Decoding the Digital Divide: Enhancing Connectivity for Sustainable Development in Africa

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1. Introduction

One of the most pressing issues for African policymakers, civil society leaders, and beyond centres on digital connectivity throughout the region. Campaigning tirelessly about this concern for economic and political participation and engagement, numerous scholars and practitioners undergird an entire research agenda about mitigating this lack of connectivity between and among many African citizens, firms, and states. In the context of sustainable development, theorists and practitioners point out a harmful lack of 'data spatialisation' because of this 'digital divide'. Harnessing the whole gamut of Information and Communications Technologies (henceforth ICTs) is essential for ensuring that a more equitable balance of power prevails for more and more states within the overall system.

The connectivity issue is paramount for this S&T-development nexus for other normatively sound reasons. For example, the quintetric of the draft Science & Technology Review highlights correlative reasons held by many within and beyond international society for working directly on various initiatives to begin combating this divide through the digital divide. Suppose this were not enough reason to engage the myriad of scholars and practitioners busy writing about this digital divide when revealing the digital space. In that case, Africa uses gestures as the rubric's case study. Numerous aspects of African public life are invisible due to low mobile penetration rates or similarly attenuated internet access.

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1.1. Background and Significance

The African continent faces both traditional and newly emerging connectivity and access challenges. Over the past century, diverse communications policies in the region have engendered a tapestry of digital infrastructures, with clear winners and losers regarding access to ICT networks. Since the close of the millennium, African states have mobilised a variety of policy instruments, from constitutionalism to legislation, to foster the universal provision of PSTN and mobile technologies across the continent. At the same time, international actors, ranging from advocacy NGOs to intergovernmental blocs, have promoted numerous global programs to realise the grand project of 'digital Africa'. The practical ramifications of such initiatives, often viewed as 'solutions in search of problems', have been varied.

This project is timely because developing 'digital Africa' continues to be a high-priority action domain for national governments and international donors. Policymakers throughout Africa are investing in bold national programs, including tax incentives to spur the roll-out of international submarine fibre optic cable gateways, targeting connecting the unconnected in rural areas through state-controlled enterprises and national funding programs, expanding ICT-industry-focused university curricula, liberalising existing PSTNs or establishing state-owned incumbents to manage communications infrastructure, reducing the price of mobile telephony, among other efforts. Indeed, according to the United Nations' 2030 agenda for the Sustainable Development Goals (SDGs), Africans engaged in ICT and connectivity development are increasingly vested in constructing reliable national, regional, and international supply-side logistical and market frameworks, which complement a universal, demand-side focus on civic and consumer access for broad-based applications and development. The persistent digital divide cuts across rural-urban, wealthy-poor, and educated-uneducated boundaries.

2. Understanding the Digital Divide

In the emergent technological context of the world, the digital divide refers to the lopsided access to information and communication technologies (ICTs). The minimal use of these services, especially in developing countries, compounds the gap between the digital haves and have-nots. The consequences of the digital

divide affect governance, business, schools, hospitals, and the economy, among other spheres of human life. Doctoral candidates and researchers hold that understanding the digital divide can be circumscribed within five essential elements embedded in the concept. These include access to ICTs, the sphere of application of ICTs, the use of ICTs, the achievement of their physical, bodily, cognitive, and socioeconomic effects on human life, and people's skills and knowledge of how and when to construct digital technology and incorporate it into their lives. Additional components include support systems and infrastructure that are likely to affect the diffusion of ICTs and the impacts of their adoption.

Regarding digital connectivity, African countries are a playing field of contrasts. The continent accounts for only three per cent of the world's information and is home to five of the six countries in the world where the telephone density is less than one per cent. An index adopted refers to the continent as 'extraneous to globalisation' as only very few countries, such as South Africa, have access to ICTs and are plugged networkers familiar with the latest information. It is not just communication, cyberbanking, e-learning, and telehealth facilities offered by the ICTs. Still, even relief operations in emergencies depend on these modern information flows on the continent. For African countries, the routinisation of ICTs lies in their application to traditional development spheres such as agriculture and industry, which gives them a social facelift.

2.1. Definition and Scope

The digital divide refers to inequalities between countries and within countries. In this report, we focus on Africa, where there is evidence of these disparities despite the growth in internet and mobile phone access over the last ten years. Access to the internet within a country can vary significantly between different sectors. For example, in South Africa, 86 per cent of adults in urban areas have access, as opposed to 52 per cent of adults in rural areas. Given that Africa has a significant wealth divide and high levels of inequality, a lack of access to ICTs can reinforce those disparities and marginalise even more population sectors.

