the form of e-wallets for farmers. This entails sending vouchers for inputs directly to the farmers' mobile phones, which can be redeemed at local suppliers. The fertilisers that the farmers buy at their local stores using these e-wallets are 50% subsidised by the Nigerian government.

### 3.2 RATIONALE FOR SUPPORTING THE ADOPTION OF 4IR TECHNOLOGIES

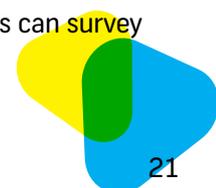
#### 3.2.1 potential applications and impacts

Technology is sorely needed to improve yields in Nigeria, where the northern and central parts are threatened by more volatile rainfall and the whole country faces the impact of climate change on plant growth. Soil degradation and desertification are an issue in the north, mostly for the nomads that live there. The country's rapidly increasing population is also increasing the pressure on agriculture to produce sufficient amounts of food.

Moving away from subsistence farming, there is a drive to commoditise agriculture in the country by digital means/platforms and thus reduce barriers to trade for farmers and make it easier for them to access larger markets for their products. There is potential for technology to help farmers invest in their farms and transport their crops more efficiently so that they can focus on the actual farming. But this requires training of farmers and awareness-raising – funding of technology on its own is insufficient.

There are only a few companies leading the use of the five new technologies in agriculture in Nigeria. While take-up of these technologies in Nigeria is still fairly low, their potential for modernising the sector is as follows.

There can be a virtuous cycle in agriculture when combining some of the technologies listed above: drones can survey



fields and collect data that is then aggregated alongside sensor data to create a pool of Big Data that can be analysed using AI and IoT solutions. This allows for precision farming, whereby irrigation and seed disbursement are carried out more efficiently thanks to data analytics. This also allows for smart application of fertilisers, all of which in turn increases yields and reduces the cost of inputs to farming. For example, an IoT application may concern cattle receiving chips that allow farmers to locate them and track their movements in real time. This helps farmers avoid loss of cattle and can help nomadic cattle herders avoid conflicts with sedentary farmers by alerting them if their cattle grazes on farmland. Currently, Nigeria experiences violent conflicts between nomads and farmers around these issues and so there is considerable potential for technology to defuse a conflict and boost stability in the central regions of the country.

With regard to the potential of individual technologies, when it comes to drones, they could have a significant positive impact on agriculture if legal barriers were removed that are currently imposed due to the military being cautious about the use of drones in the country. The agency in charge of airspace has created a committee to discuss the regulation of drones. The use of drones for commercial purposes has not really taken off in Nigeria to date. Drones are mostly used for basic purposes such as photographs. Moreover, drones are not affordable for many Nigerian farmers. Sharing models where these are rented by individual farmers living in the same village could overcome this barrier.

Blockchain for agriculture is still at an exploratory stage in Nigeria. It may help farmers in commoditising their produce (see use cases below) and reduce the need for intermediaries, thus ensuring more income stays with farmers. One stakeholder mentioned the idea (not yet under development) of using Blockchain to issue credit tokens to allow farmers to raise money to expand their agribusiness and to use smart contracts to ensure the legitimacy of buyers.

With regard to 3D printing, the fact that agriculture in Nigeria is characterised by low levels of mechanisation

means there is less scope for 3D printing to, e.g. replace tractor parts, given the lack of tractors overall.

Public investment in and support of agritech is very low. Most innovation in the sector is driven by private sector start-ups that often grow in local technology hubs. Some solutions are also being developed by larger ICT companies such as MTN (see use case below). Many innovations are still at an early stage, so it is too soon to judge to what extent there is demand for these solutions. In general, 4IR technologies can have a huge impact on the development of the sector and many farmers are keen to adopt technologies that help them overcome their daily challenges.

### **3.2.2 current use cases and level of technology take-up**

Agri-tech start-ups are seeking to solve the logistics of food waste in the country and how to get produce from the farm to the end consumer in the most efficient and effective manner. Some also create solutions for farmers to access credit to grow crops, connecting urban citizens with some disposable income with rural farmers who need the cash injection to expand their production.. According to the web scraping done for this study, Blockchain is the most frequently searched technology in Nigeria in the context of agriculture.

Below we present a set of use cases of start-ups working on applying 4IR technologies to disrupt and modernise the agricultural sector in Nigeria.

MTN, one of Africa's biggest telecoms providers, already has an IoT-based Animal Identification Management System. This is based on affordable RFID chips that are attached to each animal (mostly cows). The chips provide real-time information on the location of animals to the farmer, allowing them to manage their 'assets' more efficiently. There are automatic alerts if a cow breaks out of a designated area. In the future, this solution could also trigger an alert if a cow enters areas it should not, such as farmland.



## box 01

### Plantheus

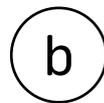
Plantheus is a plant diagnostic application that requires no internet access to run diagnostics on the condition of (cocoa) plants. In west African countries, a reduction in the quantity and quality of farm produce due to inadequate knowledge of plant diseases and their treatment is a major issue (annual losses amount to 30–40% for cocoa plants due to insects, pests and pathogens). The application provides a solution for this problem by using image recognition of plant diseases and suggesting best practices for managing the diagnosed disease. The AI algorithm that will be used in the application will be robust enough to learn about new crop diseases. Moreover, the application will be available in local languages to make it easier to use for farmers and there will be a community that connects farmers to research institutes.

A range of other use cases are under development or are already being deployed:

- Zenvus seeks to improve decision-making for farmers by providing insights into crop status based on data collected from sensors and other means (IoT). The data is stored in the cloud and can be accessed by the farmers regardless of their location. This allows farmers to use fertilisers and irrigation more precisely, increasing the efficiency of farming;
- Binkabi is a Blockchain-enabled agriculture trading platform developed in cooperation with Sterling Bank, one of Nigeria's biggest banks. The platform will allow farmers to deposit their crops in a warehouse as opposed to the current situation in which they are often forced to sell it right away after harvest. In return for their deposited crops, farmers will receive a tokenised asset receipt that is stored on the Blockchain. They can then use this token as an asset to borrow money against, allowing them to invest in their farms and to sell at the optimal time in terms of crop price rather

than immediately after harvest as the loans they can receive thanks to the token allow them to wait for optimal prices;

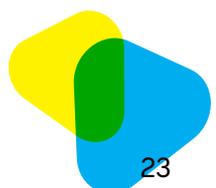
- another Blockchain start-up is XendBit which aims to build a decentralised Digital Asset and Securities Exchange in collaboration with the Nigeria Stock Exchange. The platform will work on Blockchain, allowing for alternative funding and crowdfunding of infrastructure and equipment for farms. The platform should reduce the counterparty risks when it comes to payments.



## box 02

### Vetsark

Vetsark analyses Big Data to protect crops and livestock from pests and diseases by drawing on real-time data as well as farm and clinical case files, including information on diagnosis, treatment and results. This helps to cut inventory losses and gain business insights. The start-up uses Machine Learning for disease prediction and has a field team which subsequently offers suitable products and services directly to farmers. The application works as a mobile platform for veterinarians, crop extension officers and farmers. To date, the start-up has saved \$50,000 worth of livestock and helped vaccinate 120,000 cattle. The entrepreneurs are in discussion with the Federal Government to deploy the system across the country.



- **Orbital Solutions** uses Big Data from digital farmer profiles using the geospatial platform Agroexchange and drone technology to provide small scale farmers with technology driven advisory services. The company uses multispectral drones to monitor crop health. In the future, they intend to use AI to predict yield and combat pests. They also plan to provide localised (local language) weather information prediction and advisory services. The company also teaches young people in local communities how to use ICT and smartphones to collect and interpret data to support smallholder farmers. The ultimate goal is to facilitate aggregation and reduce post-harvest losses for smallholder farmers by using geospatial data and farmer profiles to provide information about the optimal location for farming production and processing.
- **Hello Tractor** offers technology for smarter, better maintained and more profitable tractors using an AI solution from IBM. The company sells its own tractors and uses AI to automate complex decisions for the tractor owner related to the choice of tractor and for banks providing credit for the purchase of tractors to decide on who to provide with a loan. The tractors include sensors that are used to monitor their condition (IoT).
- **Farmcrowdy** connects investors and smallholder farmers on a crowdfunding platform. The start-up additionally provides seeds, farm inputs, training on modern farming techniques and a market for sale of the produce to the farmers while the investors are updated in an online dashboard about the progress at the farms they sponsor and receive a share of the profits made. The start-up has raised \$7 million in the last two years.

b

## box 03

### Track Your Build

The Lagos-based start-up **Track Your Build** uses drones, satellites, cloud computing and data analytics. The company offers services related to mapping, GIS and data management of aerial data to monitor infrastructure ranging from roads to power transmission networks. For the agricultural sector, the company enables the collection of data on vegetation, numbers of plants, plant health, height and field performance, nitrogen content and many other data in order to predict yields and maximise field productivity whilst reducing environmental impact. The start-up has won awards from the Tony Elumelu Foundation, Airbus and the German Corporation for International Cooperation.

### 3.3 DRIVERS AND CHALLENGES SPECIFIC TO AGRICULTURE

The main challenge regarding agriculture is the lack of quantity and quality of agricultural products in Nigeria. As explained above, digital solutions can provide answers to these issues, for instance, by using drones to monitor crop health. However, digital solutions require the necessary infrastructure: access to electricity, access to the internet, access to hardware (e.g. mobile phones, drones or other devices) and users who have sufficient knowledge as to how to use the applications that they are provided with. Since literacy is an issue in Nigeria, especially in rural areas, digital solutions for agriculture need to take this into account. Moreover, due to the different climate zones (ranging from tropical rain forest to the desert), advice for farmers needs to be adapted to these circumstances. Finally, there are sedentary and nomadic people in Nigeria and several languages are spoken, which highlights the need for custom-made solutions adapted to the cultural diversity of the country. Otherwise, there could be a risk of deepening inequality between those who are computer-literate and those who are not.

