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Women in the Fourth Industrial Revolution: A Gendered Perspective on Digitalization in Kenya, Nigeria and South Africa

BY
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I dedicate this thesis to all the incredible women in my life – past, present and future – who are constantly teaching me that when women uplift one another, incredible things can happen.

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LIST OF ACRONYMS

4IR	Fourth Industrial Revolution
A4AI	Alliance for Affordable Internet
AI	Artificial Intelligence
BRICS	Brazil, Russia, India, China, South Africa
DG	Digital Humanities
GDP	Gross Domestic Product
GSM	Global System for Mobile Communications
ICT	Information Communication Technology
IoT	Internet of Things
ISP	Internet Service Provider
ITU	International Telecommunication Union
KP&TC	Kenya Posts and Telecommunications Corporation
LPWAN	Low Power Wide Area Network
NCC	Nigerian Communications Commission
NGO	Non-Governmental Organization
NITA	American National Telecommunications
NITEL	Nigerian Telecommunication Ltd.
SDG	Sustainable Development Goals
STEM	Science, Technology, Engineering & Math
WEF	World Economic Forum

Introduction

In 2016, Klaus Schwab announced that a Fourth Industrial Revolution (4IR) was underway which would disrupt every aspect of human life. The revolution is already shifting the global economic structure with substantial impacts on growth, employment and the nature of work (Schwab, 2016). McKinsey & Company estimates that at the fastest rate of digital adoption, automation could replace a third of the workforce by 2030 (McKinsey & Company, 2017, p. 2). The way that we conduct business is also being transformed by the 4IR, as the increasing use of data-enhanced products is helping companies understand and respond to consumer needs more efficiently. New business models are emerging due to the availability of new digital tools (i.e. the uberization of the service industry). The way that governments operate and deliver services to citizens is shifting, particularly through the increasing implementation of e-governance and e-government. Cooperation at a local, regional and global level is being substantially enhanced by developments in ICTs. However, with increased cooperation come greater security risks, and cybergovernance is gaining an increasing amount of scrutiny on the international scale. At a personal level, privacy issues are gaining more traction as our understanding of public and private information is becoming increasingly blurred. Finally, the 4IR is having significant impacts on societal structures and individuals. The concept of a community is evolving, as is the way we form human connections. In parallel, we are witnessing a shift in identity, morality and ethics. The 4IR – characterized by Schwab (2016) as a 'fusion of technologies that is blurring the lines between the physical, digital, and biological spheres' – has brought an array of technologies into mainstream use, including big data, Artificial Intelligence (AI), the Internet of Things (IoT), quantum computing, biotechnology and 3D-printing (Schwab, 2016, p. 7).

Since the Third Industrial Revolution, the theory of technological determinism has prevailed in development-focused research. Technological determinism views each technological revolution as an inevitable driving force, the impact of which will be far reaching (Oxford Reference, 2015). This is in part due to the fact that the diffusion of ICTs promotes access to information and education. However, ICTs have been unevenly distributed between countries and within societies creating digital divides which tend to reflect physical inequalities, such as gender, age, geography, and income. Though ICTs can be enablers of inclusion, marginalized groups may not necessarily benefit if an environment is already discriminatory (The World in

2050 Initiative, 2019). In fact, they could even deepen inequalities. The inaugural report by the EQUALS Research Group (2019) finds that a gender digital divide exists regardless of overall levels of ICT access, income or geographic location of a person. In fact, the gender digital divide is exacerbated by all three of these aspects.

In order to understand why this has occurred, it is important to first contextualize the development and growth of ICTs. From the 1990s to the early 2000s, ICT development efforts in Kenya, Nigeria and South Africa predominantly focused on delivering equal access to the Internet. During this period of time, initiatives and policies targeting universal access helped overcome a large part of what is known as the "last mile" challenge. Increased connectivity proved beneficial, as ICT adoption enabled these economies to leapfrog from agricultural revolution to information revolution (Ponelis & Holmner, 2015). In the late 2000s and early 2010s, greater focus was brought to the uptake and impact of ICTs, as it became widely acknowledged that solely focusing on enhancing information flows was insufficient to fully harness the development opportunities brought on by digitalization (Ponelis & Holmner, 2015). The ITU (2017) recently found that this gender digital divide is increasing. In 2013, this gap stood at 11 percent but had increased to 12 percent by 2017. The divide was found to be even wider in Africa, standing at 23 percent. What are the main barriers to digitalization in Kenya, Nigeria and South Africa? What opportunities and challenges does the Fourth Industrial Revolution present for women?

This thesis aims to develop a framework for analysis which can drive better understand of why the digital divide is increasing. The history of the ICT sector in each country will first be explored, in order to understand how each one was shaped by the Digital Revolution. Focus will then be brought to three digital trends which will be key to the 4IR: big data, AI and the IoT, looking at how they are being developed and how they can benefit women in Kenya, Nigeria and South Africa. The digital divide will subsequently be analyzed across 5 dimensions: digital infrastructure, electricity, poverty and affordability, education and digital skills, and cultural and sociopolitical barriers. Finally, a gender dimension will be applied to each component of the framework to understand why women are being disproportionately left out of digitalization in Kenya, Nigeria and South Africa.

Literature review

The term *digital divide* was coined by Lloyd Morrisett, the president of the Markle Foundation, in 1996 (Odongo & Rono, 2016; National Communication Association, 2014; Hoffman et al., 2000). He described the existence of a divide between the *information-haves* and *have-nots* which result in an imbalance in access to technology – specifically Information Communication Technology (ICT). The term became widely used following its inclusion in the American National Telecommunications & Information Administration's "Falling Through the Net" report in 1998 which looked at access to emerging technologies (National Communication Association, 2014). By the beginning of the 2000s, the term digital divide had been widely embraced to describe technological gaps, and a variety of studies emerged on the topic.

Van Dijk et al. (2017) break down the evolution of digital divide research into three primary levels. *First-level* digital divide research began in the early 1990s. At the time, the Digital Revolution was spurring an increase in Internet access and the use of personal computers. Research then, was solely focused on Internet access. As the Internet, digital devices and broadband became more widespread in Western countries however, scholars began to criticize this approach. Simply looking at the number of people with access to the Internet had become insufficient in helping understand the root cause of the digital divide. In response to this, the *second-level digital divide* emerged which focused on digital skills and the differences in use of ICTs. This type of research also began to classify the different types of skills required to bridge the digital divide, like typing, using a mouse and information literacy. A number of scholars however have argued that looking solely at access, use and skills is still insufficient and the consequences of Internet use should also be considered. The *third-level digital divide* started in 2011, when it was recognized that access to ICT and the possession of digital skills can have negative impacts. This level of research acknowledges that the digital divide can play a major role in reinforcing existing social inequalities.

Dewan and Riggins (2005) choose to focus on the policy and managerial implications of the digital divide. Three levels of analysis are identified: the individual level, the organizational level and the global level. The *individual level* relates to those who lack access to ICTs as a result of being technologically, sociologically, or economically disadvantaged. The *organizational level* differentiates between companies that harness ICTs to gain a competitive advantage and those that lag behind as technological followers. Finally, the *global level* focuses on the disparities between countries which adopt policies to promote ICT adoption and those being left behind

due to digitalization. Additionally, Dewan and Riggins (2005) find that there are two different types of effects to the digital divide. *First order effects* relate to inequalities in access to ICTs, while *second order effects* relate to inequalities in use of ICTs.

Odongo and Rono (2016) digital divide research into four different approaches: technology access approach, multi-dimension approach, multi-perspective approach, and cultural dimension approach. The technology access approach is the classic approach to the study of the digital divide. It focuses on the availability of ICT infrastructure and promotes investment in infrastructure to bridge the digital divide. The multi-dimension approach encompasses research on the digital divide which is centered around one or more socio-economic factors. These range from income and access cost and price, to skills and experience, geography, education, family structure, age and occupation. The multi-perspective approach considers the digital divide in relation to different societal stakeholders, such as the government, race, ethnicity, gender, language, psychological factors, direct network effect, content, but also quality of service and access speed. Finally, the cultural dimension approach tackles the cultural barriers which enable the digital divide. Research on these barriers focuses on ideological differences, stereotypes, social identity theory, external influences and culture as a whole (how different cultures create different perceptions of ICT).

Despite the wealth of research on the digital divide, there are significant gaps in the research available on Kenya, Nigeria and South Africa, compared to the research available for countries in the Global North. Many papers or reports tend to look at the African continent as a whole and these countries are typically used as case studies. Mutsvairo & Ragnedda (2019) break this inequality in their book 'Mapping the Digital Divide in Africa: A Mediated Analysis'. All too often, policies are created to increase the digital participation of African nations without acknowledging the continent's complexities. Policymakers have a tendency to treat Africa as a country when developing ICT interventions, instead of understanding and historicizing the digital divide within the context of the 'continent's diverse historical, political, and cultural experiences.' The authors reject the Western ideas of technological determinism, seeking instead to demonstrate that digitalization has had adverse effects on the African continent. They argue that the digital divide is now the biggest barrier to progress in Africa, at both a socioeconomic and political level. However, our definitions and understanding of the digital divide are deeply rooted in Western experiences of digitalization. Therefore, there is a need for

digital decolonization and an acknowledgment that the current approach to the digital divide in Africa perpetuates colonial legacies.

Aiyegbusi (2018) shares this perspective, looking specifically at the field of digital humanities (DH). DH has predominantly developed in the Western hemisphere and as a result, tends to be seen as a Western notion. An analysis of the 190 DH centers in the CenterNet network reveals that the majority were located in North America, Australia and Europe. While a handful are based in Asia and South America, only two are in Africa. This is part of the reason why there is such a dearth in locally driven research. In order to develop the field of DH, having knowledge of the customs, digital cultural and regional academic structure is imperative. Methods that have been effective in one cultural setting could be a total failure in another.

Methodology

Three countries have been selected for analysis - Kenya, Nigeria and South Africa – based on the following criteria:

- Geography: equal representation of the regions of sub-Saharan Africa
- GNI per capita: all three countries are middle-income and therefore have greater financial capabilities to capitalize on the 4IR
- Availability of data: this is a wider quantity of data and research available on these countries than for other countries in Africa.

The 5 dimensions identified for this study are inspired by the nine components identified by Odongo and Rono(2016) in their study on the digital divide in Kenya. They are as follows: poverty, education, infrastructure, gender, rural and urban perspective, cultural dimensions, e-governance, age, and economic development and distribution.

Chapter 1: An Overview of Digitalization in Kenya, Nigeria and South Africa

The early stages of digitalization in Kenya, Nigeria and South Africa were intrinsically tied to democracy and governance. The Third Industrial Revolution (Digital Revolution) began in the 1960s and is primarily characterized by the development of three technologies: semiconductors, mainframe computers, and the Internet (Schwab, 2016, p. 11). Kenya – which was a new democracy at the time – did not have the institutional framework in place to fully capitalize on the Digital Revolution until the 1990s. Nigeria remained under authoritarian rule until 1999, when the Digital Revolution began to take hold in the country. Similarly, in South Africa, apartheid did not end until 1994 when the Digital Revolution was finally able to flourish. In all three countries, development of ICTs was hindered by state-owned telecommunications companies which maintained a monopoly over the sector for many years.

All three countries have now managed to establish themselves as ICT powerhouses in sub-Saharan Africa. With the prospects of the 4IR looming ahead, Kenya, Nigeria and South Africa are well positioned to capitalize on digital trends like big data, AI and the IoT. Furthermore, such technologies can enable these countries to remedy systemic gender inequalities which persist, in order to fully unlock their human development capital.

1.1 The Third Industrial Revolution: Development and growth of the ICT sectors in Kenya, Nigeria and South Africa

i. Kenya

The Digital Revolution started in Kenya at the beginning of the 1990s, when mobile cellular was deployed using network technology. However, this network was unable to support an Internet connection as it was analog. Connecting to the Internet at the time was very costly, requiring a computer, modem and telephone line. As a result, connections were predominantly established by international NGOs who provided store-and-forward email services to communicate with partner organizations (Mureithi, 2017). By 1995, the first leased-line connection was established in Kenya – bringing the Internet to the masses – and by the end of the year, many more Internet service providers (ISPs) had entered the telecommunications market. This development was poorly received by the government which held complete control over telecommunications services through the Kenya Posts and Telecommunications Corporation (KP&TC). Its dated infrastructure was unable to support the Internet which posed

a serious threat to the state-held monopoly. As a result, in July of 1995, a full-page advertisement was published across the country declaring the Internet illegal (Mureithi, 2017).