The concept of the digital divide is multi-faceted. It encompasses inequalities such as: - Lack of access to technology and the internet - Differences in skill and

technical training for using and exploiting technology - Differences in individuals' ability or legal status to purchase and use new technologies in a given country.

Internet access may hinder individuals from pursuing new economic activities in a globalised world. It may also prevent them from performing the same activities as competitors in other parts of the world equally efficiently. These people are thus marginalised as they cannot connect socially, politically, and economically because of their lack of connectivity or inability to use it. Given that these access and use differences prevent a significant part of the population from participating in and benefiting from today's information society, connectivity becomes an agenda topic on sustainable socioeconomic development.

2.2. Factors Contributing to the Digital Divide

The digital divide refers to the inequality in access to, knowledge of, and utilising information and communication technologies (ICTs). In general, the evidence suggests that Africa has a significant digital divide. The digital divide exists along various dimensions, covering, among others, the gap in teledensity, internet users, bandwidth, and telecommunications growth. The international voices point out that the digital divide exists in the information communication sector because many countries on the continent are digital consumers or recipients. The digital divide hampers Africa's participation in the global economy. There are many factors shaping the digital divide in Africa.

This review studies the shape and causes of the digital divide in Africa in light of the digital opportunities identified in many studies that have challenged sustainable development in the continent. In African countries, many factors contribute to the widening digital divide. They vary from physical to economic and social. As this problem encompasses many variables that widen the digital gap and deepen considerably, this subsection inwardly unravels such variables that together make causal complexity behind the infrastructure that shapes the digital divide or how various factors shared above are interrelated. One main factor shaping the digital divide is the lack of necessary infrastructure in the telecommunications sector, such as telephone landlines, mobile telephone coverage, and computers. Teledensity shapes the extent of the population per 1000 people. Teledensity should also be generally distributed in the country, meaning the digital divide still exists between an African country's urban and rural areas.

3. Current Connectivity Landscape in Africa

Much hope is vested in technology and digitalisation as a lever for accelerating development. However, it is widely documented that a large share of Africa's population is left out of the digital revolution. Some 59 million fewer women than men accessed the Internet in 2020 in Africa - mainly mirroring global patterns. The situation is particularly striking, given the efforts in recent years to establish undersea cables in Africa, which were expected to revolutionise connectivity. While such cables have significantly increased capacity, several studies and reports underline that Africa must still overcome severe challenges to either move to the next level in digitalisation or get online the remaining 60%.

Internet access is still primarily managed by a handful of mobile operators. Only the wealthiest people can afford large-scale broadband services, and a combination of cost and habit means overall fixed telephony usage remains paltry. The enabling conditions for local broadband networks, or the so-called 'last mile' connections, to multiply rapidly across the continent are poorly developed. This article aims to provide an overview of the prevailing issues related to Internet connectivity, primarily in the African context. The key elements it analyses are: (i) infrastructure - focusing on the extent and quality of data flows within Africa and the rest of the world (RoW); (ii) access - relating to the availability of and access to networks, including the digital divide between urban and rural populations; (iii) affordability - and the implications for digital inclusion; (iv) usage - focusing on the present usage of existing digital tools; and (v) flows - relating to Africa's dependency on digital tools developed and offered from outside the continent.

3.1. Infrastructure Challenges

The lack of infrastructure is a significant impediment to the further development and expansion of interconnectedness. Although the potential for Africa's digital infrastructure is substantial, focusing on connectivity seems critical for expanding the digital potential in Africa and domestic production, while the first stage of effectively implementing interconnectedness is setting up the physical infrastructure. The transition towards next-generation carbon-neutral Internet infrastructure assemblies is part and parcel of an integrated approach to connectivity, where sustainable infrastructure and the expansion of interconnectedness go hand in hand. Regarding economic time, connectivity is

critical for making everything else work and for the global community to align financial policies on the same basic 'climate-neutral' solution.