These challenges notwithstanding, there are considerable rewards to be reaped from using the 4IR in agriculture in

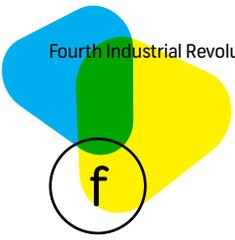
Nigeria, which should drive its take-up. The consequence of combining drones, IoT and AI would be more productive farms that increase food security and hence well-being, using fewer resources as inputs, which has a positive impact on the environment. However, increased use of technology may also reduce the need for manual labour and hence the number of jobs in agriculture. This may not be a negative development, however, as it would mean that Nigeria's workforce would resemble more that of more advanced economies, with fewer people working in agriculture and more in industries and services and working in urban environments.



4

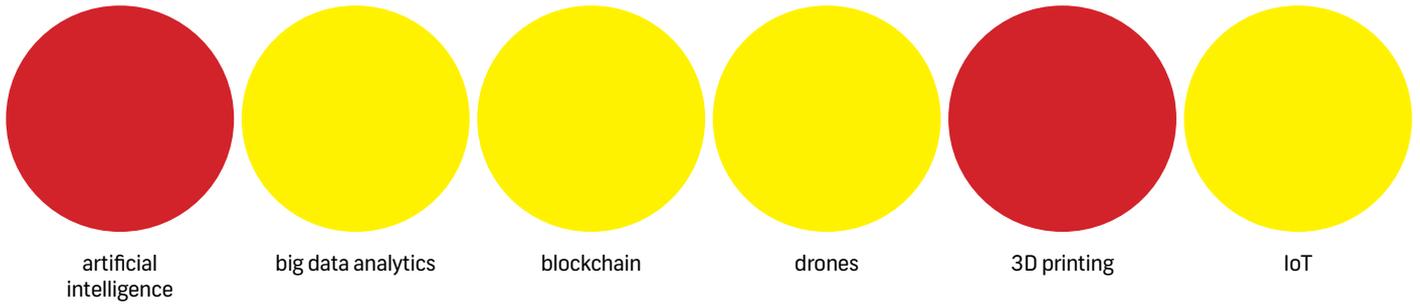
energy



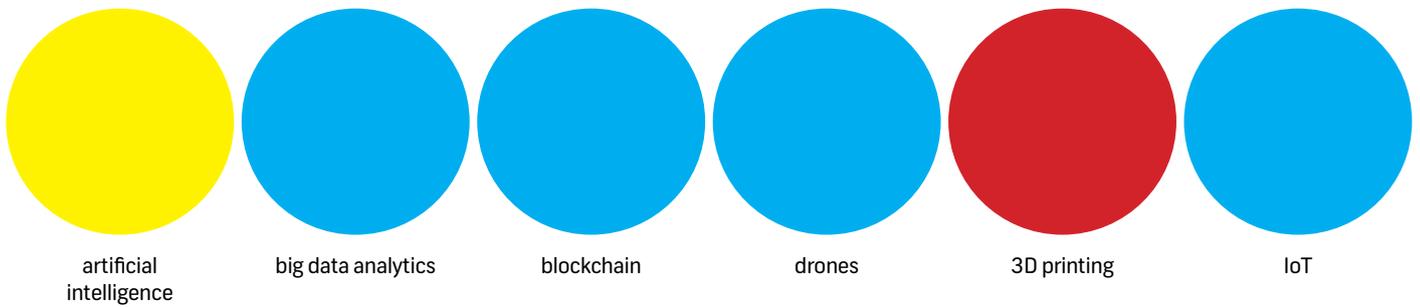


## figure B

current level of utilization of technologies



potential for applications



### LEGEND

**red**, not many / few examples; **yellow**, nascent / some examples; **blue**, good potential / numerous examples

### 3.1 PRESENTATION

For more than three decades, oil has been the driving force behind Nigerian growth, but the emergence of services activities has gradually reduced its contribution to the national wealth (which now only accounts for 16% of value added).

The growth of the non-oil sector is handicapped by a real crisis in the electricity sector.

While the country accounts for more than half of west Africa's installed electrical capacity on its own (with 13,300 MW, of which 86% in thermal gas and 14% in hydraulics), the power actually available on the network is closer to 4,500 MW before technical losses whereas the demand is at least twice as much. This difference is explained both by the bottleneck that represents the supply in gas and outdated and undersized electricity transportation infrastructure.

Electricity demand exceeds supply. Nigeria's population is over 190 million and is rapidly urbanising. In line with current levels of economic growth, Nigeria's demand for energy is forecast to increase from 15,730 MW in 2016 to 41,133 MW in 2018 and to 88,282 MW by 2020.

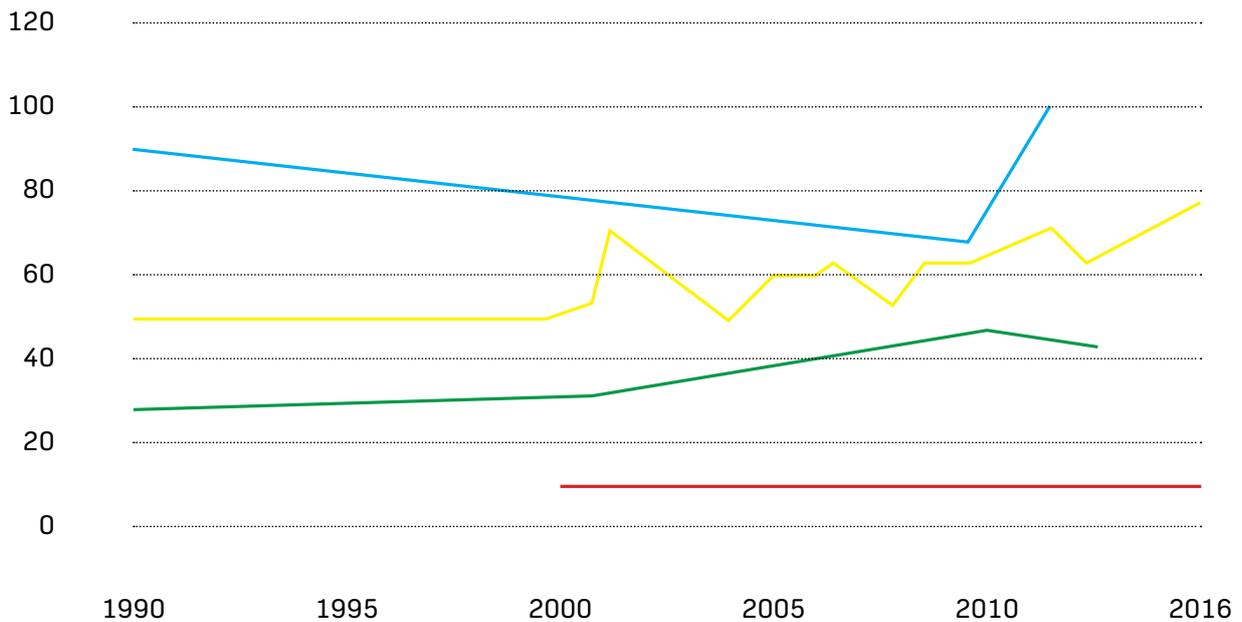
Nigeria's actual power generation is a third of its capacity. Although power generation has improved (currently 13,300 MW), power available on the network is closer to 4,500 MW, which is about a third of what the country can produce.

Based on energy data from the AfDB open portal in different African countries, the following figure shows the trends in the evolution of energy production and consumption for Nigeria.

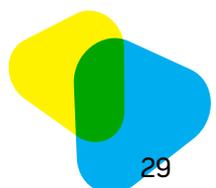


## figure 03

evolution of different energy parameters in Nigeria



- access to electricity, urban (% of urban population)
- access to electricity, rural (% of rural population)
- proportion of population with access to electricity (%)
- proportion of population with primary reliance on clean fuels and technology (%)



Constraints in terms of availability of gas. Currently, about 86% of power generation is dependent on gas as the primary energy source. Limited funds to procure gas and prevent gas pipeline vandalism are among the main reasons for insufficient gas.

Power shortcuts. Many have turned to alternate sources of power such as generators. This situation is not helpful for the economy. Records from the Manufacturing Association of Nigeria (MAN) show that Nigerian manufacturers spent N66.99 billion on generators and alternative energy resources to power their factories in the second half of 2016 due to poor power supply from DisCos.

The Federal Government's Economic Recovery and Growth Plan 2017-2020 (ERGP) sets out the medium-term structural reforms to diversify Nigeria's economy, with a top priority of expanding power sector infrastructure. The ERGP recognises the fundamental role of power to the development of all sectors of the economy.

In the long term, the ERGP aims to increase power generation by improving operational capacity, encouraging small-scale renewable projects and building additional generation capacity. In the medium term, the ERGP aims to ensure the delivery of at least 10,000 MW (on-grid and off-grid) of operational capacity by 2020 by optimising the existing installed capacity available for generation, addressing gas supply issues, including vandalism, and completing major gas infrastructure lines for power.

In addition, as part of the ERGP, the Federal Government of Nigeria (FGN) aims to improve the financial capacity of the Nigerian Bulk Electricity Trading Plc. (NBET) to support the electricity market, strengthen governance and institutional capacity of sector agencies and improve the commercial viability of Generation Companies (GenCos) and Distribution Companies (DisCos).

In order to implement this strategy, the Power Sector Recovery Programme (PSRP 2017-2021) was designed in 2017 to address challenges in power sector reform. This programme follows up the set of power sector reforms that the FGN has been implementing since 2001 that led to

the privatisation of electricity generation and distribution companies in 2013.