In spite of the ban, interest in the Internet was growing rapidly; a fact that the government could no longer ignore. By 1997, the government had shifted its stance and implemented a policy recognizing the contributions of ICT to national development. The following year, 458 Internet hosts were already in place – the highest of any country in Sub-Saharan Africa (Mureithi, 2017). In 1999, the government fully relented and introduced the Kenya Information and Communication Act which established a multi-operator environment in the ICT sector. The Kenya Internet Exchange was created by Kenyan ISPs in 2000, in response to the need for cheaper, local peering points (Mureithi, 2017). However, this threatened the monopoly of Telkom Kenya – KP&TC's successor – which shut down the Exchange for a whole year. The Internet sector was not fully liberalized until 2007 when Telkom Kenya was privatized (Mureithi, 2017).

Market liberalization and diffusion of the Internet was accompanied by significant growth in mobile network coverage. This was driven by Safaricom which quickly dominated the market for wireless services. In 2007, the company launched M-Pesa an innovative money-transfer system. Through the M-Pesa platform, Safaricom customers can transfer and withdraw money via SMS, using a basic mobile phone. The actual transfer of money occurs through a network of M-Pesa agents who operate as ATMs, ranging from small shops and gas stations to banks (De Soyres, et al., 2018). In under a decade, M-Pesa has become the largest mobile money platform in the world with operations across 7 countries (Vodafone Group, 2019). The company has also had a significant impact on Nairobi's start-up scene, with startups like M-Kopa Solar replicating its business model.

Digitalization is now seen as a cornerstone of Kenya's development policy. The Kenya Vision 2030 is "[a] national long-term development blueprint to create a globally competitive and prosperous nation with a high quality of life by 2030, that aims to transform Kenya into a newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment." One of the drivers of economic development identified in the Vision 2030 are ICT sectors. A particular emphasis is brought on developing a computer literate workforce (Government of the Republic of Kenya, 2007). The Vision 2030 was adopted in 2008 and a recent report by Siemens indicates that progress is being made towards its

objectives. Kenya has been recognized as one of the most computer literate societies in Africa. The country's tech ecosystem, known as the Silicon Savannah, is a leader on the continent. Currently valued at USD $1 billion, the sector has attracted investment and partnerships from tech giants like Facebook, Microsoft, IBM and Intel. The emergence of innovation hubs since 2010 has also facilitated and accelerated the emergence of new technology ventures (Swiss Business Hub Southern Africa, 2018).

ii. Nigeria

The ICT sector in Nigeria struggled to take off until 1999 when the country shifted from military to civilian rule (Mohamed, 2019). At the time, the Nigerian government held a monopoly over the sector through Nigerian Telecommunication Ltd. (NITEL) and its subsidiary Mobile Telecommunication Ltd. The cost of providing telecommunication services was one of the highest in the world, penetration was limited, and the communication system was highly unreliable and inefficient (Fatoki, 2005). Additionally, there were only 4 telephone lines per 1,000 inhabitant and only 50 percent of the ones constructed were functional (Banjo, 2013, p. 93). However, everything changed when mobile telephony was introduced by the Nigerian Communications Commission (NCC). The independent regulatory body started providing private licenses to telecommunications operators and ISPs in 1999. The first three GSM licenses were granted to MTN Nigeria, Econet Wireless Limited and NITEL which ended the latter's monopoly (Fatoki, 2005, p. 268). By 2001, there were already more than 150 licensed ISPs in Nigeria (Adomi, 2005). By 2004, foreign direct investment in the country's Internet sector was valued at $10 billion (Nigerian Communications Commission, 2016). Today, Nigeria is Africa's largest Internet user base and the six largest in the world (Internet World Stats, 2019). The government's liberalization policy has fostered a competitive environment for Internet providers and mobile phone operators, pushing market players to widen network coverage and improve the quality of their services (World Bank Group, 2019).

The rapid proliferation of ICTs in Nigeria has also fostered a positive environment for the development of tech start-ups in the country. It now surpasses South Africa as the premier investment destination for up-and-coming tech companies (Ramachandran, et al., 2019). The Yaba area of Lagos has been dubbed 'Yabocon Valley' as it has the highest concentration of tech companies in the region. The neighborhood is home to 31 out of the 440 active hubs in West Africa. Yabacon Valley's Co-Creation Hub, for example, was the first major incubation hub to be launched in Lagos. It currently provides support and mentoring, office space and

resources to 90 start-ups, and has partnerships with Google and Facebook (Bandura & Hammond, 2018). Investment in the ICT sector is also helping Nigeria diversify its oil-based economy. The sector is already driving Nigeria towards a digital economy accounting accounted for 13.8 of GDP in 2019, more than the oil and gas sector (Lawal, 2020).

iii. South Africa

In South Africa, the ICT sector began to burgeon towards the end of the 1980s. The UNINET project sought to connect South African universities to the Internet. This was successfully achieved in 1988 with the establishment of the first e-mail link to the Internet at Rhodes University. By the early 1990s, IP links were being established between universities across the country and the domain name '.za' had been officially registered with the Internet Corporation for Assigned Names and Numbers. At the time, maintaining IP links was extremely costly and amounted to thousands of Rands of universities' annual budgets (Venktess, 2016). The Internet was therefore exclusively used by the rich, white, ruling minority.

The end of apartheid and birth of democracy in 1994 changed this, however. Access to ICTs was seen as a universal right, and laws and policies were implemented to promote digital inclusion. The South African Constitution explicitly states that '[e]veryone has the right of access to any information that is held by state or another person and that is required for the executive protection of rights' (Ch. 2, sec. 32 of the Bill of Rights in the South African Constitution 1996). Promoting ICTs has been central to national development policy, as evidenced by the countless Presidential and Ministerial speeches which have highlighted the vision for an information society over the years (Lesame, 2014).

ICTs have struggled to proliferate across South Africa however due to a monopoly by Telkom South Africa. The organization was created in 1991, when the South African Posts and Telecommunications was split up and its monopoly over the telecommunications sector was vested in Telkom (Cogburn & Adeya, 2001). The end of apartheid ushered in managed liberalization and Telkom was partially privatized. However, the company was also tasked with implementing government policy to expand access to ICTs. This led to uneven distribution of ICTs across the country and stagnating growth has been witnessed in the sector in recent years (Mondiwa & Paremoer, 2016). Mobile telecommunications experienced a strong duopoly in South Africa from the early 1990s to the early 2000s. Two foreign companies – Vodacom and MTN – were early movers in the industry, obtaining licenses as early as 1993. Vodacom and

MTN were subsequently able to expand their networks and control market prices at a time when few regulations were in place. Though challenger companies Cell C and Telkom Mobile entered the market later, they have struggled to compete on the same level as the two market dominators. (Mondiwa & Paremoer, 2016). In recent years, the Independent Communications Authority of South Africa has played a role in introducing positive market competition, notably cutting mobile phone rates in 2011. Market liberalization has also had positive impacts on South African ISPs. The 2009 entry of Seacom in the provision of undersea cables reduced the cost of bandwidth for ISPs by 35 percent, for example (Mondiwa & Paremoer, 2016).

The South African Department of Trade and Industry formed a Chief Directorate for Future Industrial Production and Technologies in 2017 to examine the impacts of emerging digital technologies, including the IoT, big data, AI, robotics, and new materials. The unit aims to build government capacity to address these challenges and partner with industry to enhance South Africa's readiness. Science and Technology Minister Mmamoloko Kubayi-Ngubane has also said that the government aims to boost its investment in research and development, support for entrepreneurs, and skills development (Access Partnership, 2018).

1.2 The Fourth Industrial Revolution: Digital trends and opportunities for women

The ICT policy process has become fairly protracted in Kenya, Nigeria and South Africa in recent years. Renewed investment in the sector can enable these countries to harness key digital trends like big data, AI and the IoT which are becoming key forces in social change. Research indicates that under the right conditions, when ICT sectors expand from basic voice services to broadband, a significant number of multiplier effects appear which positively impact a country's economic growth and the well-being of its citizens (Gillwald, et al., 2017). They can help overcome logistical bottlenecks, as well as corruption and resource constraints (Gillwald, et al., 2017).

i. Big Data

Data science is the foundation of 4IR. Technologies such as AI, the IoT, augmented reality and machine learning are all considered key to the 4IR, and big data is one of the base technologies required to operate all of them.

The term *big data* refers to large, diverse sets of information that grow at ever increasing rates. This data can be structured or unstructured, often originating from multiple sources (including IoT devices) and therefore produced in multiple formats (Segal, 2019). Big data is typically stored in computer databases and requires complex software and algorithms which can analyze such diverse datasets in real time. It is qualified not only by the volume of information being handled, but also by the speed at which it is created and collected, and the variety or scope of the data points being covered (Segal, 2019).

As computers have become faster and more powerful over the last decade, so has their capacity to process larger amounts of data and discern patterns that cannot be identified through manual analysis alone. Estimates by the International Data Corporation indicate that the volume of data generated worldwide could double every two years and rise to 180,000 billion gigabytes worldwide in 2025 (The World in 2050 Initiative, 2019).

There are many implications for the increasing availability of big, including a move towards more evidence-based decision-making. Additionally, initiatives like Data2X are using big data to fill existing data gaps which disproportionately impact women and girls. Gender disaggregated data is lacking in many areas, especially in the collection of traditional household surveys. Data2X is a 'collaborative technical and advocacy platform that works with UN agencies, governments, civil society, academics, and the private sector to close gender data gaps' (Pryor, 2017).

Big Data in Kenya

The Kenyan government has played an important role in promoting the collection and use of data, both nationally and regionally. One of the flagships initiatives included in the Kenya Vision 2030 is the creation of the Konza Technopolis, a 5,000-acre smart city and technology hub south of Nairobi. In addition to businesses, housing, parks and a transit system, Konza Technopolis will also house a National Data Center which will drive Kenya's transition to a digital economy (Tetra Tech, n.d.). The national government is also championing data usage across the African continent. The Kenyan government has committed to developing online healthcare platforms in partnership with other African countries. These platforms will model the successful Community Life Centers which have been operated by Philips in Kenya since 2014. The Centers use big data to improve access to healthcare, but also act as tailor-made community hubs where technology meets personal healthcare provider (Philips, 2017).

A number of initiatives have already been rolled out in Kenya which aim to empower women and girls by harnessing big data. In 2015, Shujaaz (formerly known as Well Told Story), a socially driven multi-media platform which engages Kenyan youth through comics, radio shows, social media and SMS-communications conducted a project using big data. Users of the Shujaaz platform engage in dynamic conversations, sending thousands of messages on digital channels like WhatsApp and Facebook every day. By analyzing this data, the company developed a better understanding of the most popular topics being discussed by young people. One of the issues central to the Shujaaz strategy is the improvement of sexual and reproductive health outcomes (Hutchinson, et al., 2018). Consequently, the company also analyzed the vocabulary employed by users to discuss contraception and sexual health. The company was then able to produce content which related directly to these topics and included particular slang words which had been identified (Africa's Voices, n.d.).

Big Data in Nigeria

Big data analytics has struggled to substantially develop in Nigeria which is in part due to the high levels of unemployment. In 2019, 20 percent of the youth population was unemployed (Plecher, 2020). A large part of today's youth is graduating from school without the necessary skills to obtain a job in the modern economy. This includes data analytics which requires a particularly technical skillset. However, DataLab Nigeria is trying to bridge this gap by offering eight different professional online training courses in data analytics tools, including Python, SQL and Power BI (DataLab Nigeria, 2020).

Despite these promising efforts, Nigeria faces one major hurdle: major gaps exist when looking for reliable, locally sourced data. Nigerian data analysts have spoken out about the need for a central government portal which would give citizens open access to data (Afeye, 2019). However, the Federal government is hoping to change this through the National Technical Working Group on Mobile Big Data Analytics. The group will explore the applicability of big data solutions to some of the country's social issues (Federal Ministry of Communications and Digital Economy, 2019). Additionally, the 2019 enactment of the Nigeria Data Protection Regulation creates an important framework for the protection of data and personal information in Nigeria (George Etomi & Partners, 2019).