The problem with policy attention to ICT has been argued in Africa as a 'bandwagoning' effect designed to spread expertise in the digital environment to Africa. This argument follows the notion that deficient infrastructure impacts the cost effect of ICT relative to other parts of the world. Suppose the cost differences between Africa and the developed world are significant. In that case, there is a 'great digital divide', and ICT will not be widely taken up at a price, imported goods, and vast infrastructural capacity. While affirmative attention on ICT for poverty reduction should not be discountenanced, it should start with the infrastructure upon which connectivity within, between, into, and out of African high-capacity networks are based. Robust, long-term infrastructure is a necessary investment to bridge the digital gap and foster a domestic community and economy to develop and reinforce African countries' support for development. Appreciating a marked relationship between infrastructure and registry bottlenecks in developing these sustained capacity networks is crucial.

3.2. Access and Affordability Issues

Access to digital technologies and affordability of connectivity in Africa lags behind the rest of the world, with an increasingly large divide between urban and rural areas. Less than a third of Africans used the Internet in 2019, nearly three times higher in urban areas (48.7 per cent) compared to rural ones (16.4 per cent). Furthermore, connectivity is not evenly spread, as 77 per cent of those living in areas with high levels of development had access to mobile-broadband networks in 2019. This was true for only 31 per cent of those living in areas with low development indicators. Internet use and access to digital technologies matter as they hold the key to world-class education, remote access to potentially lifelong learning, decent work opportunities, and fundamental services.

In this era of 'technological climate change', where traditional drivers of development such as emissions and resource consumption are increasingly being replaced by non-physical assets including data, algorithms, and networks, digital inequalities are not only a threat to socio-economic inclusion, but they may also hinder progress on the 17 Sustainable Development Goals (SDGs). A failure to address this divide may increase the digital development gaps among and within

countries, leaving the most vulnerable groups struggling to realise the promise of the Fourth Industrial Revolution. This, in turn, may raise pressure for protectionism and developmental nationalism. Cyber policymaking is, thus, an integral part of development policy for sustainable global governance in the African region.

4. Impact of the Digital Divide on Sustainable Development

The digital divide can impact Africa's ability to reach many development-related objectives. African countries are making efforts to increase technological connectivity with the world. However, these efforts have never been enough, and Africa's connectivity lags behind the rest. This paper has shown that efforts to increase Africa's connectedness to the digital world have significant economic implications. For example, increasing internet connectivity and use has improved GDP growth in developing countries.

The lack of connectivity has essential social and cultural consequences, which are often overlooked. African leaders and the many companies and institutions that provide investment money to Africa tend to focus solely on economic arguments. However, more connectivity does have profound implications for science, medicine, and culture. For example, in the modern medical world, more drugs and diagnoses are being developed with the help of an internet link. The vast majority of African doctors do not have access to these new drugs, which means that more African diseases are being classified as orphan diseases. Orphan diseases are considered to be rare. Pharmaceutical companies are unwilling to spend millions to develop drugs that might be marketable in an African country. As a result, many ordinary Africans who might benefit from increased connectivity to Western medical information are dying from relatively simple and non-contagious diseases that are considered rare in Europe and North America.

4.1. Economic Implications

Digital connectivity is presented along various dimensions and layers of complexity. The economic dimension plays a central role in shaping views of digital connectivity as a political priority and influencing economic development and growth prospects. Numerous publications have noted an association between

faster digital networks and more robust economic growth. Recent calls for digital infrastructure investment's "big push" rest on this analytical foundation. The flip side remains equally significant: gaps in digital connectivity may reduce or close off the expected economic and social benefits. To use only the economic dimension, farmers with access to relevant information can improve productivity, small businesses trade with other parts of the world, people can access new consumption opportunities, and firms can hire talent from elsewhere, with the promise that all this will be beneficial for the African continent's economic performance.

The evidence base for these economic estimates is an entire of ongoing debates and discussions. While the economic implications confirm links between digital connectivity and financial outcomes, the global link is influenced by the level of digital maturity, with substantial potential impacts expected in places like Africa if the digital divide can be narrowed. Size, among others, calculated that with 50 million additional users having an online connection, continental GDP could expand by $35bn annually. The underlying argument is that broadband infrastructure transfers innovation, economic growth, and social inclusion for a broad societal power. Aggregate ICT investment ($65b in 2018) and its estimated related output ($104bn annually) further confirm the economic dimension as strategic and beneficial now and in the future.

4.2. Social and Cultural Consequences

Social and cultural: Apart from the economic aspects related to an uneven distribution of knowledge, information, and communication technologies, various aspects of social life may contribute to the digital divide. For example, lacking technological infrastructure or competencies for efficient technology use can lead to social exclusion. Analysing the digital divide in terms of the social and cultural consequences of its dynamics, van Dijk (2005) identifies three modes of exclusion: from social networks, cultural consumption and practices, and political participation.