The Power Sector Recovery Programme (PSRP) is a series of carefully thought out policy actions, regulatory, operational, governance and financial interventions to be implemented by the FGN over the period from 2017 to 2021 to restore the financial viability of Nigeria's power sector, improve transparency and service delivery, resolve consumer complaints, reduce losses and energy theft and reset the Nigerian Electricity Supply Industry for future growth.

The objectives of the programme are to: i) Restore the sector's financial viability; ii) Improve power supply reliability to meet growing demand; iii) Strengthen the sector's institutional framework and increase transparency; iv) Implement clear policies that promote and encourage investor confidence in the sector; and iv) Establish a contract-based electricity market.

The PSRP intends specifically to increase electricity access by implementing off-grid and renewable energy solutions and by creating a framework for an off-grid development plan, including mini-grids and solar home systems.

A dedicated implementation monitoring team has been set up to coordinate and monitor the implementation of the PSRP and report to His Excellency, the Vice President. The implementation monitoring team provides the expertise to deliver the various interventions in the PSRP on behalf of the FGN.

## **4.2 RATIONALE FOR SUPPORTING THE ADOPTION OF 4IR TECHNOLOGIES**

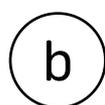
### **4.2.1 potential applications and impacts**

The significant gap between the supply of and demand for electricity has led to recurrent power shortcuts. Thus, the heavy reliance on gas, limited technical/technological know-how, lack of energy efficiency practices and infrastructure maintenance, inadequate regulations and attacks on energy infrastructure contribute to the challenges that the sector faces.

There is potential for the 4IR to overcome some of the challenges in Nigeria's energy sector, mostly related to maintenance of infrastructure, including transmission lines, and to the efficient management of electricity supply and demand. In addition, stable power supply is needed for the 4IR to play an effective role in Nigeria across sectors.

#### 4.2.2 current use cases and level of technology take-up

Currently, there are few applications of 4IR technologies in the energy sector in Nigeria. Most of the current use cases of 4IR technologies in energy are related to Blockchain, IoT, Big Data analytics, and drones. Artificial Intelligence seems to have very few applications, as does 3D printing in energy in Nigeria.



## box 04

### OneWattSolar

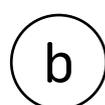
#### Blockchain

OneWattSolar is an Energy-As-A-Service start-up that seeks to help people pay for the energy that they consume using Blockchain without the need to own the solar infrastructure that provides the power. With this payment method, users are charged for their exact energy usage and do not need to purchase the equipment. Moreover, due to the use of a Blockchain and AI-enabled architecture, information about the functioning of the solar home systems is processed in real-time, allowing technical support to intervene quickly in case of system failure. The Blockchain energy start-up is looking to provide affordable and reliable electricity to as many people as possible. Currently, about 6,400 households are on the company's waiting list. Also, OneWattSolar plans to expand in the near future. In 2025, the start-up hopes to access one million households without adequate power supply and provide solar energy through distributed technology.

On the supply side, the technology providers are mainly start-ups that are leveraging technology to solve challenges in the energy sector. Some use cases imply multinational and State cooperation to implement innovative solutions in order to reach national objectives in the sector.

The demand is driven by households and businesses who see an opportunity to have the alternative of accessing energy in a cheaper and more durable way.

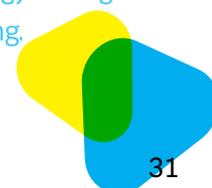
Another example of the use of Blockchain in the energy sector is Solar Bankers. This start-up launched a full-scale smart grid project using its Blockchain-enabled P2P energy trading platform in Nigeria. The start-up has signed an agreement for a pilot project with the Kaduna State Power Supply Company (KAPSCO) to deploy its P2P energy trading platform to the city of Kaduna in the north of the country. The project will connect 66 commercial and residential buildings in the Atiku Abukakar house cluster in a local smart grid infrastructure.



## box 05

### Arnergy

Arnergy, a start-up, provides IoT-enabled solar energy and offers remote monitoring and predictive maintenance services through its tracking software. The tracking software monitors parameters such as battery level and energy consumption to give insight into current performance and to ensure that the system works properly. Generally, the company provides services ranging from an initial assessment of needs to planning and installation of the solar energy systems and their continued operation and maintenance. So far, the installed capacity amounts to more than two megawatts and the current storage capacity amounts to more than five megawatts. The company offers its clients (e.g. a hospital or a provider of student housing) different payment models, including subscription, outright sale and lease to own models. In 2019, Arnergy managed to raise \$9 million in a Series A round of funding.



Another start-up, Upnema.ng, is an IoT-powered platform which provides real time information and a history of electricity supply in selected communities and homes across Nigeria.

### Big Data

The Nigeria Electricity Access Project (NEAP) used Big Data analytics to pilot geospatial least-cost planning to move towards universal electricity access by 2030. The project was developed as part of the World Bank's Energy Sector Management Assistance Programme. The data set used for this project covers the service area for the Kano Electricity Distribution Company (KEDCO) Nigeria. The data collection has been undertaken by the Earth Institute, Sustainable Engineering Lab, in close collaboration with KEDCO.

General Electric and the Massachusetts Institute of Technology (MIT) are involved in a World Bank-sponsored project to put the Reference Electrification Model (REM) into practice in Nigeria. REM is a geospatial package that utilises Big Data to identify cost-effective ways to install distributed power with microgrids. It creates unique power plans specific to a location. It can pick the least expensive energy source, such as solar power, where there is enough sunshine or hydropower near a reliable water source. It can even create a detailed project plan, down to how many wires need to run to which buildings — information vital to effective project budgeting and planning. It uses population data, existing grid information, natural-resource surveys, satellite-sourced topography data and other variables to optimise the cost and benefit of either extending an existing electrical grid or constructing a microgrid.

Early findings in one state, Sokoto, indicate that, under certain assumptions, of the 1,500 sites in need of electrification, 85% will be more economical to electrify with microgrid systems. These sites include Soron Yamma Alela, a village of 384 people that currently relies on rechargeable batteries charged from diesel generators for intermittent access.

The Nigerian government is using GE and MIT's research to design a 172-kilowatt solar-power system in the village with energy storage that will use 18 kilometres of cabling

and poles to connect its 273 homes and five businesses to 24-hour electricity.

### Drones

Beatdrone is a multi-sector drone service provider operating in oil and gas. It provides detailed optical imagery in case of flare stack head inspections without the need to shut down the facility as well as early detection of weak pipelines while providing real time security surveillance. Oando Plc had been issued the first Remotely Piloted Aircraft/drones (RPAS) operator certificate that will enable the oil firm to legally deploy the drones on flights with the purpose of aerial work, specifically for environmental observation, monitoring and protection in its area of operations.

### 4.3 DRIVERS AND CHALLENGES SPECIFIC TO ENERGY

The demand from end users (households and businesses): the positive response of the market (as shown by the use cases of OneWattSolar and Solar Bankers) to some of the use cases illustrates that there is potential for 4IR technologies to be successfully integrated.

The privatisation of the energy sector is an opportunity for the development of innovative solutions using Industry 4.0 technologies. However, the privatisation process has remained incomplete as the State continues to control the transmission network (NBET), which allows the transmission of electricity between generators (GENCOs) and distributors (DISCOs). In addition, this segment suffers from more than one investment that is too small in relation to needs and large amounts of electricity continue to be lost during transmission.

Vandalism is one of the challenges that will likely hamper the integration of a smart grid in some of Nigeria's towns and cities (World Bank, 2013).

The lack of implementation of clean energy policies and the lack of coordination among major government agencies has created distortions and hampers the development of clean energy. Inter-ministerial rivalries, overlapping mandates and outright protection of specific areas often send the wrong signals to prospective investors. The

absence of a clear political vision and leadership, weak regulatory institutions and poor human capacity, coupled with limited funding by government, all add up to make the country's renewable energy market look small compared to that of many other smaller countries such as Kenya. Currently, there is little hope for a rapid transition to a green economy. There is no programme to prepare rural women with small-scale renewable energy education and knowledge. The Climate Change Commission would have the potential to increase synergies across ministries and government agencies at the federal, state and local levels. All of these elements will have a negative result on the smart grid if the technology is to be introduced (Folarin and al., 2017).

Despite the considerable challenges, the potential for 4IR usage in energy is there and, to the extent that it can accelerate the transition to renewable energy, it should a) have a positive impact on the environment and b) on well-being by providing off-grid electricity to rural inhabitants previously without access to electricity. No impact on jobs can be discerned at this point.



# 4

## industrialisation

Manufacturing accounted for 8.5% of Nigeria's GDP in 2017. The largest manufacturing sub-sectors are agro-processing, comprising food, beverages and tobacco; light manufacturing, including textile and wood products; and resource processing, e.g. cement and basic metals. Traditionally, manufacturing has been dominated by Micro, Small and Medium Enterprises (MSMEs) that create jobs.