New initiatives have been developed in recent years to harness big data to uplift women. In 2014, a partnership was established between Diamond Bank, MTN and Women's World Banking to improve women's financial inclusion with a particular focus on making digital financial services accessible to low-income women (Busara Center for Behavioral Economics, 2017). The partnership developed Diamond Y'ello – a simple mobile-based banking platform, however after two years of being operational only 36 percent of the 2 million active users on it were women. The partnership sought to identify how to increase uptake with women by conducting a big data analysis where 15 different interventions were designed over the course of which text-messages were sent to 400,000 users. Responses enabled the partnership to identify the three main barriers to adoption among women and increase activity rates on the outset (Busara Center for Behavioral Economics, 2017). According to the 2017 Global Findex Database, Nigeria houses half of the world's unbanked population and the majority are women – with 25 percent of unbanked men compared to 35 percent of unbanked women (World Bank Group, 2017). As a result, initiatives like this partnership are much needed.

Big Data in South Africa

The South African government has recognized the importance of data for digitalization and a number of efforts have been undertaken to increase the quality of data available. One government-led initiative aimed to efficiently digitalize the census and household survey process. In partnership with Digital Globe, the government used high-frequency and high-resolution satellite imagery feeds, as well as mobile phone apps to geo-locate each residential dwelling with an address (World Bank, 2017). Big data is also being increasingly used in the healthcare sector in the country. Major South African health insurers are using big data analytics tools and AI-powered chatbots which allow clients to access up-to-date information on how to maintain a healthy lifestyle. These services include fitness workouts, food recommendations, and even rewards systems where clients receive flight discounts for example, in exchange for healthy habits. A number of other companies are employing big data analytics to develop lifestyle management for diabetes, as well as conduct genetic analytics (Ameer-Mia, et al., 2020).

South African women are vastly underrepresented in the IT sector and STEM fields in general. In a recent study on the gender digital divide in South Africa, women stated that the lack of female representation in STEM is one of the main deterrents to pursuing a career in those fields. The Women in Big Data (WiBD) South African Chapter was recently launched by SAP

Next-Gen, in an aim to bridge this gap. The initiative will seek to develop innovative solutions to improve the education of female data scientists and encourage them to enter STEM fields. The South African Chapter will work towards the organizations overall objective to increase women's representation in big data to 25% by 2020 (Kamau, 2019).

ii. Artificial Intelligence

The term *artificial intelligence* was coined by John McCarthy in 1955, when he convened a group of researchers (across a range of disciplines) for the 'Dartmouth Summer Project on Artificial Intelligence'. The 2-month study aimed to 'find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves' (McCarthy, et al., 1955, p. 2). 65 years later, the concepts discussed by the Dartmouth group have become a reality, as scientists have digitized decision making processes through algorithms and neural networks (Relander, 2015). AI is already in use in most industries and the global AI software market is expected to grow to USD $126 billion by 2025 (Tractica, 2019). Though AI research and development was initially focused on building technology that could mimic the human brain, this has now shifted to identifying the problems that AI can solve and developing solutions for them. In 2016 for example, industry leaders including Amazon, Apple, DeepMind, Google, IBM and Microsoft launched the Partnership on AI to Benefit People and Society. Together these companies develop and share best practices, advance public understanding, provide an open platform for discussion and identify aspirational effort in AI for socially beneficial purposes (Marr, 2018).

According to a recent report measuring Government Artificial Intelligence Readiness (Oxford Insights; International Development Research Centre, 2019), no African country is ready to reap the full benefits of AI and only 12 are featured in the top 100 of the report's index. Women also run the risk of being left behind by advances in AI. The latest Gender Gap Report by the World Economic Forum (WEF) identifies data science and AI, as part of eight professional clusters which will be part of the new economy. Unfortunately, women only represent 26 percent of this employment cluster. As demand continues to rise for employees with machine learning and data science skills, the nature and quality of women's career prospects are shifting; they consequently run the risk of being negatively impacted (World Economic Forum, 2019).

Investments in the AI sector have been ramping up throughout Africa however, in recent years. Google's Andela Learning Community Partnership with Udacity, for example, provides 500

nanodegree scholarships to aspiring developers from across the continent every year – effectively equipping a new generation with the necessary skills to work in AI (National Merit Scholarships, 2020).

AI in Kenya

Kenya has invested significantly less in the field of AI than South Africa and Nigeria. In the last ten years, Microsoft estimates that Kenya has invested Sh13 billion (US $12.5 million) in AI. This investment mainly comes in the form of support for start-ups and entrepreneurs – the government itself has actually invested very little. In contrast, investment in Nigeria reaches Sh60.3 billion (US $564.2 million), while South Africa's investment reaches Sh165.8 billion (US $1.6 billion) (EY Consulting, 2018). The government's creation of a Blockchain and Artificial Intelligence Taskforce at the start of 2018 could change this, however. In 2019, the group published 12 policy recommendations on how blockchain and AI can be used to enable transformations across healthcare, agriculture, education and government services. The report specifically highlights that leveraging such emerging technologies can help the government deliver on its Vision 2030 (Distributed Ledgers Technology and Artificial Intelligence Taskforce, 2019).

AI is already enabling transformations in women's health. Jacaranda Health is a Kenyan non-profit using AI to improve maternal health. Their PROMPTS digital platform provides mothers with free, lifesaving advice and healthcare referral. An AI-based triage system helps answer thousands of questions a day, sifting through them for urgency and prioritization (Jacaranda Health, 2020). The AI bot assigns a priority level to each question and suggests a response, before passing it along to a help-desk service. This system allows help-desk agents to respond to urgent messages within four hours, inciting mothers to act quickly when recognizable signs of infant or maternal danger appear (Jacaranda Health, 2020). Today, this service is already being used by 120,000 pregnant women and new mothers across more than 200 hospitals in Kenya. The potential impact of such a technology could be tremendous, significantly reducing the near third of maternal deaths caused by delays in seeking healthcare (Jacaranda Health, 2020).

AI in Nigeria

The AI sector is still fairly nascent in Nigeria, but like in Kenya, new government policy in the area could change this. Most notably, one of the overarching goals of the Federal Government's

2017 National Science, Technology and Innovation Roadmap is to drive the AI economy forward (Heldreth, et al., 2019). The 2018 launch of the Artificial Intelligence Hub in the University of Lagos could provide an additional push to the sector. The hub aims to develop research and innovation around deep learning, while also offering a space for young people to engage and learn about AI. Through a partnership with MainOne – West Africa's leading connectivity and data center solutions provider – free Internet access will be provided to students attending classes held in the hub, and to the AI researchers and start-up entrepreneurs who frequent the hub (MainOne Nigeria, 2019).

AI solutions are being applied to a variety of social issues, including financial inclusion and maternal mortality. Kudi.ai, a fintech start-up, is tackling financial inclusion through a text-messaging app. Kudi is an AI chatbot which helps users make financial transactions, buy airtime and pay bills through a simple, conversational system (Kudi.ai, 2020). By making financial services more accessible, Kudi.ai could have a substantial impact on the growing poverty problem in Nigeria, especially for women who run a much greater risk of falling into extreme poverty. In an effort to increase financial accessibility for the unbanked and underbanked, Kudi.ai have expanded their services to include a network of Kudi Agents who operate on a similar basis to M-Pesa agents (Kudi.ai, 2020). MOBicure is a digital health company which develops innovative solutions to solve some of Nigeria's most pressing healthcare problems. The company's newest app, myPaddi, an AI-powered, mobile and web app providing young people with access to information on sexual and reproductive health (Owobu, 2020). The app aims to reduce the country's high burden of maternal mortality which young women predominantly bear the burden of. This is predominantly due to the fact that close to a million teenage girls become pregnant annually – many of which are unwanted and a result of sexual violence. As a result, the myPaddi app puts a specific emphasis on preventing sexual abuse, teenage pregnancy, as well as HIV/STDs (Owobu, 2020).

AI in South Africa

The AI sector in South Africa is still in its very early stages too, though significant efforts are already underway. As the first Internet connection was established at a university, it is not surprising that numerous efforts are being led by academics in the AI field. Since 2011, the Centre for AI Research has been conducting research across nine components of AI: Adaptive and Cognitive Systems, AI and Cybersecurity, AI for Development, Applications of Machine Learning, Computational Logic, Ethics of AI, Foundations of Machine Learning, Knowledge

Representation and Reasoning, and Probabilistic Modelling (Centre for Artificial Intelligence Research, 2020). Research is conducted by a network of academics from six universities: the University of Cape Town, the University of KwaZulu-Natal, North-West University, University of Pretoria and Stellenbosch University (Centre for Artificial Intelligence Research, 2020). At the University of Pretoria, the Data Science for Social Impact research group is working on a number of thematic areas, including machine learning (Data Science for Social Impact, 2020). The university has also created an Intelligent Systems Group which studies machine learning to develop AI solutions adapted to the South African context, as well as an Institute of Big Data and Data Science (University of Pretoria, 2018).

President Cyril Ramaphosa has highlighted the potentials of AI throughout his mandate which is already having a positive impact on the development of the sector in Africa. Through the establishment of the Presidential Commission on the Fourth Industrial Revolution, he has emphasized the need to be adaptive and responsive with regards to disruptive technologies like AI, big data and machine learning (Ramaphosa, 2020, pp. 71-72). The Commission's preliminary includes a number of recommendations for the government to follow in order to capitalize on the 4IR. One of these recommendations is to develop an AI institute to facilitate the expansion of AI expertise in the region. Additionally, when President Ramaphosa took over as the chair of the African Union in February of 2020, he announced the creation of an Africa AI Forum (Marwala, 2020). Such marked interest and focus on the AI by the South African government is set to put the nation at the forefront of the sector over the coming years.

Organizations like Zindi are helping develop the data science community in South Africa and beyond. The social enterprise allows companies, NGOs and government institutions to submit problems for which they require data-driven solutions. These are spun into a competition framework where Zindi's network of data scientists – who are all provided with the same datasets – compete against one another to solve issues such as drought, flooding, fraud and financial inclusion. Solutions are automatically ranked based on the accuracy of the solution submitted. In a bid to bridge the gap of female employees in data science, the CEO of Zindi announced in June 2020 that the company would be adding 9,000 female data scientists to the company's network (Zindi, 2020).

iii. Internet of Things

The term *Internet of Things* (IoT) was first used by Kevin Ashton in 1999. He used it to describe the process of assigning a digital identity to real objects, such as QR codes for example. As the concept evolved, it has grown to encompass a set of technological innovations from different fields, namely wireless and mobile connectivity, nanotechnology, radio-frequency identification (RFID) and smart sensor technologies (WBGU, 2019, pp. 66-67). Today, the International Telecommunication Union (ITU) defines the IoT as 'a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies' (ITU, 2018). A dispute exists regarding the specific kind of technologies which should be included as part of the IoT. All definitions agree that machine-to-machine – or any direct communication between networked devices which does not require manual human assistance – is an integral part of the IoT. However, some definitions also include ambient intelligence and smart environments within their scope (ITU, 2015).

Some researchers are predicting that the impact of the IoT could be larger than the Internet itself. Though it is difficult to accurately assess how many devices are interconnected today – due to the different definitions that exist – however this number is estimated to be between 20 and 26 billion (WBGU, 2019; ITU, 2015). The IoT network encompasses a wide range of smart devices from industrial machines transmitting production data to sensors tracking data about the human body. Applications of the technology are therefore set to impact a wide range of areas from industrial production, transport and logistics, to health, the environment, energy, and agriculture (WBGU, 2019).

Though it is unclear whether any IoT initiatives are currently underway in Kenya, Nigeria or South Africa targeting gender equality, initiatives in other countries are demonstrating how the technology can be applied to solve women's issues. In 2017, the government of Andhra Pradesh in India, launched a pilot IoT project to improve women's safety. The Abhaya Passenger project connects a mobile app to 100,000 rikshaws which have been fitted with IoT devices. The app includes a panic button, an emergency contact and direct contact with the nearest police station (Vodafone, 2019)

IoT in Kenya

In 2018, Kenya became the first West African country to introduce a Sigfox 'Low Power Wide Area Network' (LPWAN) – the world's leading provider for IoT services in over 45 countries. In partnership with Liquid Telecom Kenya, the LPWAN is being deployed across the country with an overall objective to reach 85 percent of the Kenyan population. Deployment of the network will support the government's Vision 2030, connecting sensors across every sector of the economy from agriculture, transport and energy to wildlife conservation and smart city projects (Liquid Telecom, 2018).

The 2019 report by the Blockchain and Artificial Intelligence Taskforce in Kenya identifies numerous issues in which the IoT can positively contribute to the country's development. This includes using data from IoT devices to predict and diagnose certain issues such as extreme weather events, disease outbreaks, pest attacks and soil nutrient deficiency (Distributed Ledgers Technology and Artificial Intelligence Taskforce, 2019). Further investment into developing the IoT can therefore be expected in Kenya over the coming years, as the report also highlights the need to modernize the country's digital infrastructure in order to accommodate its expansion. As data privacy and security are major considerations when it comes to the IoT, the government recently issued guidelines on the use of this technology (Communications Authority of Kenya, 2018). However, more robust measures need to be put in place in order to regulate future developments and ensure consumer data is adequately protected.