In addition to the aforementioned, Moyo (2015) mentions that "there is minimal attention given to the implications or societal effects of the changing use of the internet, mobile phones, or apps, and rather simplistically, the possibilities of connectivity are appreciated as a potential fix to developmental crises". Yet, access

solutions to the digital divide "have been predominantly oriented towards providing internet connectivity and services for educational and health purposes in rural areas while making urban spaces 'smarter'". Mobile media's transformative possibilities have not been embraced as promising technologies for rural development.

At the same time, the digital divide can be solved mainly by allocating some of the financial resources towards connecting mobile internet in rural areas that are no less connected than urban areas. There are proposals in the WEF or by private companies like Orange that this issue could be quickly addressed via a concerted effort based on evidence about the actual disparities between urban and rural areas. The efforts to better connect urban areas to broadband infrastructure could be shaped by long-term strategic investments rather than as a consequence of the provision of mobile internet in the living spaces of the farmers who produce before making a profit.

5. Strategies for Bridging the Digital Divide in Africa

Bridging the digital divide in Africa will require a suite of intervention approaches considering each African society's distinct yet interconnected nature. In crafting these strategies, policy interventions and regulatory initiatives are necessary to enhance market expansion and direct investments in underserved and unserved communities. Bridging the digital divide will require a concentrated effort from different stakeholders. As vast parts of Africa remain cut off from the total dividends of the digital age, governments and industry leaders must continue to explore policy options that would make connectivity sustainable, inclusive, and affordable and ensure that no one in Africa is left behind. A positive step to this end is a paradigm shift to inclusive public-private partnerships driven by action – Africa needs pragmatic actions that can be borrowed from Africa's myriad successes within existing resource limitations.

Overall, the following strategies may be employed to bridge the digital divide:

Promoting the enabling environment for market expansion; Making regulatory interventions; Promoting impact networks; Promoting asset-based subsidy – fewer handouts; Promoting public-private partnerships: the role of subsidies; Promoting the internet exchange in Africa;

5.1 Conclusion In closing, it is non-contestable that digital connectivity is indisputably the future. Africa could likely leapfrog development stages through an efficient telecommunications framework. Policy formulation, guided by national-level policies and driven by the practice of these policies, could lead to inclusivity, bringing the rural poor and marginalised into the mainstream economy and political processes. Making Africa part of the connected world is critical in ensuring that Africa becomes an active participant in international discourse as an equal member of the global community. The philosophy of inclusion embraces an African perspective. It is the only hope for stopping Africa's isolation in the 21st century and making Africa a participant in the global economy – not just a source of low-priced commodities. The main goal is to ensure the creation and maintenance of an active open marketplace for ICT products and services driven to an extent by inclusive policies and government goodwill.

5.1. Policy and Regulatory Interventions

Governance remains at the centre of several mechanisms that shape progress. Most importantly, the World Summit on the Information Society (WSIS) represents one of the policy advisory mechanisms that can jointly combine such elements and provide guidelines for regulators. Identifying such mechanisms is not the scope of the paper. Still, it is noteworthy for advancing how different political mechanisms and policy elements may pull together and guide African governments as they seek to advance in a world increasingly "pulled" by the allure of the global digital village. Against this background, we discuss policy and regulatory intervention in matters where developments in extension have pushed or can push into.

The realisation of these components of internet readiness is not solely "driven" by developments in internet connectivity. A hub of readiness enables end markets to materialise through government policy that allows the introduction of new internet services, such as genuine e-banking at the local level, e-education and e-health solutions and Information and Business Process Outsourcing. In advanced nations, concepts such as "inclusive access to information and communication technology" are articulated in policy pronouncements, reflecting a bid to bridge the technological gap. Several interventions have been suggested and adopted to influence the convergence among stakeholders to encourage better access to primary forms of access that folks worldwide require for connecting to them and

each other. A conclusive or somewhat unambiguous understanding of what policy positions engender the most inclusive connectivity is difficult to identify, perhaps because developing nations rate lowest in internet readiness and use.