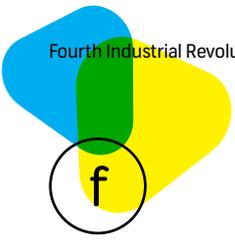
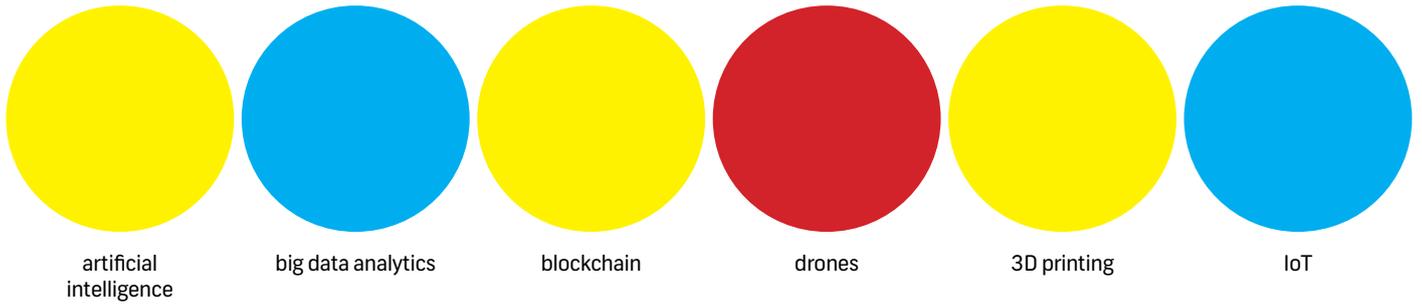
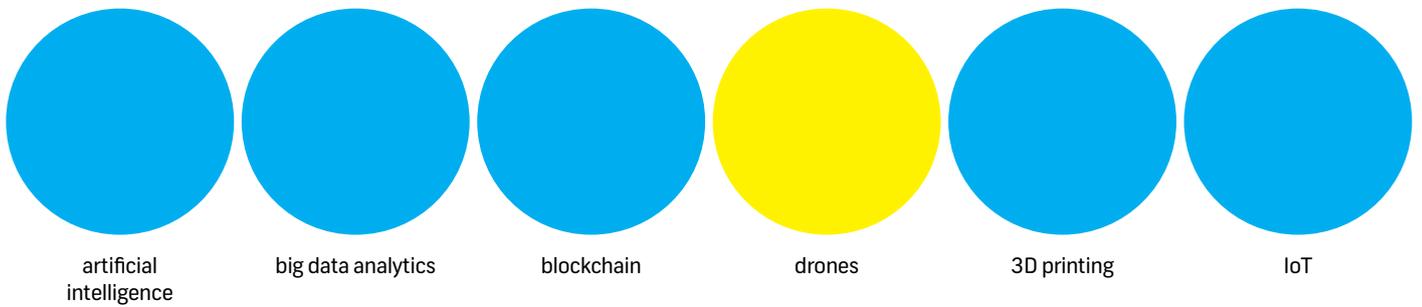


figure C

current level of utilization of technologies



potential for applications



**LEGEND**

**red**, not many / few examples; **yellow**, nascent / some examples; **blue**, good potential / numerous examples

## 5.1 PRESENTATION

Manufacturing accounted for 8.5% of Nigeria's GDP in 2017. The largest manufacturing sub-sectors are agro-processing, comprising food, beverages and tobacco; light manufacturing, including textile and wood products; and resource processing, e.g. cement and basic metals. Traditionally, manufacturing has been dominated by Micro, Small and Medium Enterprises (MSMEs) that create jobs.

According to the UNIDO Competitive Industrial Performance Index 2018, Nigeria was ranked 115th out of 150 countries in 2016, placing it in the lower-middle (second) quintile of all countries and in 11th place out of the 29 Sub-Saharan African countries, suggesting Nigeria's industrial potential remains somewhat underdeveloped.

The ERGP is building on the Nigeria Industrial Revolution Plan (NIRP), which addresses the key challenges in manufacturing, such as limited access to credit and financial services, poor infrastructure and unreliable power supply, which force businesses to rely on generators, thus increasing their input costs and reducing their overall competitiveness and profitability.

The Nigeria Industrial Revolution Plan (NIRP) was designed to accelerate the build-up of industrial capacity within Nigeria. It aims to achieve this objective by developing four industry groups where Nigeria already possesses a clear comparative advantage:

- agri-business and associated sectors: Maximise the benefits from the country's agricultural resources by building an end-to-end integrated agriculture value chain, boosting local production to meet local demand and reducing the country's reliance on imports of processed food products;
- solid minerals and metals: Create an enabling environment targeting large-scale investors to institutionalise world-class production standards in the country's solid minerals sector;
- oil and gas related industries: Provide the foundation for Nigeria to build competitive oil- and gas-driven industries, encourage high value-adding downstream investments and build institutional industrial strength within the country;

- construction, light manufacturing and services: Leverage the significant opportunities in local markets for construction (i.e. housing), light manufacturing and services offered by Nigeria's large consumer population, business demands and infrastructure needs.

Policy objectives are to:

- ensure manufacturing GDP growth moves from a dip of -7.84% in 2016 to 10.6% in 2020, translating to an average of 8.48% from 2018 to 2020;
- create forward and backward linkages among industrial sub-sectors and other sectors of the economy, e.g. solid minerals, agriculture, oil and gas;
- increase local content to reduce the amount of foreign exchange required to buy raw materials and machinery, and to create jobs;
- enhance the foreign exchange earning capacity of manufactured goods to increase foreign exchange earnings;
- increase R&D, technology and innovation to generate the competitive edge needed to penetrate the global economy;
- increase the employment share of manufacturing by 8% per year up to 2020.

The Nigeria Industrial Policy and Competitiveness Advisory Council was appointed in May 2017. The Council's terms of reference include driving an ambitious industrialisation programme aimed at increasing the contribution of manufacturing to GDP by 250% over five years (albeit from a low base), making Nigeria a manufacturing hub in west Africa, and diversifying the economy from its over-dependence on oil. Other terms of reference for the Council include proposing targets for national industrial output and investments across major industrial sectors; and tracking the progress made on specific public and private sector initiatives aimed at transforming the industrial sector and meeting industrialisation targets.

While these plans may be overly ambitious, they point to the government's willingness to prioritise the upgrading of industries and manufacturing to create future-proof jobs

and economic value for citizens, a development in which the 4IR can play a role as a catalyst. At the same time, one should also recognise the environmental damage that rapid industrialisation without concerns for negative externalities can have, as demonstrated by the case of China.

## 5.2 RATIONALE FOR SUPPORTING THE ADOPTION OF 4IR TECHNOLOGIES

### 5.2.1 potential applications and impacts

In order to modernise the Nigerian economy and make it competitive in the 21st century global economy, its industrial policy must be linked to a digital and technology-led strategy for growth.

Artificial Intelligence faces several problems, ranging from a lack of adequate infrastructure to cultural and socio-economic barriers to adoption. However, there is potential for future development of this technology. Some initiatives are being developed for capacity building in the field. For example, Data Science Nigeria, a non-profit, recently launched Nigeria's first AI-focused hub at the University of Lagos and there is a slew of AI-focused start-ups building great solutions.

This uptick in activity within the AI space in Nigeria is largely due to improving conditions within the general ecosystem in the last few years. There is more investment coming into the space and the skills needed to do AI are becoming much more accessible with programmes like Andela and Google's ALC Udacity scholarship.

### 5.2.2 current use cases and level of technology take-up

On the supply side, 4IR technology producers are either start-ups, local companies or multinationals. The demand is driven by businesses in some industries (financial sector and telcos mainly), end users and the government. The use cases in the manufacturing sector seem scarce.

Some interesting AI/Big Data analytics use cases include:

- Intelia is a data-first software company with emphasis on the use of Artificial Intelligence to power solutions for web, mobile and enterprise and has

developed products that have impacted people and businesses on different continents while maintaining a local connection;

- Kudi.ai uses AI to facilitate financial transactions and payments on chat platforms such as Facebook Messenger, Slack and Telegram. The start-up has developed a chatbot which allows users to make payments and send money to friends and family in Nigeria through messages. It uses Artificial Intelligence to understand user requests, drive conversations, understand their spending habits and prevent fraud. The start-up is piloting with banks and telecommunication companies to learn and see how far it can scale up;
- Versus.ng is a sentiment analysis product that enables objective reporting while measuring sentiment across different brands, companies and individuals. It monitors news sources and social networks to see whenever a brand is mentioned. It then provides sentiment and popularity reports as a result of the monitoring. This helps brands and companies make intelligent decisions. Versus is a product of technology firm EnterFive LLC;
- Lara.ng, a WhatsApp-styled chatbot offers turn-by-turn directions and fare estimates for transportation within Lagos. It uses Artificial Intelligence to offer conversation style directions for public transport, tricycles and other transportation modes in Lagos;
- Touchabl, described as the 'Shazam for pictures' is an AI-based image recognition product;
- banks are exploring the use of AI and adopting AI technologies including software robots to streamline and automate processes and chatbots which, on more advanced platforms, use AI and Machine Learning to provide human-like interaction and dynamic banking services via chat conversations. Chatbots such as Diamond Bank's Ada, Stanbic IBTC's Sami, Access bank's Tamara and UBA's Leo allow customers to perform basic banking transactions on the go at various levels of sophistication. While these are not pure AI, they are a good starting point as an introduction to AI;
- Nigeria's telecommunications industry is set to begin the use of its first Artificial Intelligence to enhance service delivery. The Glo AI platform, which will be the

first in the telecoms sector, would enable conversation in English and Pidgin through voice and text;

- Facebook, with its NG Hub set-up in Lagos in partnership with CcHub, is also validating the advent of AI in Nigeria.

The use cases of Blockchain are concentrated in financial services:

- two gaming and lottery companies in Nigeria are set to deploy Blockchain technology in their gaming platforms. One of Nigeria's largest gaming companies, the International Lottery and Gaming Limited, popularly known as NaijaLottery, signed a partnership deal with Blockchain-based lottery platform Quanta to revitalise the traditional lottery. Quanta is a gaming platform which is built on the Ethereum Blockchain and is the first fully certified and licensed Blockchain lottery in the world;
- Nigeria's Customs service is among the global early adopters of the Oracle Blockchain Cloud Service, which has recently been introduced. The service allows organisations to easily build blockchain networks to drive more secure and efficient transactions and to track goods through supply chains on a global scale;
- the Central Securities Clearing System (CSCS) Plc., the Central Securities Depository (CSD) of Nigeria, has successfully completed a pilot using the Quartz Blockchain technology for cross-border corporate action information exchange.