IoT in Nigeria

IoT adoption is still relatively slow in Nigeria, as evidenced by a recent study on organizations in Lagos State. Somewhat surprisingly, 20 percent of these organizations s cited "high costs of required investment" as their biggest obstacle. However, nearly half (44.8 percent) felt that the government should be doing more to support the development of the IoT sector (Ogidiaka, et al., 2017). In this respect, the Nigerian government is certainly lagging compared to Kenya and South Africa where governments are issuing guidelines and investing in the sector. The 2018 approval of six Cisco-executed IoT labs in Federal Unity Colleges across Nigeria shows a recognition of the IoT potential at a national level. Nevertheless, the federal government has fallen short of issuing white papers or investing in programs specific to the IoT as of yet (Okunola, 2018).

The Innovation Habitat Initiative for Indigenous Technology is a start-up working to expand the scale of IoT applications in Nigeria. The organization has developed the OBUNO IoT Engine – a development board and educational kit. 95 percent of its components are made in Nigeria (iHabitat, 2020). IoT Africa Networks Ltd is another company working to develop the IoT sector in Nigeria. The company is the exclusive operator for Sigfox in Nigeria which is currently deploying the LPWAN required for the IoT sector to fully develop (IoT Africa Networks Limited , 2020).

IoT in South Africa

Overall AI investment in South Africa is significant, standing above US $1.6 billion in the last 10 years. The bulk of this investment went towards IoT and social media, with other areas of investment including planning, scheduling, optimization and smart mobile (Business Tech, 2019). As a result, South Africa has a far more developed national IoT infrastructure than Kenya and Nigeria do. Sigfox's LPWAN has been deployed across the country since 2016. It currently reaches more than 90 percent of the South African population and covers 90 percent of the country's roads (SqwidNet, 2020).

In May of 2019, Vodacom – South Africa's leading mobile operator – announced the acquisition of a 51 percent share in the start-up IoT.nxt. The software development company offers IoT-based solutions to businesses around the world and is currently leading the IoT sector in South Africa and putting it on the map globally with offices in the Netherlands and the USA. (Jackson, 2019). IoT is also being applied to solve social issues in South Africa. One such initiative is helping tackle poaching in Kruger National Park. A point-to-multipoint router network has been set up around the reserve to identify people entering the park perimeter with metal objects like guns or machetes. The sensors pinpoint their location which is sent to park rangers who can track and arrest poachers using helicopters. The program was first rolled out in 2016 and in the first 18 months, poaching fell by 96 percent (Pozniak, 2018).

Chapter 2: The Digital Divide: Barriers to Digitalization in Kenya, Nigeria and South Africa

2.1 Digital infrastructure

Historically, research on the digital divide has focused on barriers to access and the gaps in technical infrastructure creating these barriers. The most common measure for this dimension is to look at the proportion of Internet users. Inequalities in Internet use tend to reflect geographic and spatial disparities, particularly between rural and urban areas, and between countries in the Global North and South (Odongo & Rono, 2016). Investing in the infrastructure to provide Internet access can be cost-intensive, putting lower-income countries at a disadvantage. Countries that already have efficient technical infrastructure in place are at a significant advantage to capitalize on the 4IR (Odongo & Rono, 2016).

In order to fully assess the extent of the divide in this dimension for each country, it is key to also take into consideration the proportion of mobile phone users. One of the most significant effects of the Digital Revolution in Kenya, Nigeria and South Africa has been a widespread diffusion of mobile phones. The 2018 After Access Report indicates that the adoption and proliferation of the mobile phone has reached a critical mass in adoption. Mobile phones are now commonplace across sub-Saharan Africa offering portable and simple services to people, including mobile financial services (Gillwald & Mothobi, 2018).

i. <u>Kenya</u>

Despite the tremendous advances experienced in Kenya since the start of the Digital Revolution, the opportunities which have emerged have been unevenly spread. Today, only 22.3 percent of households have Internet access while only 26 percent of Kenyans are using the Internet (ITU, 2017). The quality of the existing digital infrastructure varies greatly, making it difficult to provide Internet access across the country (Odongo & Rono, 2016).

In Kenya, more than 80 percent of the population has a mobile phone which is primarily attributed to the success of M-Pesa. According to the Communications Authority of Kenya, only 30 percent of Kenyans owned a mobile phone in 2007, the year the platform was launched. Just 7 years later, this figure stood at roughly 80 percent (Mureithi, 2017, p. 271). Despite these figures, many Kenyans cannot access the Internet through their mobile devices

as this requires 2.5G coverage. However, the majority of mobile users in Kenya are on 2G technology (Ndung'u, et al., 2019).

ii. Nigeria

Despite the fact that Nigeria has Africa's largest Internet user base, levels of Internet access are relatively low. In 2017, 27.7 percent of Nigerians were using the Internet –significantly lower than the global average of 48.6 percent (ITU, 2018, p. 133). The fixed-broadband penetration rate stands at 0.04 percent which is extremely low. Fixed broadband tends to be reserved to high-income, urban households, as well as public institutions and some businesses (ITU, 2018, p. 133).

Close to 76 percent of the population has a mobile phone subscription and mobile broadband is the preferred method of accessing the Internet. However, mobile broadband coverage is unevenly distributed between urban and rural areas. In 2018, the ITU found that 90 percent of households in urban areas own a mobile phone, while only 70 percent of rural households do. This can be attributed to the uneven spread of mobile broadband networks across the country, with many being left out of the 2.5G network coverage required for Internet access (ITU, 2018, p. 133). Furthermore, many Nigerians do not even own phones capable of an Internet connection. Only about 20 percent of the population has a smartphone, while 44.84 percent own a feature phone and a further 32.16 percent own a basic phone (Gillwald & Mothobi, 2018). Unlike with basic phones, owners of feature phones can access the Internet. However, these phones are limited in the types of apps they can support, meaning users are limited in the information they can access (World Bank Group, 2019, p. 12).

iii. South Africa

The most advanced ICT network in sub-Saharan Africa is located in South Africa. With 56.2 percent of individuals using the Internet, this stands much higher than the regional average of 22.1 percent and is even above the global average (ITU, 2018, p. 167). However, a major disparity can also be found between urban and rural areas in South Africa. According to a 2018 household survey, while 17.3 percent of households in metropolitan areas had access to the Internet in 2018, only 1.7 percent did in rural areas (Statistics South Africa, 2018, p. 58). The survey indicates that South Africans predominantly rely on mobile devices in order to access the Internet (60.1 percent), over access at home, in the workplace and Internet cafes or

educational facilities. This includes Internet access via mobile phones, but also the use of mobile access devices such as 3G cards (Statistics South Africa, 2018, p. 58).

2.2 Electricity

The second dimension of the digital divide is access to electricity, as it is not only essential in order for ICTs to function but also for the expansion of mobile and fixed-broadband networks. In a 2018 survey on ICT use, 25 percent of unconnected respondents cited a lack of electricity as the reason they were not online.

i. Kenya

The Kenyan government has made notable efforts to remedy access and connectivity issues for electricity. Consequently, 75 percent of Kenyans currently have access to electricity through grid and off-grid solutions – the highest access rate in East Africa. There has also been an increase in the deployment of solar home systems to increase electricity access. Kenya, along with Tanzania and Ethiopia, accounted for 50 percent of the 5 million people gaining electricity access through solar systems in East Africa (International Energy Agency, 2019).

ii. Nigeria

The lack of power capacity in Nigeria is one of the biggest cruxes to the country's development. In 2018, only 56.4 percent of the population had access to electricity. However, the majority of the population without access can be found in rural areas where only around 31 percent of the inhabitants have electricity, compared with 81.7 percent of the urban population (World Bank, 2018).

Despite this, electricity supply in urban areas is unreliable with power outages occurring on a daily basis in Lagos. Many businesses have to turn to diesel generators for power which puts a considerable strain on tech companies especially. Mobile operator MTN spends around 70 percent of its operating expenditures in Nigeria on generator fuel. Inefficiencies in the power sector were estimated to result in annual losses of 534 billion naira ($1.5 billion) (Ramachandran, et al., 2019).

iii. South Africa

South Africa has a much higher rate of electrification (91 percent) than Kenya and Nigeria, and access hardly varies between urban and rural areas, at rates of 92 percent and 89 percent

respectively (World Bank, 2018). However, the electricity supply in is plagued with frequent load shedding which affects the daily lives of citizens - impacting the delivery of services and public goods from the provision of healthcare services to economic growth. 90 percent of the electricity in South Africa is supplied by Eskom, a monopolistic state enterprise. Eskom's electricity infrastructure has been characterized as 'an ageing, poorly maintained fleet that is struggling to meet electricity demands' (Tshwane, 2019). Furthermore, it has been plagued with controversy related to state capture. In 2019, the Minister of Public Enterprises unveiled a plan to breakdown Eskom's monopoly over the course of three years. While the plan's primary aim is to liberalise the market, it also includes a framework to invest in the existing transmission grid, which includes 33,000 kilometres of transmission lines (Tshwane, 2019).

2.3 Poverty and affordability

Poverty is a major challenge when it comes to bridging the digital divide. Despite a decrease in the cost of ICTs over the last decade – especially mobile phones – they remain unaffordable to many people. Owning digital products typically comes with additional costs, such as data plans, repairs and maintenance. For those living in extreme poverty, buying digital products falls below other priorities like shelter or food (Odongo & Rono, 2016).

The Affordability Report is published annually by the Alliance for Affordable Internet (A4AI). It assesses the policy and regulatory frameworks of 61 low- and middle-income countries, determining how they are enabling affordable and universal Internet access. The report defines affordability as '1GB of mobile broadband data costing not more than two percent of average monthly earnings.' (A4AI, 2019). The Index should be complemented with data on poverty.

i. <u>Kenya</u>

Kenya does not meet the A4AI's affordability benchmark, as Kenyans spend around 3.1 percent of their monthly earnings on data every month. While this is fairly low compared to other Sub-Saharan countries, it is substantially higher than in South Africa and in Nigeria especially (A4AI, 2019). According to calculations by the World Data Lab (2020), there are currently 8 million people living in extreme poverty (under $1.90 per day) in Kenya, meaning mobile broadband data remains out of reach to most of this population.

Results from the 2017 After Access Survey indicate that countries where smartphone penetration levels are high are more likely to have high levels of Internet use as well. Though

many Kenyans own a mobile phone, only around 25 percent own a smartphone. More than half of the survey's respondents cited cost as the primary reason for this (Ndung'u, et al., 2019).

ii. Nigeria

According to the 2019 Affordability Report, Nigeria has the most affordable Internet access following Mauritius and Morocco, out of the 29 African countries analyzed (A4AI, 2019). The liberalization of the ICT sector in the country resulted in a lowering of data costs, as mobile connections became more accessible. Liberalization also enabled a significant decrease in the cost of mobile phones.

Despite these factors, access to ICTs remains unaffordable to the many Nigerians living in extreme poverty. there are currently more than 100 million people living in extreme poverty in the country[1] which represents half of the population. Between November 2018 and February 2019 alone, 3 million people fell into extreme poverty and this number is constantly rising (Iheonu & Urama, 2019). Fixed-broadband – which is much faster than mobile broadband – remains out-of-price, costing approximately close to US$900 annually. A proposed communications Bill could make ICTs more unaffordable to Nigerians. The Bill would impose a 9 percent collect communication services tax (CST) on charges payable by customers of communications services, including voice calls, SMS, MMS and data usage (Deloitte, 2019).

iii. South Africa

South Africa has made notable progress in lifting people out of poverty since the end of apartheid. According to World Bank estimates, the percentage of people living below the poverty line in South Africa fell from 33.8 percent in 1996 to 18.8 percent in 2015 (World Bank, 2020). However, ICTs remain unaffordable for the majority of the population. 47 percent of respondents in the 2017 After Access survey cited the cost of data as the main reason they are not online, while 36 percent cited smart devices as cost-prohibitive and 15 percent stated the Internet is too expensive (Gillwald, et al., 2017).