5.2. Public-Private Partnerships

Assuming both public and private entities pay taxes within the given economy, public-private partnerships may serve as a powerful instrument to address the needs for financing digital infrastructure projects. The state, typically equipped with limited resources and personnel, often enters into contracts with private entities to engage in infrastructure development, management, and maintenance. Through establishing close ties between stakeholders in the public and private sectors, public-private partnerships seek to achieve strong synergy between their diverse capacities, resources, and shared goals. This section will examine the potential of a public-private partnership in tackling the digital divide. By bringing together data from infrastructure projects, relevant technologies, and state and private sector capacities, our discussion will center upon: a) robust contextualization of the current connectivity ecosystem; and b) a set of proposed frameworks for collaboration in the pursuit of enhanced connectivity.

Public entities may provide public goods directly or use competitive tendering processes to provide them through procuring merchant goods and services available from the private market. Relevant data suggests several strategies by which Ghanaian companies will benefit from government contracts originating from the public sector. First, we know that public procurement law regularly and directly links the actions of intervention on the part of the state to development goals. Such goals may include reducing deprivations and inequalities, as well as addressing vulnerabilities encountered by various segments of society. To make transactions more visible, we can also track the growth of a body of regulation and law that steers public procurement actions towards preferential treatment of economically or otherwise vulnerable groups. A strong and transparent legal framework for preferential procurement is already in place in Ghana. This is also not just any kind of state action, but is a conclusion drawn in the Ghana 2020 Country Report by the Public Procurement Authority that tends towards 'local content' legal requirements.

6. Case Studies of Successful Connectivity Initiatives

UUNET in Uganda

TEAMS Cable Landing Station in Mombasa, Kenya

SEACOM from Dar es Salaam, Tanzania

RCIP in Botswana

BRCK, Kenya

SEACOM's National Fibre Backbone, Uganda

The Express Highway PPP Network in Uganda

The Rwanda Utility Regulatory Authority (RURA)

COMTEL in Chad

Revealing the Methodology Behind Successful Connectivity: Through a review of the state of research on the digital divide, this publication presents how we went about our research on sustainable connectivity initiatives in the African context. It explains the research approach to better understanding the impact of such initiatives, showcasing the methodologies and groundwork needed to assess the social, economic and environmental returns on investment for connectivity initiatives in Africa. While these can be return on investment in the business sense of the term as well, the networks we are mainly studying are built as public infrastructure in one way or another and our perspective on return on investment is more in the developmental domain.

6.1. Kenya's Mobile Money Revolution

The emergence of digital financial technologies has led to a revolution in the use of informatics applications with the potential to widen the connectivity bounds. The mobile revolution in Kenya is used as an example to highlight how its adoption has transformed socio-economic lives. The technology penetration in the African continent is correlated to incentives given by authorities in the form of licenses and an open and accountable regulatory framework. Safety, security, and ease of the platform and the costs form part of the critical factors that will be key to possible changes in financial applications uses.

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Telecommunications technology innovators such as Vodafone have over time collaborated with various partners to enhance financial inclusion through the use of cutting-edge technology. In Kenya, the company's innovation that resulted in the establishment of Safaricom and limited ownership of the company to Kenyans has played a significant role in transferring useful mobile phone technology and financial resources through an easy-to-use money transfer platform. One key result of this innovation is that Kenya is today a hub on mobile money technology. It is well known in leading mobile technology circles as M-PESA, and is generally termed "em" or "m" to reflect the mobile context. The generation of cross-networkless scratch cards for different mobile service providers helped to increase the speed with which value could be transferred from the normal weekly transfer of minutes between customers known as "airtime."

6.2. Rwanda's National Broadband Plan

Launch, in collaboration with the Commonwealth Telecommunications Organisation (CTO), published a report titled "Decoding the Digital Divide: Enhancing Connectivity for Sustainable Development in Africa." The report examines various initiatives that have been devised to enhance broadband penetration in African countries, with a focus on four case studies: Rwanda's National Broadband Plan, Nigeria's National Broadband Plan, Ghana's eWorks Program, and the United Republic of Tanzania's National Financial Inclusion Framework. This supporting series of Working Papers includes in-depth versions of each case study.

The decisive nature of the four case studies suggests that each has been successful in enhancing the limited level of digital access across a country. Whether through financial incentives, progressive regulation, increased cooperation between stakeholders, or binding legislation, all four countries demonstrate that these strategies have been beneficial in creating improved levels of connectivity and enhancing the potential to reach further unsustainable economic development in a digital context. No one solution fits all. However, there are solutions that can be proven successful and are replicable for reconstruction and implementation across borders.