The Blockchain community in Nigeria argues that the country is missing an opportunity to attract major investment in the sector; investment in Blockchain-based financial services such as cryptocurrencies are today going to Rwanda and Malta, which have provided regulatory frameworks that guide operators of the technology. In fact, the Central Bank of Nigeria (CBN) does not recognise a cryptocurrency as legal tender (i.e. as currency that must be accepted if offered in payment of a debt). However, the population of the country accounts for the world's third largest holdings of bitcoin, as a percentage of GDP, after Russia and New Zealand. Recently, the country's parliament has decided to hold an inquiry to figure out the pros and cons of crypto-based payment.

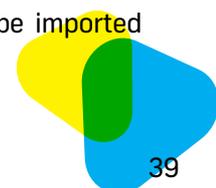
## IoT

with about 48 million active internet users, Nigeria is an African country with an enormous market for the IoT. Nigeria has been building the infrastructure needed for the IoT slowly from the year 2010, when it formulated its national information communication technology strategic plan 2010-2015. Like many countries in Africa, while Nigeria is yet to establish major IoT projects, a remarkable initiative was taken by the National Agency for Food and Drugs Administration and Control (NAFDAC). Faced with the perennial counterfeiting problem, NAFDAC in 2010 resorted to a product verification initiative using Radio Frequency Identification (RFID). The technology, which was put in place in collaboration with Verification Technology Limited (VTL), offered use tags equipped with RFID to authenticate drugs throughout their supply chain starting from manufacturers, distributors, wholesalers, retailers and even consumers.

## 3D printing

a shortage of 3D printing experts tends to slow down this development in Nigeria. It is believed that more established training and adequate funding from government agencies, industries, NGOs and research institutes could spur rapid growth in the development of the technology. Very few universities and institutes in Nigeria are currently researching and using the technology. The known ones include the Prototype Engineering Development Ilesa (PEDI), Edo University Iyamho (EUI) in collaboration with the Federal University of Petroleum Resources, Effurun (FUPRE), Ahmadu Bello University Zaria, Federal University Oye Ekiti, Afe Babalola University Ado Ekiti (ABUAD) and ELIZADE University Ilara Mokin. General Electric (GE) launched the 'Lagos Garage', a new and advanced manufacturing programme in Lagos, Nigeria, at the University of Ibadan and the National Agency for Science and Engineering Infrastructure (NASENI). Nigeria is gradually developing the FDM technology.

Elephab refined the idea of the production of replacement parts using 3D printing in GE Lagos Garage's advanced manufacturing training programme. Its founders want Nigerians to be able to repair things when they break rather than waiting for new parts or products to be imported from overseas.



### 5.3 drivers and challenges specific to industrialisation

- Nigeria can count on a young, adaptable and motivated workforce and entrepreneurs, as well as a strong entrepreneurial culture, to foster the integration of 4IR technologies in the industry;
- 
- some major players in emerging technologies (GAFAs) have installed hubs in Nigeria;
- 
- key challenges include a lack of experts and skills in the mastery of certain technologies, mainly 3D printing (prototyping);
- 
- the manufacturing sector is not currently showing the drive needed to implement 4IR technologies. Most of the current use cases are concentrated in the financial sector and telecommunications.



# 6

## regional integration

## 6.1 PRESENTATION

As the largest Sub-Saharan economy, Nigeria has an important role to play in fostering regional integration. This is reflected in it hosting the headquarters of ECOWAS, a regional West African trading bloc. At the same time, Nigeria is one of a few countries that did not (yet) sign up to the recently launched African Continental Free Trade Area due to the Nigerian governments' concerns about the agreement harming Nigerian entrepreneurs and enabling cheap foreign products to flood the Nigerian market.

## 6.2 RATIONALE FOR SUPPORTING THE ADOPTION OF 4IR TECHNOLOGIES

### 6.2.1 Potential applications and impacts

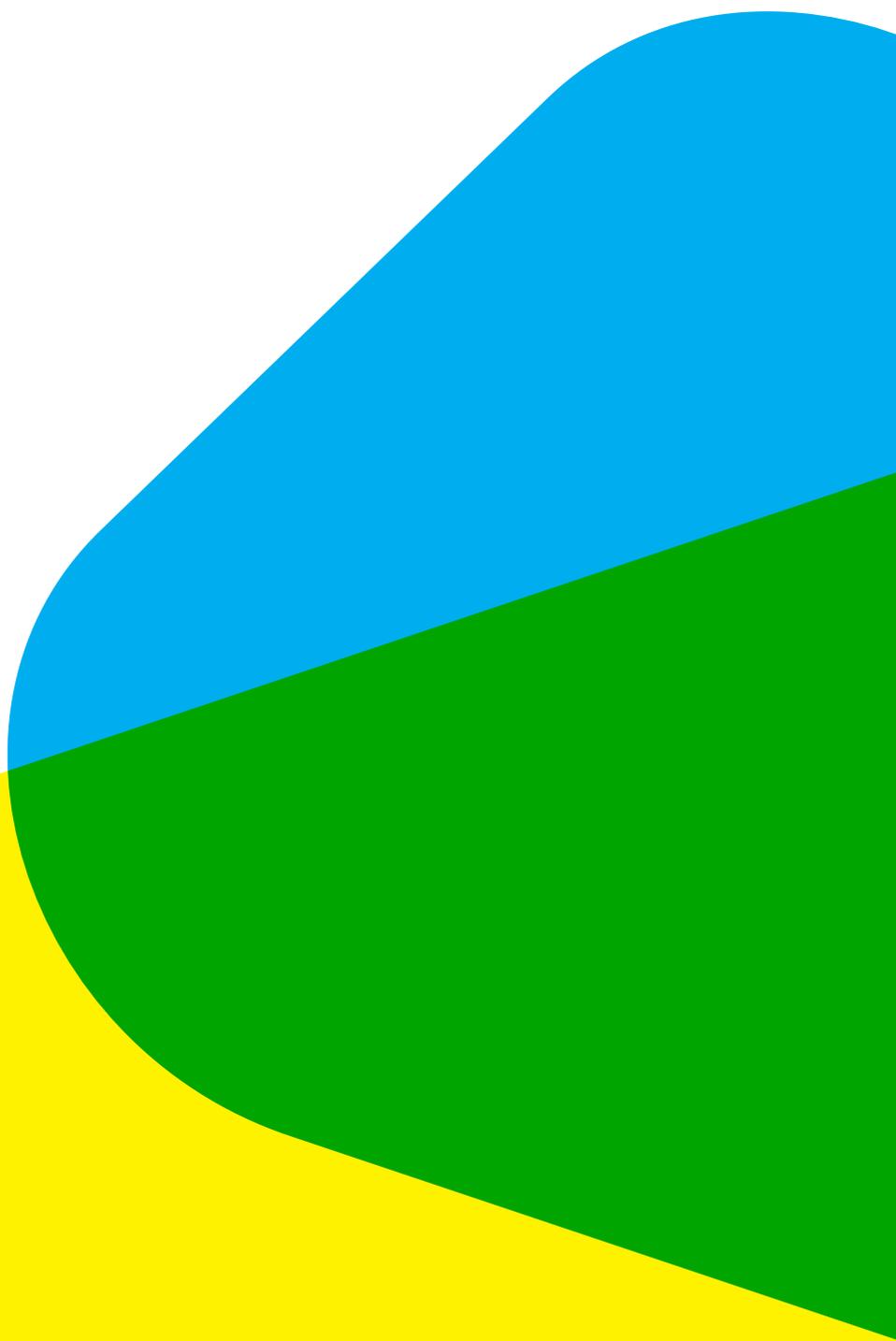
Overall, the current level of Nigeria's integration into the regional economy is still fairly low, pointing to considerable potential for cross-border facilitation through technology, provided that the political will is there. Technologies such as Blockchain may be used in the future to facilitate the financing of cross-border trade, which would contribute to regional integration. Currently, Nigerian banks tend to be cautious about financing cross-border trade. Blockchain may help create alternative markets by providing the necessary liquidity.

### 6.2.2 Current use cases and level of technology take-up

According to the web scraping done for this study, Big Data is the most frequently searched technology in Nigeria in the context of regional integration.

- Kobo360 is a start-up disrupting the logistics sector by using data from trucks, which is analysed using Big Data to reduce friction in logistics and help manufacturers find new markets. The company provides effective monitoring solutions for logistics operators and explicitly aims to power trade and commerce across Africa.
- The Nigerian customs authority is working on a cross-border trade platform project using smart contracts via Blockchain. This should facilitate intra-regional trade and allow traders to import products from neighbouring countries rather than faraway places.

# 7 wellbeing



## 7.1 PRESENTATION

This section looks at key policies in the areas/sectors of education, healthcare and smart cities, which all make up the AfDB's Wellbeing Priority. Rather than providing a comprehensive overview of developments in each of these areas in Nigeria, we will only highlight the most relevant trends for 4IR take-up.

**Education.** The latest reform of Nigeria's education policy dates back to 2004. This policy aims at unification and equality of the national education systems and provides for the introduction of federal governmental control and funding of education. The National Centre for Technology Management is working on integrating ICT in education, notably in higher education institutions.

### Health

In 2016, the Nigerian Federal Ministry of Health announced its presumably latest version of the national health policy. This document addresses the fundamental health issues afflicting Nigeria's population:

- health of specific groups such as mothers and children (according to the World Health Organization, one out of 10 live-born children die aged five or younger);
- combatting specific illnesses e.g. HIV/AIDS (in 2016, Nigeria had 220,000 new HIV infections and 160,000 AIDS-related deaths; only 30-40% of HIV-infected people have access to therapy), TB (tuberculosis) and malaria;
- structural weaknesses in the healthcare system related to funding, low use of technology, human resources, research and development, and access to primary health care centres in remote areas.