2.4 Education and digital skills

Since accessing and navigating the Internet requires basic literacy, education is another key component of the digital divide. 14 percent of the world population over 15-years-old is

[1] Numbers have been adjusted by the Lab to reflect the impact of Covid-19.

illiterate (Roser & Ortiz-Ospina, 2016) and the majority lives in underdeveloped areas where ICT penetration tends to be relatively low. While technologies like text-to-speech software can empower illiterate populations, they are typically unavailable to communities with low literacy rates.

Furthermore, certain digital skills are required to use ICTs, such as knowing how to use a search engine or how to communicate through media platforms. The new digital technologies emerging from the 4IR are pushing individuals to update their skills on a regular basis, in order to keep up with developments in ICTs. A 2010 study in South Africa, identified a five-year lag between accessing a new digital technology and becoming proficient in its use (Chetty, 2018). This indicates that the digital divide may only widen further as those with the relevant skills continue to expand their knowledge, leaving the digitally illiterate behind.

i. Kenya

Since the early 2000s, Kenya has made notable efforts to increase primary school enrollment, including making primary education free in 2003. As a result, enrollment in primary education went up to 81.3 percent in 2012. Nevertheless, a wide disparity in education prevails between urban and rural areas – literacy rates reach 86 percent in Nairobi, compared with 8 percent in North Eastern Kenya. Children from nomadic communities, such as the Turkana, Maasai, Borana and Rendille are also at a disadvantage as it can be difficult for them to attend school consistently (Odongo & Rono, 2016). Though the Kenya Vision 2030 is incorporating ICT into the national school curriculum, many adults were not exposed to ICTs during their education. This creates an age gap where children and teenagers are using the Internet and computers more than any other age group (Odongo & Rono, 2016).

ii. Nigeria

Nigeria has the largest population of out-of-school children; there are 10.5 million children who are currently not in school or 1 in 5 out of the world's out-of-school children (UNICEF Nigeria, 2020). Though education is both free and compulsory in the country, such low school enrollment rates can primarily be attributed to geography and gender. Even students who reach a tertiary level of education struggle to receive a high-quality education – hindered by a lack of basic resources like running water and electricity in academic facilities (Bandura & Hammond, 2018). Tuition fees have increased in recent year causing unrest among students. Though the quality of education received at Nigerian universities may be quite low, admissions processes

tend to be competitive and difficult to navigate for many students who received insufficient primary and secondary educations (Bandura & Hammond, 2018). Under the government's new Digital Economy Strategy, it has set itself a 95 percent digital literacy target to achieve by 2030. This objective aims to ramp up the contributions of the ICT sector to the economy by empowering the workforce with the necessary digital skills to actively participate in it (IT Pulse, 2020).

iii. South Africa

Since the end of apartheid, South Africa has spent 6 percent of its GDP on education – more than most other BRICS countries. Such heavy investment has led to more than double the number of primary-aged children being enrolled in school in the last twenty years. In 2002 only 40 percent of children over-five were in school, compared with 85 percent by 2018. Rates of illiteracy also decreased during this time, from 35.8 percent in 2006 to 14.6 in 2016 (Amesty International, 2020, p. 31)[2].

The quality of education is lowering however which is becoming a major issue. A 2017 Global Parents' Survey by the Varkey Foundation, found that nearly three-quarters of parents in South Africa feel the quality of education has decreased over the past decade – the highest of any country surveyed (Amesty International, 2020, p. 32). Quality education is predominantly provided by private institutions which are unaffordable to many, especially black South Africans. 82 percent of parents surveyed whose children attended public schools said they would be 'likely' or 'very likely' to send them to a private school if they could afford to (Amesty International, 2020, p. 32).

2.5 Cultural and sociopolitical barriers

Culture is identified by Odongo and Rono (2016), as an important contributing factor of the digital divide. People's behaviors and attitudes can both create and reinforce it by perpetuating myths and stereotypes related to digitalization, for example. Misconceptions that computers are for a younger, well-educated and typically male population, still permeate the tech sector around the world. These cultural barriers not only inhibit the proliferation of ICTs, but also negatively affect their perceived utility (Odongo Owuato et. al., 2016). In addition to the

[2] Amnesty International notes that there has been caution expressed about the reliability of these figures.

cultural dimension, a number of sociopolitical barriers have been identified which contribute to the digital divide on many levels: corruption and political instability.

i. Availability of relevant content

Being able to access relevant content online can also play a major part in motivating someone to get online. According to the World Bank (2014), at least 80 percent of all content on the Internet is in just 10 languages. This can be a major barrier to the access of ICTs, especially for populations that speak local dialects. In Kenya, there are two official languages (Swahili and English), but a total of 68 languages are spoken across the country. English may be the only official language in Nigeria, but more than 520 local dialects are spoken across the country. South Africa's Constitution recognizes 11 of the 35 countries spoken by its citizens (Ethnologue, 2019).

ii. Corruption

In a recent study on the digital divide in Kenya, 55 percent of organizations saw corruption as a major to sever obstacle to conducting business – higher than for most other countries. However, only 4 percent of these firms admitted to paying a bribe or gifting something for tax evasion purposes when they were asked during the study. Though corruption is detrimental to business, most firms deny perpetuating this culture (Bandura & Hammond, 2018, p. 13).

The 2019 Corruption Perceptions Index ranks Nigeria as one of the most corrupt countries in the world (Campbell, 2020) which will be a challenge for the future development of the ICT sector. Internet speeds have significantly improved over the last decade due to the deployment of four new undersea fiber-optic cables with links to international cables. However, Nigeria only uses 10-20 percent of the total bandwidth of these cables and many users are unable to install a broadband connection in their homes. This is mainly due to government surcharges on laying cables, coupled with expensive inputs (Economist Intelligence Unit, 2016).

South Africa has also been plagued with corruption in recent years scandals in recent years. In particular, it was revealed that extensive state capture occurred under the presidency of Jacob Zuma which was primarily orchestrated by the Gupta family who leveraged their relationship with the President to control various government functionaries. This resulted in the degradation of the country's electricity network, for example (SA Public Protector, 2016)

iii. Political instability

Political instability is a major barrier to digitalization in Nigeria and tech firms have cited this as a major concern. The negative impacts of various regional conflicts on the business climate (i.e. firm productivity and sales) have been highlighted in recent studies, with a specific emphasis on violent conflict and a lack of security (Ramachandran, et al., 2019, p. 27). A marked North-South divide has emerged in the country due to the insurgency which has been waged by Boko Haram in the north of the country since 2011. Though most of the territory once owned by the terrorist group has now been reclaimed by government forces, more than 37,000 lives have been lost since the start of the conflict (Global Conflict Tracker, 2020). This has posed tremendous setbacks for development in the region.

South Africa has one of the highest rates of inequality in the world with the richest 10 percent holding around 71 percent of the net wealth, while the bottom 60 percent hold just 7 percent of net wealth in South Africa. Wealth distribution remains strongly correlated to race, with black households earning less than 20 percent on average than white households (Amesty International, 2020). South Africans have grown frustrated with the government's inactions in the face of growing inequalities. Consequently, South Africans have learned to make their demands heard in other ways, primarily through protest – between 1997 and 2013, an estimated 68,000 protests took place. Protesting is widely perceived as a more effective way for people to make their demands heard (Msimang, 2019). The 2015 Fees Must Fall protests, for example, pushed the African National Congress to assign significant resources to education and shift the national policy agenda are a good example of this (Msimang, 2019).

Chapter 3: Measuring the Gender Digital Divide in Kenya, Nigeria and South Africa

The barriers to digital inclusion which women face are reflective of the gender inequalities that are prevalent in the physical world. Though digitalization and technology present significant opportunities for women and girls, they can also reinforce gender-based inequalities. The Sustainable Development Goals for 2030 represent an international recognition of the significance of both ICTs and gender equality in driving global sustainable development. In particular, target 5.B of the Goals aims to '[e]nhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women'. Progress on this target is measured by looking at the proportion of women who own a mobile phone, compared to men (Global Goals, 2018). However, looking solely at access to technology is restrictive too restrictive to understand the gender digital divide. The gender inequalities and digital divides prevalent in Kenya, Nigeria and South Africa range across many different issues, therefore a variety of political, economic, political and cultural factors should be taken into consideration.

The Global Gender Gap Report will be used as a basis for analysis on gender equality in each country. This report has been published annually by the World Economic Forum since 2006. It includes an Index which measures gender gaps in 153 countries, across four dimensions: economic participation and opportunity, educational attainment, health and survival, and political empowerment (World Economic Forum, 2019). As the Index analyzes gaps in access to resources and opportunities rather than the levels of available resources and opportunities, it will serve as a solid basis for the following analysis of the gender digital divide. Each country is analyzed against 14 indicators and given a score for each based on how close they are to imparity (0) or parity (1) (World Economic Forum, 2019).

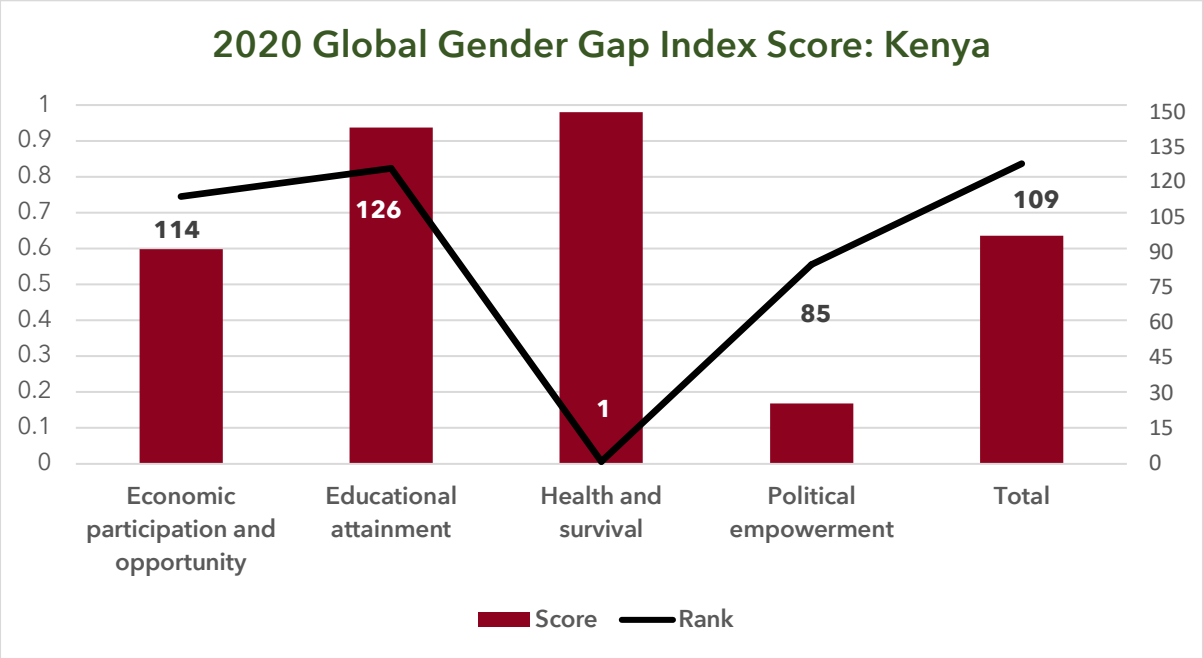
3.1 An overview of gender equality

i. Kenya

Since the start of the millennium, efforts have been made at a government level to empower women and bridge the gender gap in Kenya. Article 27 of the Kenyan Constitution protects citizens against discrimination. It is within this Article that women's right to live free from gender-based discrimination is enshrined. Article 27(3) stipulates that '[w]omen and men have

the right to equal treatment, including the right to equal opportunities in political, economic, cultural and social spheres.' (The Constitution of Kenya, 2010, Art.27, Sec. 3). The National Policy on Gender and Development and Action Plan (2008-2012) drove actions to build institutions, infrastructure, plus develop opportunities targeted at Kenyan women. Despite the recognition and inclusion of gender issues at a national level, gender-based discrimination is still prevalent and many women lack access to basic services.