In the same year, the national health ICT strategic framework was announced. This document states the considerable importance of ICT services for healthcare in Nigeria. It envisages building an architecture for health information exchange so that patients, service providers and administrative bodies can interact. There is also a study available providing an inventory of digital health solutions in Nigeria as of 2017.

Smart cities. On the city and regional levels, there are several initiatives to build smart cities, for instance in Lagos, Kaduna and Abuja. In 2016, the city of Lagos started its Smart Cities Initiative with the support of the city of Dubai. The overall aims of this project include job creation and carbon neutrality for the city. The first steps towards implementation included the installation of free Wi-Fi infrastructure to facilitate the connectivity and data flow needed for smart city solutions and training of state government staff to align them with the vision for a smart city and to secure their buy-in. Other related activities include government support for private smart city initiatives such as Eko Atlantic City close to Lagos. Despite all these efforts, one should keep in mind that issues such as a lack of financial means still pose considerable challenges to the realisation of the smart city.

## 7.2 RATIONALE FOR SUPPORTING THE ADOPTION OF 4IR TECHNOLOGIES

### 7.2.1 potential applications and impacts

**Education.** The 4IR technologies have, according to the stakeholders consulted for this study, considerable potential for upgrading education in Nigeria but currently this is the sector perhaps least disrupted by these technologies. Education is a special sector in that it can both benefit from 4IR, especially benefitting those without formal education by democratising the use of technology, but also contributes to creating the right preconditions for 4IR by ensuring human capital and skills are available. Here, also Virtual Reality (VR) can play an important role (see examples described in section 7).

### Health

Stakeholders pointed to the use of Blockchain in digitalising and sharing medical records. As things stand, patients and healthcare providers would not trust a central entity to hold such a database but rather would favour a decentralised, anonymous database which requires a Blockchain solution. This could create the basis for Big Data and AI solutions improving healthcare provision and diagnostics in the country. 3D printing can also play a role in healthcare by reducing the costs for prosthetics and samples. However, the market entry barriers for new technologies in healthcare are particularly high as this is

a highly regulated and largely public sector and is more hesitant vis à vis the adoption of new technologies.

Hand-held devices can be used to detect if a pharmaceutical product is genuine or a call centre can provide information on HIV/AIDS. There is also a description of the existing national digital health management information system, called DHIS2, which is described as a “tool for collection, validation, analysis and presentation of aggregate and patient-based statistical data”.

Video therapy and remote diagnosis and care can also be enabled by technology and be upgraded with the 4IR, e.g. by using image recognition to automate diagnostics.

Another area where technology could help concerns the fact that hospitals in Nigeria are currently often not paid by insurance companies for years for the services that they provide, making it more difficult to operate them. A governance system using smart contracts and Blockchain, whereby payments are made automatically no later than three months after service delivery, could address this problem and help hospitals budget more efficiently. But such a solution would require government buy-in to take off.

MTN Nigeria is already working on bringing the IoT to healthcare. Wearable sensors that communicate an individual's health status may in the future replace some medical check-ups, but this requires robust health management systems that are not yet in place in the country. Insurance companies may also be interested in tracking customers' health status and intervening to protect their health.

### 7.2 current use cases and level of technology take-up

According to the web scraping done for this study, AI is the most frequently searched technology in Nigeria in the context of well-being.

The following use cases highlight the potential of 4IR technologies in Nigeria in the healthcare sector:

- Gridc is an IoT start-up that provides an affordable and portable cold chain device for efficient storage of

b

## box 06

### Project MIMCURE

Every year, 245,000 Nigerians die from tuberculosis (TB). It is considered one of the most major infectious diseases across developing countries by the World Health Organization. TB is curable but there has been an increase in drug-resistant cases of TB, which points to a lack of adherence to treatment by patients.

This project is being implemented by the Lagos-based Co-Creation Hub in conjunction with the Nigerian Institute of Medical Research. The project aims to leverage AI to improve surveillance and detection of outbreaks of tuberculosis (TB) around the country and to improve adherence to TB treatment.

This is achieved by building a system that continuously collects, analyses and interprets health data in order to predict and plan for outbreaks and epidemics at an earlier stage than currently. The system consists of a digital public health intelligence platform. AI is used to recognise patterns in the data collected (disease case reports) and identify and report, at an early stage, on any anomalies and patterns indicative of possible outbreaks to healthcare organisations, facilities and the public. The system also draws on a wider range of data to identify anomalies, including healthcare product purchases, absences from work or school, presenting symptoms to a healthcare provider or presenting prescriptions for laboratory tests.

In addition, Nimcure promotes adherence to TB treatment using a digital care tool helping patients and caregivers to better manage the treatment process remotely and on the go. This draws on video-observed therapy.

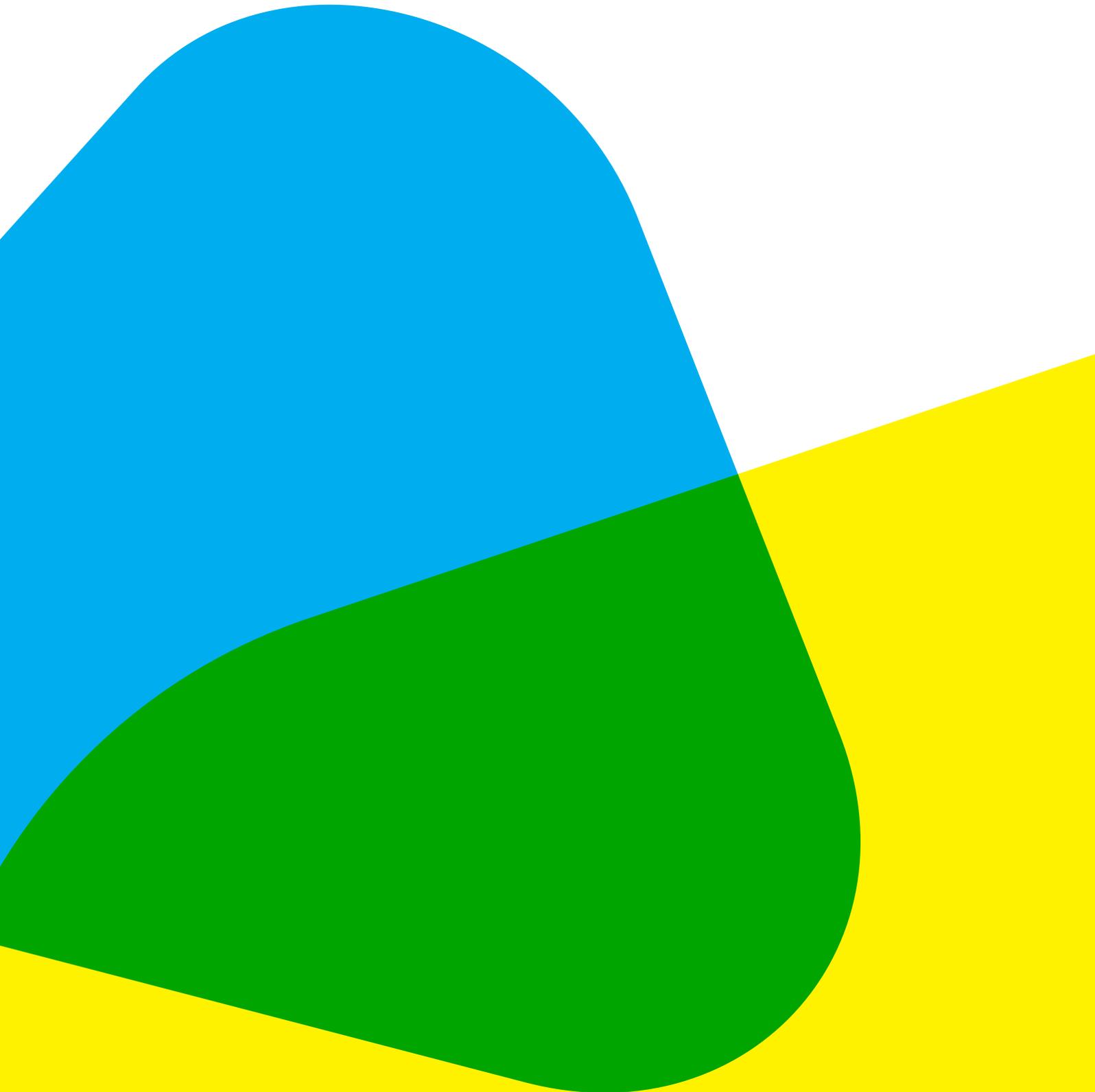
Nimcure was carried out as a pilot project between April 2018 and March 2019.

vaccines, blood and other health/agricultural products (also to be potentially used in the oil/gas sector, in and around abattoirs, and for fast moving consumer goods like refreshment beverages). The solution improves 'last mile' delivery using a smart, IoT-enabled cold chain box sending real-time data to customers. For instance, in case a vaccine to be transported has been tampered with, it can be located en route before it is delivered to patients. The data collected includes the temperature in the box (automatically issuing an alarm when the temperature exceeds predefined levels), location and battery duration;

- Treplabs is a start-up installing sensors at blood drip pumps that can prevent clinical and surgical errors by monitoring infusion treatment. The device that they develop can prevent the backflow of blood during drip treatment by monitoring flow rates and volumes administered and automating the drip treatment process. Medical staff can check the flow rate via a mobile app and web dashboard. The device sends automated text messages to staff once the fluid left drops below 5%.

### **Smart city**

RoadPreppers have developed a solution that allows users to navigate traffic congestion with driving directions and public transport options. In addition, an app uses a chatbot to provide public transportation directions and fares for commuters in Lagos. Both are viewed as better than existing options, such as Google Maps. As an interviewee noted, they provide the commuter with more transparent information on fares from different public transport providers. The system could be rolled out across developing and fragmented cities to better plan, commute and connect on their trips. The data thus generated could also be used by traffic planners to improve traffic, contributing to the emergence of smart city solutions.



8

overall conclusion for a business  
case in the country



## 8.1 IS THERE A BUSINESS CASE FOR 4IR TECHNOLOGIES IN NIGERIA?

AI, IoT and Big Data are interlinked and are seen by stakeholders consulted for this study as having the widest range of (potential) applications in the country and hence the greatest potential for having a positive impact on socioeconomic development. Moreover, given that they are largely software-based, with the exception of sensors used for the IoT, they are more affordable for entrepreneurs wishing to try out new solutions compared to the upfront cost of 3D printers and drones, which need to be imported and on which tariffs are levied. This means that IoT and AI solutions may be more affordable to end consumers too. In the long run, it would accelerate 4IR take-up if 3D printers and drones could be produced locally, according to some stakeholders consulted for this study.

4IR technologies may also have potential in establishing Nigeria as a market for data analytics outsourcing, e.g. from the US, similar to the outsourcing that is already happening from US companies to Indian service providers. However, this requires a layer of quality control between Nigerian developers and western clients. The aforementioned company Andela is trying to do this to some extent.

In the following section, we summarise a few key cross-sector trends with regard to the existing and potential impact of some of the five technologies in Nigeria.

### Big Data

Big Data is the main resource for IoT and AI applications. One entrepreneur consulted for this study explained that the definition of Big Data is constantly evolving (currently it refers to amounts of data in the order of multiple terabytes). The only companies with access to such large data sets in Nigeria are the telecommunications providers such as MTN or Interswitch. As such, it is difficult for start-ups to disrupt the economy using Big Data and a lot of entrepreneurs work with data obtained from Google rather than local data. Another limiting factor is the lack of data analytics specialists in the Nigerian workforce, an issue that is currently being tackled by the aforementioned initiative Data Science Nigeria, which is co-sponsored by MTN (see also section 2.3 for further details). This means

that the impact of Big Data remains rather limited in Nigeria for now although there is considerable potential.

### AI

AI has a wide range of applications in Nigeria, as was seen in the previous sections of this report. The biggest limiting factor right now is the lack of appropriate skills in the local workforce. Some initiatives are trying to change this. There are a few training facilities on AI and Machine Learning in Nigeria, for example Developers Circle Lagos and Coven works. DeepQuest AI is developing a self-hosted Artificial Intelligence (AI) Server that will enable developers to build AI-driven applications and solutions for companies in sectors such as healthcare and transport. The company addresses the issue of stable internet connectivity as it represents a low-cost offline solution for which no continuous internet or cloud connectivity is required.

### Blockchain

Blockchain is increasingly used in Nigeria. By allowing transactions to be organised on a decentralised basis, it helps create trust among market participants, which is needed to exchange data and value. Blockchain thus increases market efficiency by creating trust and reducing the scope for fraud and the risk of monopolies. One entrepreneur consulted for this study predicts that the more data is shared through digital means in Nigeria, the more people will become concerned about data protection, which will create a tipping point for Blockchain to take off since it provides anonymity.

An interesting project aimed at supporting capacity-building in Blockchain is the Blockchain Lab in Lagos, which runs training courses, provides consultancy services for corporates (mostly banks) and also aims to incubate Blockchain start-ups. Several Nigerian companies (Korapay, Qudax, Xendbit) aim to facilitate the transaction of remittances by Nigerian expats using Blockchain and cryptocurrencies to deliver the rapid settlement of remittances within minutes instead of days. Several stakeholders also suggested that Blockchain can play an important role in e-government, securing land registry and solving trust issues in elections.

## Drones

In Nigeria, the potential of drones largely lies in them acting as a tool facilitating the collection of Big Data for analysis using AI algorithms. One stakeholder proposes that the government promote drones by providing training on how to effectively use drones against a token fee and registration of the said drones.

## 3D printing

3D printing training facilities are being set up around the country. One such lab is Colab, where an inventor is producing filaments (the equivalent to ink for 2D printing, which so far had to be imported into Nigeria) for 3D printing locally. In order to accelerate the use of 3D printing solutions in Nigeria, courses need to be developed and taught in 3D design as the execution is the easier part, with the upfront cost of equipment being a factor that can be dealt with by setting up 3D printing facilities. One such facility is GE Garage in Lagos, where training on 3D printing is also provided.

Several stakeholders suggested that Virtual Reality (VR)/ Augmented Reality (AR) is another important technology in Nigeria. Examples of use cases under development in Nigeria include in education, Augmented Reality can be used to replicate science labs in secondary and tertiary education. Given that chemistry labs are expensive to build, it is more cost effective to train chemists using VR & AR simulations. Immersive experiences can also be created in architecture to simulate buildings. One start-up in Lagos (Quadron Studios) is working on occupational health and safety applications using VR, creating the benefits of on-site training without the associated infrastructure costs and personnel risks. Another Lagos start-up (KanjiDrive) aims to train truck drivers using a VR driving simulator to improve road safety whilst reducing the cost of training. AR can also be used to enhance video conferencing given the difficulties of travelling around Nigeria in an affordable manner, thereby reducing barriers to business mobility.

Finally, one sector is certainly the most advanced in Nigeria by using the five technologies in the scope of the study, which is the financial industry. It has of course considerable impact, as a cross-cutting sector, on the AfDB's five

priority areas. In Nigeria, FinTech start-ups are busy using technologies to build new payment systems, to lend products and to offer asset securitisation; helping customers save, acquire credit and take part in the global economy of buying and selling with digital money solutions. Given the country's - thankfully waning - reputation for internet fraud, local bank cards often do not work for international transactions. FinTech start-ups create solutions for Nigerian customers to pay for foreign products. A relevant project in the FinTech sphere using Blockchain concerns a Blockchain-powered mortgage registry as a one stop shop for land transactions and secure mortgages. The use of AI is particularly prominent in FinTech, where data is mined to innovate financial services. An example is the start-up Paylater, which analyses applications for micro loans via a mobile app. Another example is Kudi.ai, which uses AI to carry out financial transactions and payments via chat platforms and online with a chatbot that can carry out transactions and recharge cards and make other miscellaneous payments on behalf of customers.

The field visit carried out for this case study suggests that FinTech is one of the most dynamic sectors in Nigeria when it comes to 4IR technology adoption, notably Blockchain, Big Data and AI. Alongside the telecommunication providers, digital payment providers collect the most data on end consumers, forming the basis for new business models around how to monetise this data, e.g. to create credit scores for citizens based on their purchasing behaviour, thus improving people's access to finance. These innovations are not only driven by start-ups but also by major Nigerian banks that operate in 10-15 African countries and can thus act as a good multiplier to disseminate FinTech innovations across the continent. In turn, this makes Nigeria a good test case for FinTech in Western Africa. The financial system is quite well developed in Nigeria and multiple banks are launching their own technology hubs.

A summary of markets that can be targeted by sector and technology is presented below.



**LEGEND**

**red**, not many / few examples; **yellow**, nascent / some examples; **blue**, good potential / numerous examples

As section 3 has shown, there are already plenty of use cases in agriculture for 4IR technologies, especially for drones in combination with IoT in driving precision farming and Blockchain in facilitating the trading of agricultural commodities.

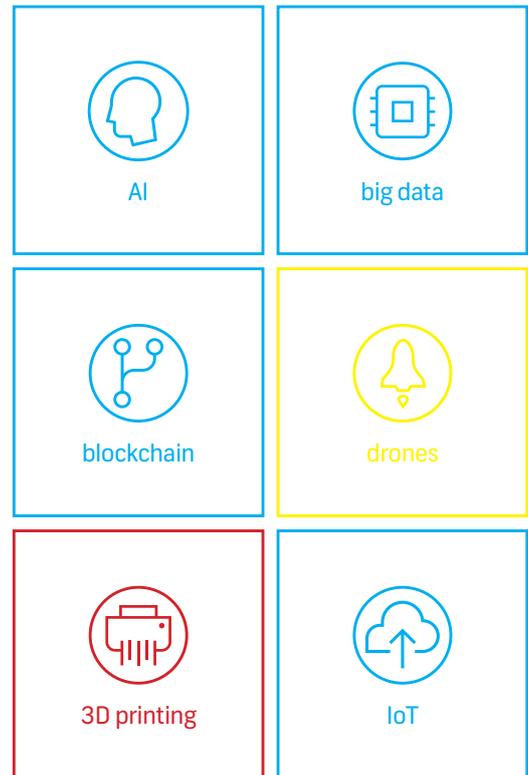
As section 4 has shown, there are only a limited number of use cases for 4IR in energy in Nigeria, mostly related to Blockchain-powered trading platforms and Big Data being used to efficiently install micro-grids.

As section 5 has shown, there are very few use cases of the 4IR being used to drive industrialisation in Nigeria that have gained traction, which may partly be explained by the fact that the manufacturing sector is of relatively minor importance to Nigeria’s economy.

As section 6 has shown, there are very few use cases of the 4IR facilitating Nigeria’s regional integration.

As section 7 has shown, there are plenty of use cases of the 4IR being used to transform Nigeria’s education and healthcare systems, notably using AI to predict epidemic outbreaks and using AR/VR to modernise educational experiences (as mentioned in section 8.1).

**TECHNOLOGIES**



**LEGEND**

**red**, not many / few examples; **yellow**, nascent / some examples; **blue**, good potential / numerous examples

The above assessment is based on an analysis of existing use cases and the stakeholder feedback obtained on the relative potential of the different technologies for Nigeria's socioeconomic development. Overall, a combination of IoT, Big Data and AI is at the core of many of the use cases analysed in this report and is expected to transform many sectors of Nigeria's economy, from agriculture to healthcare. Drones may play an important role in modernising farming and infrastructure maintenance, but this depends on overcoming regulatory hurdles. 3D printing appears to have limited potential, also in the context of Nigeria's underdeveloped manufacturing sector. Blockchain can be expected to play an even more important role in FinTech in the future and in creating markets and platforms for data-sharing.