Figure 1



Source: WEF, 2019

The 2020 Global Gender Gap Report ranks Kenya 109th out of 153 countries (Figure 1). This is the lowest ranking Kenya has ever held since the Index was first published, though this has been a gradual process as the country has been slipping down the ranking since 2014. Kenya scores the highest for health and survival ranking first in the Index (alongside 38 other countries, including South Africa) with near parity in this area (World Economic Forum, 2019, p. 207). However, this is the only sub-index for which Kenya scores highly. With only 21.8 and 25 percent of women in parliament and ministerial positions respectively, further efforts are necessary to achieve women's full political empowerment. The fact that Kenya has not had a female head of state brings down this score further (World Economic Forum, 2019, p. 207). In terms of economic participation and opportunity, Kenya ranks 126th in the Index – a score which is especially brought down by the significant lack of women in leadership positions. Only 24.8 percent of women hold roles as legislators, senior officials and managers compared to 75.2

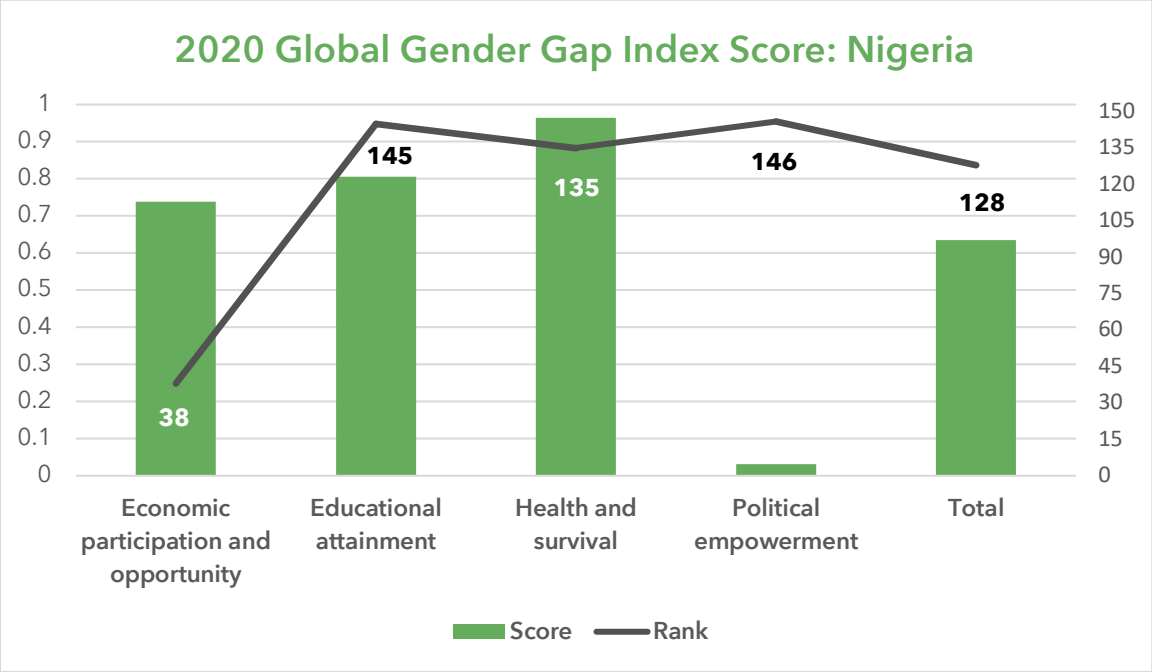
percent of men (World Economic Forum, 2019, p. 207). Kenya receives its lowest score for the educational attainment sub-index. Though near parity can be seen here (0.938), the country has low enrollment rates in secondary and tertiary education for both male and female students (World Economic Forum, 2019, p. 207).

As the results of the 2020 Global Gender Gap Index indicate, gender equality persists at many levels in Kenya. Women are disproportionately affected by poverty and limited in their capacity to effectively participate in the formal economy, especially as producers or market actors. This is exacerbated by the fact that women disproportionately bear the burden of unpaid domestic work and childcare in the household (USAID, 2020). According to the International Institute for Sustainable Development, Kenyan women spend twice as much time than men doing unpaid care work. In rural areas, women are also responsible for fetching fuel and water for domestic work and other household needs, spending around an hour and half more than men on this daily. They have less time to spend on non-productive activities such as learning, social and cultural activities or sleep (Puzyreva & Roy, 2018, p. 5). Women in Kenya also face a lot of discrimination when it comes to land ownership. In 2018, the Kenya Land Alliance published a disaggregated data analysis on land title issuance in the country. The analysis – which looked at a third of all land titles issued in Kenya – revealed that only 10.3 percent of land titles had been issued to women. This gap has only widened in recent years, as the analysis found that women received only 1.62 percent of land titles between 2013 and 2017 (Puzyreva & Roy, 2018, p. 6).

ii. Nigeria

Women in Nigeria suffer from high levels of discrimination across areas of economic and social development. While the Nigerian Constitution does protect its citizens from being discriminated against on the basis of their sex (Article 15[2]), it falls short of explicitly protecting women's rights to equal economic opportunities, for example (Federal Government of Nigeria, 1999). This, in part, has led to a culture of systemic gender inequality which permeates every level of Nigerian society.

Figure 2



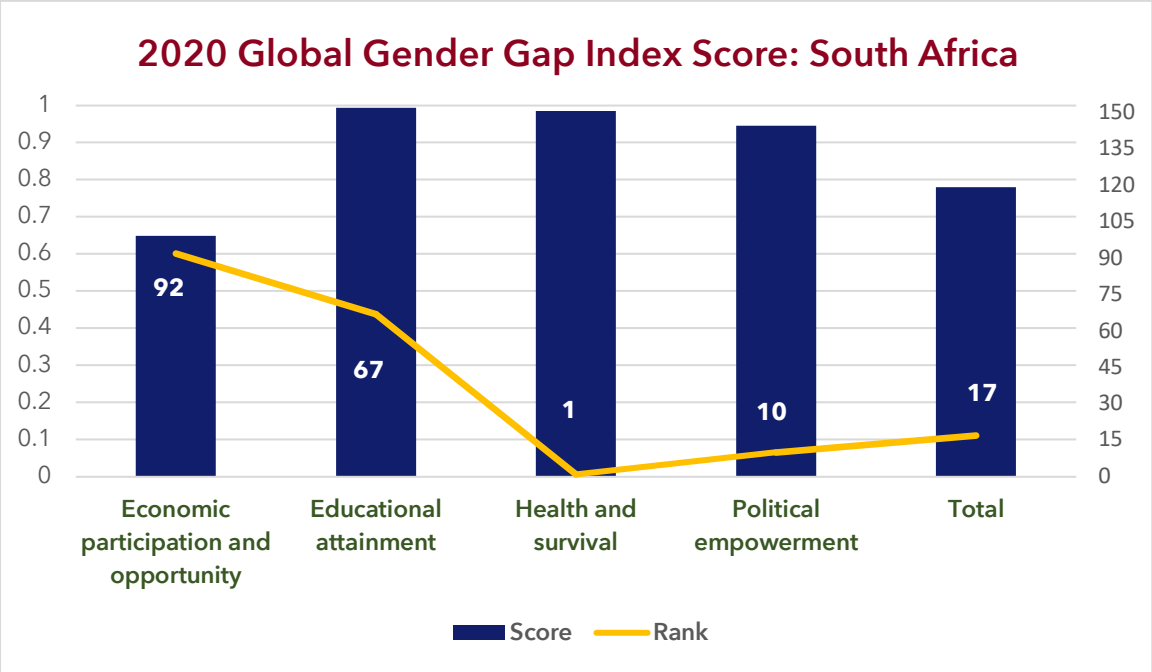
Source: WEF, 2019

Nigeria is ranked 128th in the 2020 Global Gender Gap Index (Figure 2). Overall progress towards gender equality has stagnated since 2006 with only economic participation and opportunity increasing substantially. Nigeria has one of the highest proportions of professional and technical workers that are women. 64.6 percent of these workers are female, as opposed to 35.4 percent of men (World Economic Forum, 2019, p. 269). However, unemployment is very high, and women are disproportionately affected with only 50.5 percent of women participating in the labor force, compared to 59.9 of men. Nigeria ranks relatively low in the health and survival sub-index, on account of how low life expectancy in the country is. Women can expect to live an average of 49.2 years while men can only expect to live for an average of 48.7 years (World Economic Forum, 2019, p. 269). Educational attainment is also low for Nigerian women. As in Kenya, enrollment in secondary and tertiary education remains low for both male and female students. However, a disproportionate number of primary-aged girls are not enrolled in school, leading to high levels of illiteracy among women (World Economic Forum, 2019, p. 269). Nigeria scores the worst in the political empowerment sub-index, ranking 146th. Only 3.4 percent of parliamentarians and 8 percent of ministers are women. Furthermore, Nigeria has never had a female as a head of state (World Economic Forum, 2019, p. 269).

iii. South Africa

South African women played a vital role in the struggle against apartheid. Women's movements were crucial in reversing discriminatory legislation in gender, human rights, education and labor that had been in place during the apartheid era (Naidoo, 2007). Article 9(3) of the 1996 Constitution protects women from being discriminated on the basis of their gender. Furthermore, the Constitution established a Commission for Gender Equality to 'promote respect for gender equality and the protection, development and attainment of gender equality' (The Constitution of the Republic of South Africa, 2010, Art.187, Sec. 1). Throughout the democratization process, women's issues like welfare and empowerment were a priority in the quest for an egalitarian society and many initiatives were targeted at reversing apartheid-era discrimination in the workplace (Naidoo, 2007). As a result, progress has been made on a number of issues from educational attainment and economic empowerment, to access to credit, land and properties (Sinden, 2017).

Figure 3



Source: WEF, 2019

South Africa is one of the top 20 countries in the 2020 Global Gender Gap Index, coming in 17th position (Figure 3). The country is ranked first, alongside Kenya, in the health and survival sub-index. The country also comes in 10th for political empowerment with 46 percent of women in parliament and 48.6 percent in ministerial positions. A female head of state would push

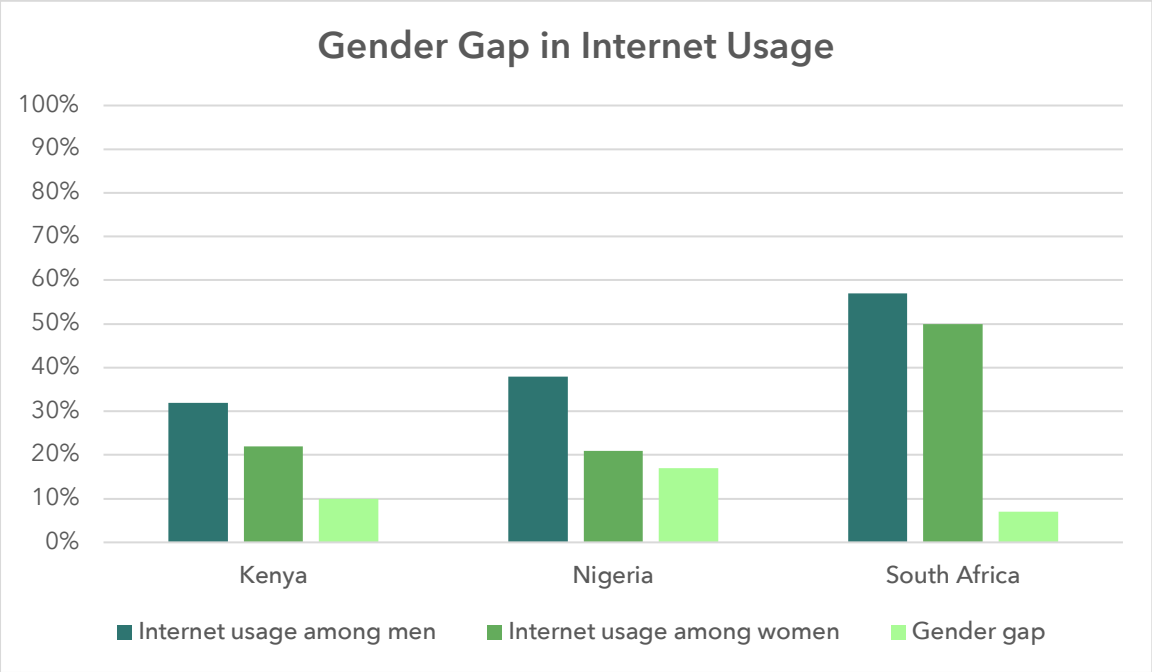
parity forward significantly in the coming years (World Economic Forum, 2019, p. 315). Educational attainment in South Africa is relatively high for women, with near parity in literacy and primary enrollment. Notably however, there are more women enrolled in secondary and tertiary education than men (World Economic Forum, 2019, p. 315). It is in terms of economic participation and opportunity that the greatest gender gap exists in South Africa. This is primarily due to wage inequality and a lack of women in leadership positions, with only 30.5 percent of female legislators, senior officials and managers (World Economic Forum, 2019, p. 315).