## 8.2 OVERALL SWOT

### strengths

young, adaptable and motivated workforce and entrepreneurs and strong entrepreneurial culture
large number of tech hubs providing electricity, internet connectivity, training and mentorship
large number of use cases of 4IR solutions under development (even if often not yet fully deployed)
lack of coherent national strategy on how to leverage 4IR
a successful diaspora

### weaknesses

weak infrastructure: roads, lack of stable power supply, especially in rural areas, lack of stable internet connectivity – both broadband and mobile, especially in rural areas and regarding 'last mile' connectivity
skills mismatch: insufficient training specifically on 4IR technologies
low attractiveness of job offerings locally due to non-competitive salaries, consequently: brain drain of software developers to other countries
insufficient access to risk finance for 4IR tech start-ups; weak corporate involvement in developing 4IR solutions outside the banking and telecommunications sectors

disconnect between research institutions, entrepreneurs and corporates (no proper integration)
not a strong force for regional integration due to it being a protected market
weak manufacturing base makes take-up of hardware (3D printing, drones) more difficult/costly
resistance by stakeholders to technology

### opportunities

largest market in Africa; Nigerian banks active across Africa; potentially good test bed for new technologies although market somewhat closed
potential of Blockchain and other 4IR tech to increase transparency and reduce scope for fraud
sectors such as agriculture, health, education, e-government, which are very important to the Nigerian economy, have considerable potential to benefit from the 4IR
potential for outsourcing 4IR-related work (e.g. Big Data analytics and development of affordable AI APIs) to Nigerian experts
national plan to improve broadband connectivity well on track (reaching predefined targets)
awareness at national government level of importance of broadband connectivity and skills development for taking up the 4IR and increasing openness to try out 4IR solutions such as drones
some promising initiatives at regional level (e.g. Smart City Lagos)

### threats

threat to employment – ambiguous impact (some job losses and some new job opportunities expected)
threat to inequality between urban and rural areas being exacerbated by 4IR technologies
threat from potential abuse of digital data and platforms

# 9

## recommendations

One barrier to wider 4IR take-up is resistance by certain stakeholders to technology. For instance, a start-up trying to create a digital land registry using a Blockchain platform to modernise the mortgage system in Nigeria faced resistance by landowners who did not want to digitalise their titles since they were concerned that this could expose new taxes to be paid on their property. This is problematic in so far as a digital land registry could help landowners access the banking system and obtain loans that can be backed up by their property, a key step in helping people lift themselves out of poverty.

Beyond such concrete concerns, there may also be cultural barriers and scepticism towards technology by its potential users. There is a need to 'demystify' technology, i.e. to clearly explain its advantages and risks, its concrete use cases and benefits for stakeholders and the associated costs so that unfounded scepticism can be overcome, and real risks can be appropriately discussed. Awareness-raising measures need to be funded to create openness and change behaviour so that technological innovations fall on fertile ground. Crucially, creating openness helps ensure that technological solutions are affordable to a wider share of the population. There are already ideas about how to make technology more affordable, from creating sharing models for drones, doing away with the need for farmers to purchase their own drone, to IoT-enabled solar panels that are handed out on credit and automatically switch themselves off when their users are not paying the agreed instalments, reducing the upfront cost of such solutions for villagers. The project Lumos (supported by MTN) does just that, demonstrating how the use of the IoT can enable consumption for low income families.

A potential driver of the 4IR in Nigeria is the well-educated and motivated diaspora that wants to bring Nigeria forward and can bring innovations to the country. One way to accelerate this trend would be to set up a fund (perhaps co-financed by the AfDB) to attract Nigerian academics from abroad to the best education institutions in the country. Nigerian banks could also play a role in funding teaching on key disciplines such as Machine Learning that are not being taught right now in Nigeria. Education needs to be improved so that entrepreneurs need not self-teach in order to apply technology but can draw on resources and institutions in this endeavour.

## **9.2 potential projects to be funded by multilateral/bilateral development institutions**

The field visit and interviews have revealed a wide range of intervention points in Nigeria for the AfDB or other multilateral/bilateral development institutions to facilitate the take-up of 4IR and boost its impact on society and economy.

- the AfDB could support investments in solar power and off-grid solutions to bring a stable power supply also to remote regions of the country. It could do so by funding relevant pilot projects using 4IR technologies such as IoT-enabled pay-as-you-go-schemes, which reduce the cost of solar energy for villagers and allow the development of micro-grids. Such pilot schemes could then encourage existing energy companies in Nigeria to develop and roll out products and services along similar lines across the country;
- complementing Federal Government investments in ICT infrastructure and training such as the national ICT park. The Nigerian Federal Ministry of Communication (MoC) plans to establish hubs that would include software test centres and other facilities. Specifically, donors such as the AfDB could support the development of data science centres and connecting training facilities to tech hubs and start-ups;
- in domains with a strong public sector influence such as healthcare and education, the AfDB may work closely with private sector stakeholders to incentivise the government to open these sectors up to disruption by 4IR technology. On a practical level, the AfDB could run strategy sessions and seminars inviting key government stakeholders to raise awareness about the importance of 4IR technologies. AfDB funding could also be used as a bid for government to open up their data to help entrepreneurs build technology-based solutions;
- since data is the raw material of much of 4IR technology, the AfDB may use funding to incentivise corporates to make available the data they hold on Nigerian citizens, with start-ups working on data-driven solutions. By getting corporates aligned on that, the AfDB may also induce them to lobby the Federal Government to open up more parts of the economy to innovation. Another stakeholder suggested that the AfDB set up a lobby fund to be used not only by big corporates but also by start-ups and NGOs in a transparent manner to try out new innovative ideas and solve infrastructure challenges;
- the AfDB could also provide incentives for government to foster an enabling environment. For instance, the AfDB may fund 4IR pilot projects in Nigeria using

- drones, e.g. in agriculture, on the condition that regulations on the use of drones are loosened where these currently prevent the commercial use of drones.
- some private sector stakeholders consulted would rather have the AfDB work with the private sector in PPPs to fund projects in the country. In terms of type of funding, one stakeholder suggested adopting a blended approach of debt and equity, potentially working with other donors such as the German development bank KfW, to support technology start-ups. The donors could take equity in beneficiaries to foster long-term cooperation;
  - the AfDB may also support the wider innovation ecosystem and community by co-financing technology hubs, start-up incubators and training centres. The AfDB may also help set up new AI research centres and provide business grants to entrepreneurs developing AI solutions. This could also be seen as a contribution to regional integration if these labs and training centres are open to students from around Africa, as is often the case with existing centres (see profile in this report on Data Science Nigeria). Ideally, each research centre thus supported would have a thematic focus (e.g. one centre could focus on AI for medicine, another on IoT for farming) to maximise their utility and impact. Centres should be located at or in proximity to universities with the right competences and invite experts from all over the world to share their knowledge there;
  - in order to address the human capital precondition for the 4IR in Nigeria, the AfDB could help set up a recruitment agency and define standards for training modules that corporates may then fund across the country in training centres and technology hubs. This would facilitate matching between people with the right skill sets and companies. As things stand, the recruitment industry in Nigeria is underdeveloped, aggravating the skills mismatch issue and slowing down the take-up of the 4IR;
  - consideration should be given by the AfDB to equitable funding across Nigeria's vast territory and many regions. This means that not all AfDB funding should go to Lagos and the south but that rather some funding should also benefit innovators also active in the north of the country;
- one complication with regard to Blockchain may be that, for the AfDB to integrate Blockchain solutions into some of their pipeline projects, they would need to clarify to what extent they are legally permitted to work with cryptocurrencies.



# Appendix A

## list of stakeholders consulted for this case study

<b>African Development Bank, Abuja office</b> , Samuel Kariuki Kuria and Linda Chinyee Amadi
<b>Beat Drone (start-up)</b> , Confidence Odionye
<b>Independent Blockchain expert</b> , Daniel Bloch
<b>Blockchain Nigeria User Group</b> , Chuta Chimezie
<b>Colab (private company)</b> , Sanusi Ismaila
<b>Drawp (private company)</b> , Kessiena Majemite
<b>Ecobank</b> , Kayode Odeyemi
<b>Federal Ministry of Communication</b> , Monilola O. Udoh and Dr. Abdur-Raheem Adebayo Shittu
<b>Federal Ministry of Finance</b> , Dr. Israel Igwe and Timothy Komolafe
<b>Hello Tractor</b> , Jehiel Oliver
<b>Hub One by First City Monument Bank Limited at CcHUB</b> , Nonye Okolie
<b>IoT/SmartCity with Oracle</b> , Kehinde Olashore
<b>Lagos State Ministry of Education</b> , Ready Set Work Scheme & CodeLagos, Simi Lawoyin
<b>Leadspace</b> , Nonye Okolie
<b>MTN Nigeria/DataScience Nigeria</b> , Bayo Adekanmbi
<b>Nigerian Communication Commission</b> , Dr. Henry C. Nkemadu and Quasim Odunmbaku
<b>Nigerian Communications Satellite Ltd.</b> , Raji Kazeem Kolawole
<b>NG_Hub</b> , Francis Sani and Busayo Oladejo
<b>Orbital Solutions Global Services</b> , Adewale Adegoke
<b>Passion Incubator</b> , Olufunbi Falayi
<b>PWC</b> , Binkabi, Andrew Nevin
<b>Releaf</b> , Uzoma Ayogu
<b>The Next Economy</b> , Elemike Berings
<b>Xendbit</b> , Bolaji Onibudo

# EN

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African Development Bank Group  
Immeuble du Centre de commerce International  
d'Abidjan CCIA

Avenue Jean-Paul II  
01 BP 1387  
Abidjan 01, Côte d'Ivoire

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