Despite these promising figures, recent studies have shown that progress towards parity is slowing down. In the labor market, for example, only 8 percent more women entered the workforce between 1996 and 2015. At this pace, parity will not be achieved for another 50 years (Sinden, 2017). Part of this is because many women in South Africa are informal workers and their participation in the economy is hidden. As this type of employment falls outside the remit of labor laws, women are more vulnerable to low pay and unsafe working conditions (UN Women, 2016).

3.2 Women's access to ICTs

i. Internet usage

Figure 4

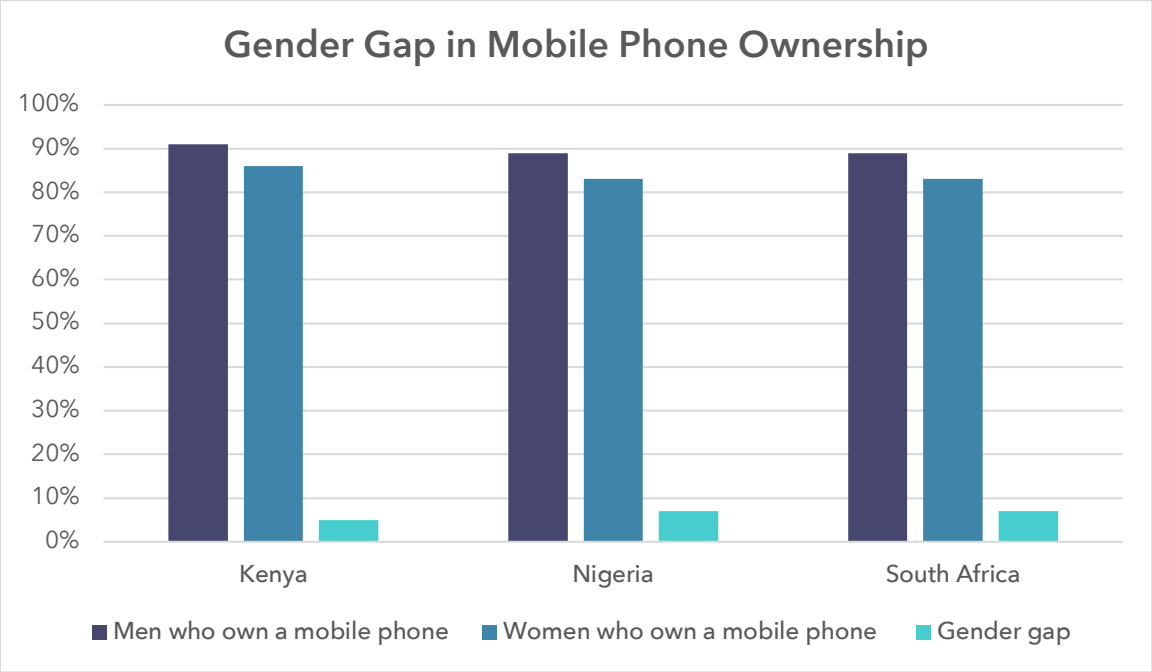


Source: After Access Survey, 2017

Figure 5 indicates that South African women have the highest level of Internet access and are closer to parity – 50 percent of women compared to 57 percent of men use the Internet in the country. In Kenya and Nigeria, only 22 and 21 percent of women respectively are actively using the Internet (Figure 5). Such low rates in access, even for men would indicate that very few women currently have access to ICTs. However, looking at the number of women that own a mobile phone should paint a more accurate picture

ii. Mobile phone ownership

Figure 5



Source: GSMA, 2020

The mobile gender gap is fairly even across all three countries, though ownership is slightly higher and more equal in Kenya. 91 percent of men and 86 percent of women own a mobile phone there, compared with 89 percent of men and 83 percent of women in Nigeria and South Africa (Figure 4). However, the 2019 Mobile Gender Gap Report finds that while women may own mobile phones, they may not be aware of mobile Internet. Despite high levels of mobile ownership among Kenyan women, only 72 percent were aware that mobile phones could be used for Internet access. In contrast, 76 percent and 85 percent of Nigerian and South African women reported awareness of mobile Internet (GSMA, 2020). Men are also more likely than women to own a smartphone across all three countries.

3.3 Women's access to electricity

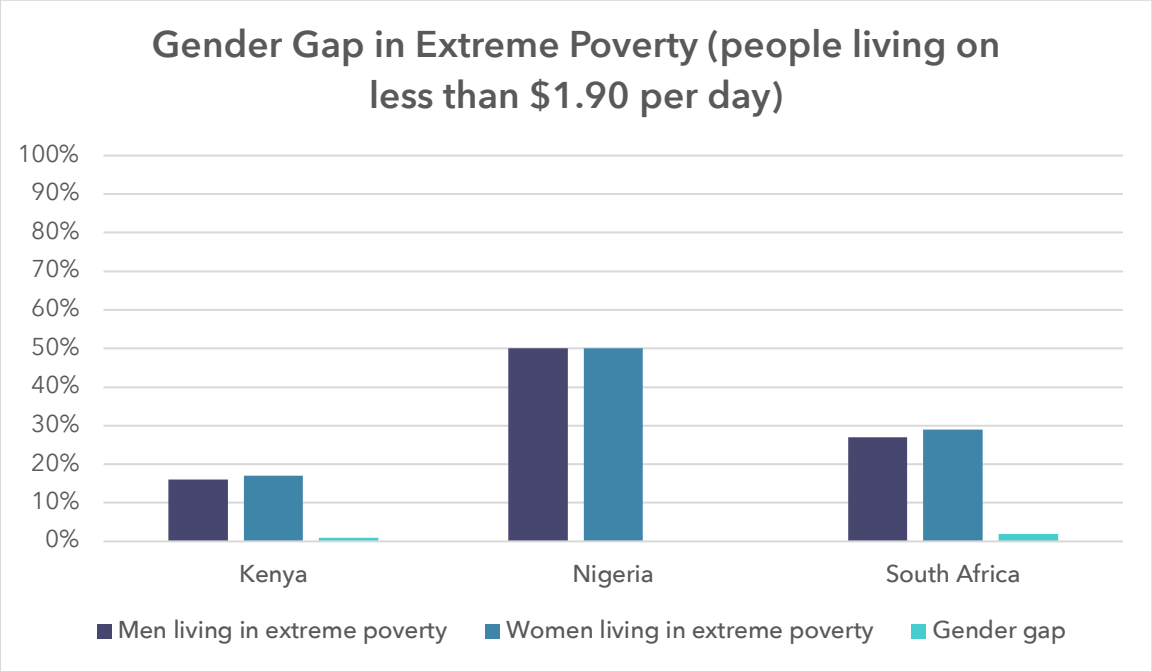
Gender disaggregated data does not exist nationally for electricity access, and yet, women are disproportionately affected by a lack of electricity. As women spend significantly more time than men on domestic work, they also spend significantly more time at home. Many of their household chores could be more effectively done with electricity and provide women more time to spend on non-productive activities. For example, electric stoves cut out the time women spend collecting fuel and also reduce indoor pollution, improving women's health (Köhlin, et al., 2011).

Some evidence shows that electrification in rural areas can help reduce fertility rates, with positive impacts for women. This is thought to be related to television ownership – an offshoot of electrification – as mass media can provide information and images of empowered women (Köhlin, et al., 2011). However, there is a dearth in studies which clearly identify how to effectively unlock the benefits of electrification for women. Though gender disaggregated data would be difficult to collect for women, since electricity access is typically measured on a household basis, it is evident that gender should be a key consideration in the development of electrification programs.

3.4 Gender and poverty

Data from the World Poverty Clock – developed by the World Data Lab – seems to indicate that little to no gender gap exists in Kenya, Nigeria or South Africa for poverty (Figure 6). In Nigeria, women and men are almost equally affected by extreme poverty – 51.6 million Nigerian men (50 percent) and 50.5 million women (50 percent) live in extreme poverty. In Kenya, there is a 1 percent gender gap, as around 3.8 million men (16 percent) and 4.2 million women (17 percent) live under the poverty line. Finally, the gender gap in South Africa stands at 2 percent, with around 7.6 million men (27 percent) and approximately 8.8 million women (29 percent) affected by extreme poverty (World Data Lab, 2020).

Figure 6



Source: World Data Lab, 2020

However, these figures do not necessarily mean that women are not being negatively impacted by poverty. In Kenya, living in poverty is a major barrier for women's participation in many areas of society. Women are predominantly affected by family and rural poverty which hinders their ability to engage in productive activities. The unequal burden of domestic work that women bear leaves them with little to no personal income (Anyango, et al., 2018), leaving them far more vulnerable to unemployment as they generally would not receive government assistance. Inequalities in land ownership are a further hinderance to women's financial independence. For example, while 80 percent of Kenyan women work as smallholder farmers, only 1 percent actually own their own land and less than 1 percent are the beneficiaries of agriculture credit (UN Women Africa, 2020). Additionally, poverty has been found to contribute to the lack of women in public office and leadership positions (Anyango, et al., 2018).

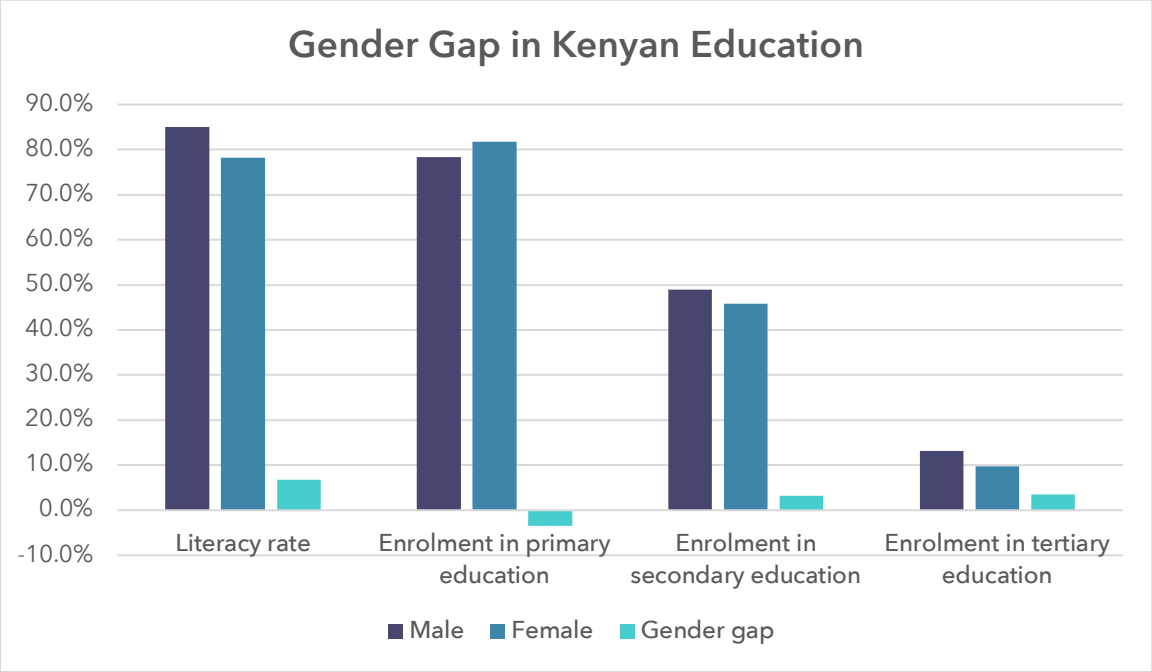
A study by Ajala (2016) on women's poverty in Nigeria, finds that gender discrimination is not necessarily the root cause of the issue. Instead, women's poverty is found to be caused by the traditional beliefs and cultural practices in many communities which treat female children as inferior to male children. These beliefs and cultural norms permeate to many social constructs, including education and training. In turn, this creates difficulties for women in gaining employment and becoming financially independent. The discriminatory nature of gender roles

in Nigeria also means that women are limited in their property rights, and consequently limited in their capacity to accumulate wealth, but also attain economic and political power. Efforts to end women's poverty in the country should focus on ending traditional beliefs and cultural norms which perpetuate gender inequalities in Nigeria (Ajala, 2016).

In South Africa, though poverty decreased following the end of apartheid, women have become increasingly more at risk of falling into extreme poverty. This shift occurred during a time when the government's social grant system was being expanded (Rogan, 2016). A recent study found that government investments failed to bridge the gender poverty gap when they focused solely on the risks of poverty resulting from the discrimination of women in the labor market (Rogan, 2016). However, these risks carry over to their higher risks of multidimensional poverty, which is the negative impacts on women's health, education and standard of living due to poverty.

3.5 Women's access to education

Figure 7



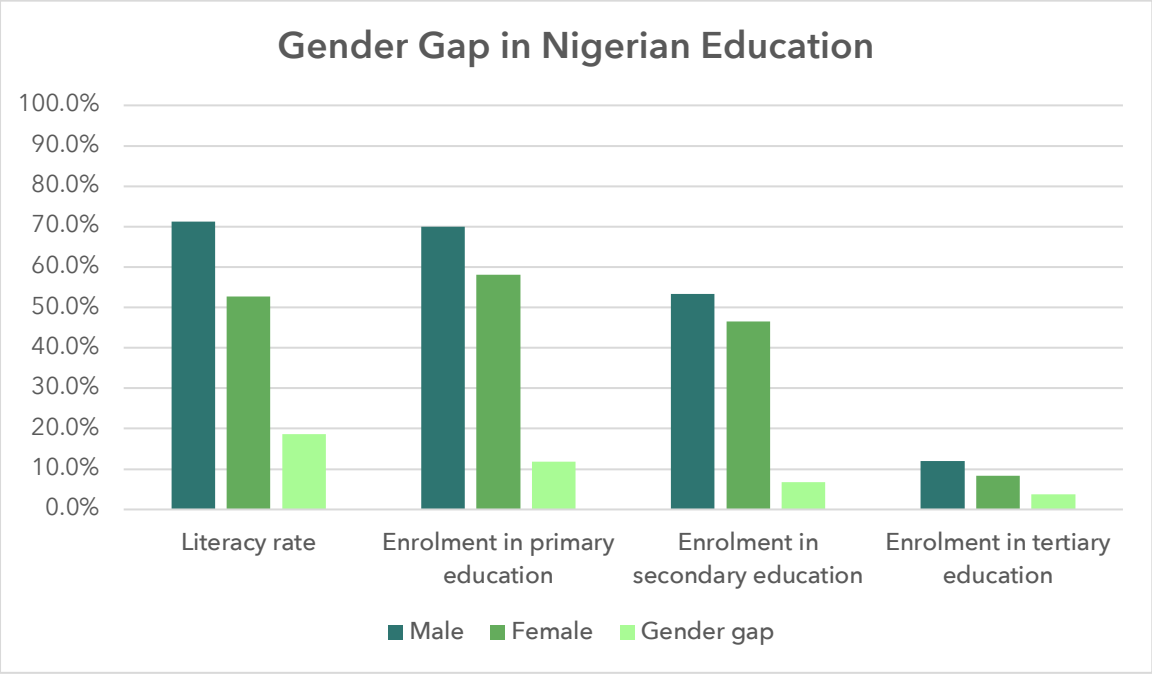
Source: World Economic Forum, 2019

Women and girls' access to education is steadily improving in the Kenyan education system. In fact, there are now more girls enrolled in primary school than boys (Figure 7). Despite this, government policies aimed at bridging gender gaps have failed to translate into considerable improvements beyond primary education. Less than 50 percent of girls proceed to secondary

education and fewer than 10 percent are enrolled in higher education – less than a third of total enrollments (Figure 7). A recent study shows that girls in Kenya are more likely to drop out of school than boys as a result of poverty, insecure learning environments, the high cost of education, and the long distances to learning institutions (Akala, 2019).

Another study (Mbirianjau, 2018) focused on women's participation in STEM degrees at Kenyan universities, where a 30-35 percent gender gap exists. Results from the study showed that women generally performed worse than their male counterparts as a result of gender stereotyping, sexual harassment and family responsibilities. Additional biases were found in certain policies which favored male students in STEM (Mbirianjau, 2018). Such a disparity is a major hinderance to bridging the gender digital divide for Kenyan women - fewer women are gaining the technical skills required to pursue careers in STEM. Additionally, this means there are fewer women who can develop ICTs that work for women and empower them.

Figure 8

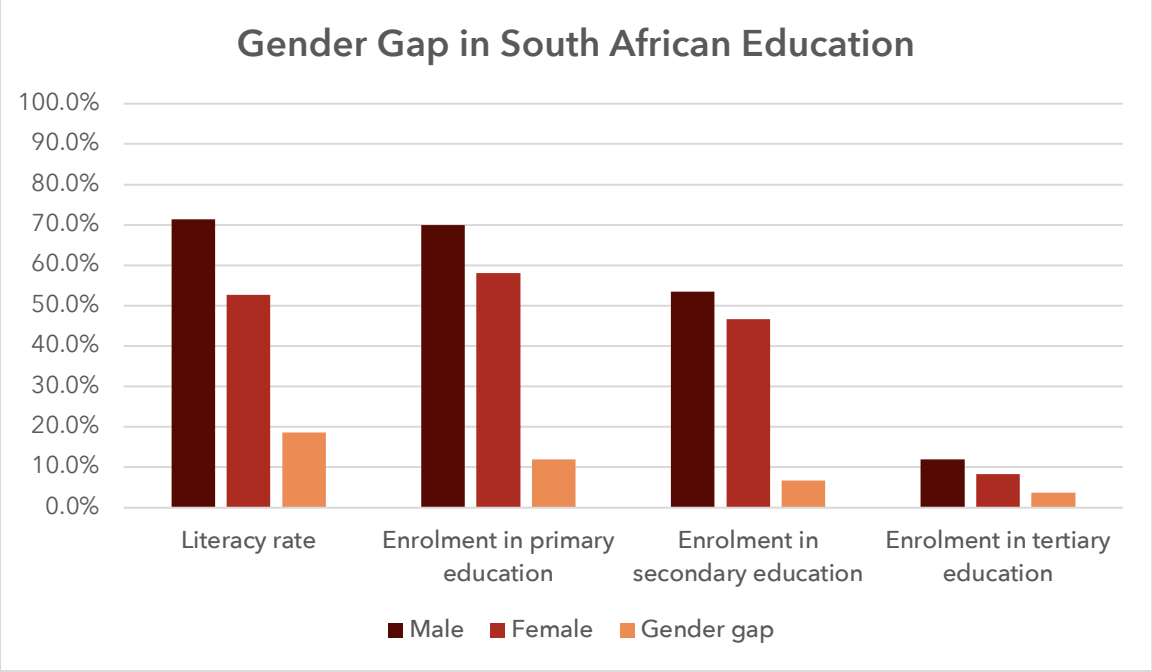


Source: World Economic Forum, 2019

Looking at the data on the education system in Nigeria paints a bleak picture. The country has the highest population of out-of-school children in the world and the vast majority of them are girls. Only 52.7 percent of women and girls are literate compared to 71.3 percent of males (Figure 8). Gender is one of the three principle factors causing educational marginalization,

alongside geography and poverty. In the North-East and North-West regions of Nigeria, net attendance rates for girls stand at 47.7 percent and 47.3 percent respectively (UNICEF Nigeria, 2020). This is driven by a variety of factors, including poverty and socio-cultural norms and practices which discourage girls' attendance in schools. In conflict affected states such as Borno, Yobe and Adamawa, many children do not have access to education as many schools have been shut for years, while others have been destroyed (UNICEF Nigeria, 2020). As Figure 8 shows, female enrollment in higher education remains below 10 percent.

Figure 9



Source: World Economic Forum, 2019

Data in Figure 9 indicates that there is no gender gap in South Africa's education system. Parity has been achieved between boys and girls at a primary level, and at a secondary and tertiary level there are significantly more female students than male students. However, the legacy of apartheid endures and enrollment in higher education is limited by income and affordability (Albertus & Tong, 2019). Academic institutions based in non-white areas (urban and rural) typically have fewer resources and lower quality of education the institutions based in predominently white areas. Since apartheid, black South African women have suffered from a 'triple marginalization' at the levels of race, sexism, and social class. All three factors contribute to a a higher proportion of girls dropping out of school than boys (Albertus & Tong, 2019). This extends into higher education where systemic inequality permeates enrollment practices,

course selection which reinforces gender stereotypes and lower graduate prospects (Akala, 2019). Additionally, only 28.5 percent of female students graduate with STEM degrees (UNICEF South Africa, 2020).

3.6 Digital Skills and Literacy

A 2017 study by Accenture develops a Digital Fluency Model, an overall measure of the impact of digital tools on working men and women by country and generation. Digital fluency is defined as the extent to which people embrace and use digital technologies to become more knowledgeable, connected and effective. Women are underrepresented in the workforce around the world making them a significant source of untapped talent. In fact, in 2019, fewer than 50 percent of women around the world were actively participating in the workforce (World Bank, 2020). Considering the current shortage of digitally skilled talent, as well as the high levels of unemployment in Kenya, Nigeria and South Africa, increasing the digital fluency of women can have significant impacts on economic growth. For example, a report by the International Monetary Fung found that Nigeria's GDP per capita growth could increase by more than one percentage point annually, if gender equality was reduced to similar rates as other West African countries (IMF, 2018).

Developing internationally comparable measurements such as the Digital Fluency Model is crucial in order to capitalize on the potential benefits of digitalization for women. Unfortunately, the study does not cover all three countries selected for this analysis - only South Africa was selected to be part of the study, therefore data does not exist for Kenya and Nigeria. The report does find however that at current rates of ICT adoption for women countries in the Global North won't achieve gender equality in the workplace until 2065 and in the Global South this won't be achieved until 2100 (Accenture, 2018). However, if governments and the private sector accelerate the current rate of digital adoption and digital fluency of women, gender equality in the workplace could be achieved by 2040 in the Global North and 2060 in the Global South. Furthermore, the study finds that countries with higher rates of digital fluency for women also have higher rates of gender equality in the workplace (Accenture, 2018).

3.7 Cultural and socio-political barriers for women

Poverty, education and numerous other dimensions of the gender digital divide are deeply rooted in discriminatory cultural beliefs and traditions. However, it is virtually impossible to measure the extent to which the divide is being affected by cultural barriers. Nevertheless, such

stereotypes and perceptions have to be taken into account. For example, cultural biases in northern Nigeria discourage girls' attendance in formal education. Girls tend to be withheld from education to complete household tasks like fetching water or due to early marriage (Bandura & Hammond, 2018). Additionally, in Kenya and South Africa, harmful traditional practices like female genital mutilation and child marriage persevere in certain communities.

Conclusion

The gender digital divide in Kenya, Nigeria and South Africa exists across every level of this analysis. Each dimension reinforces the other, indicating the difficulties of bridging this divide and the challenges ahead.

Kenya suffers from low Internet penetration and there are fewer female users than men. However, the country has the highest mobile penetration rate among women. A gender gap does exist in the ownership of mobile phones, as a proportion of women are unaware they can access the Internet through their devices. While mobile rates have lowered in recent years, these still remain unaffordable to the many Kenyans living in extreme poverty. Literacy and school enrollment rates have significantly improved in the last two decades, however female students are at a higher risk of dropping out than male students. Women and girls living in rural areas and from nomadic communities are not enrolled in school at disproportionate rates. Most female students do not reach higher education and very few of those who do, choose degrees in STEM. Kenyan women are also at a higher risk of poverty as they predominantly bear the burden of unpaid domestic work. They face further barriers to their financial empowerment as a result of the discriminatory land ownership structure.

Low Internet use and high mobile phone ownership can also be found among Nigerian women. However, women living in rural areas are at a significant disadvantage due to uneven mobile network coverage across the country. Though the Internet is extremely affordable in Nigeria, the half of Nigerian women currently living in extreme poverty are still unable to prioritize such costs over food or shelter. Women's poverty is reinforced by traditional patriarchal beliefs which persist at every level of society. The majority of children that are out-of-school in Nigeria are girls. In the country's northern regions, the Boko Haram insurgency has pushed millions more out of school and girls have been the targets of sexual violence and kidnappings.

South Africa has the most advanced ICT network by far, which translates to half of the female population using the Internet. Nevertheless, access to the Internet is unevenly distributed between women living in rural and urban areas. A high proportion of women also own mobile phones in the country which could indicate that South Africa has the smallest gender digital divide. However, the cost of the Internet and digital tools is too high, and South African women – who are at a higher risk of falling into extreme poverty – may not be able to afford these. Non-white women are still the victims of systemic inequalities dating from apartheid. In higher

education especially, black South African women face discrimination in enrollment, course selection and graduate prospects.

The technologies of the 4IR such as big data, AI and the IoT can help us better understand the issues that women face and tailor solutions to address them. However, corruption, political instability and unreliable energy supplies are all major barriers to future ICT developments. The complex results of this analysis reinforce the fact that future research on the gender digital divide in Africa should be focused on bridging these gaps at a local level, rather than a regional level.

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