The three areas explored in this paper include the contextual landscape in which Rwanda exists, the technical details and development of the National Broadband

Plan, and the soon-to-be-upgraded version - the Connectivity Plan. To ascertain the level of digital access, the National Broadband Plan mentions three different factions into which Rwandans can be placed corresponding to their current primary use of digital networks. These are unconnected, those with limited connectivity ("partially connected"), and those identified as connected and are regular users of broadband at speeds or emerging future high-speed with a potential bandwidth capability of 1.5Mbit/s or higher.

7. Technological Innovations for Enhancing Connectivity

Technological innovations that have the potential to enhance connectivity and are underexplored in the African context are those offered by satellite internet solutions. Recently, companies such as OneWeb, Amazon, Space X, and Telesat have begun to launch satellite networks that are intended to provide global broadband coverage with a system consisting of hundreds or even thousands of small satellites. Satellite systems are inherently suitable for uncovering unserved and underserved areas due to the global coverage offered. The development of satellite internet solutions has historically suffered from high costs, which have limited companies' operations to traditional broadband customers in affluent and sparsely populated areas of the world. This limits the ability of existing satellite solutions to bridge the digital divides experienced by countries in Africa and also explains why satellite systems have been historically unpopular in the African context when they need to serve low-income and relatively low user density areas.

The substantial wireless communication technology advancements in the last decade have reduced the unit costs for satellite equipment, thrust a diverse range of use cases, and allowed sustainable, affordable pricing in areas with low user densities or modest consumer willingness-to-pay for Internet services. Advancements in equipment cost and size as well as in launch costs have now opened up the potential for widespread price-competitive use of existing and upcoming SmallSat mega-constellations in CTIS. Lower equipment costs have been driven by developments in microwave and 4G technology, while lower satellite costs have been driven by progress in miniaturization technologies, leading to CubeSats and smallsats, which are smaller and much cheaper than traditional Earth observation or geostationary communications satellites. Wireless

communication technologies, especially ever-improving 4G, are important potential enablers of CTIS. LTE and 5G fixed wireless access (FWA) networks promise to be a game changer for remote regions, as wireless systems are relatively breakout and can offer the same levels of performance as fixed-line broadband.

7.1. Satellite Internet Solutions

There are several satellite-based solutions that are becoming increasingly popular in envisioning the broadband network for challenging, difficult to reach, and remote/underserved areas. Two of the potential ways to deploy next-generation connectivity solutions with the use of satellites include high-throughput, geostationary (GEO) communications satellites in the skies above the Earth at an altitude of around 36,000 km, providing Ku-, Ka-, or V-band frequencies aimed at serving passengers and crew onboard aircraft, ships, and vehicles. As well as low Earth orbit (LEO) satellites able to provide global coverage for a wholesale offer aimed primarily at local Internet Service Providers (ISPs), including regional and rural Australian High-Capacity Data Users (HCDU), as well as on-sellers who resell data capacity to customers.

Satellite Internet has an oversized potential to cover remote islands and rural or suburban places with difficult topography, encompassing about 12% of the Australian population living far from the reach of fiber and wired network solutions. On-farm requirements include the need for more reliability and capacity than possible with cellular-based solutions (i.e. NBN™ Fixed Wireless or NBN Satellite services). Fixed wireless technologies, while providing high-speed internet, can be easily disrupted due to bad weather – such as thunderstorm – and due to trees and hills blocking the antennas used to connect individuals to the wireless towers. LEO-based satellite solutions may be beneficial in Australia to address the geographical challenges with the provision of reliable wireless technologies for off-farm use within and near peri-urban areas, as well as in hard-to-connect locations, such as valleys in folded mountain ranges, limited access, or dynamic topography impacted by seasonal changes.

7.2. Wireless Communication Technologies

Wireless communication technologies are used to facilitate widespread and pervasive access to communications that can easily cover millions of end systems (e.g., tablets and mobile phones) within a single communications service. A wide

variety of wireless communication mechanisms exist, each posing their own unique properties. Some of these wireless communication mechanisms operate over large parts of the world, enabling access to a global network, while others operate at smaller scales (e.g., within a city or at a LAN-scale within a single room or meeting hall). The wireless technologies that operate over large parts of the world have impressive global reach in that they enable internet connections in quite remote geographical locations. In many of those locations, the demand for internet connections is continuing to rise.

The use of wireless communication technologies can provide workarounds for infrastructural constraints. In the world's less-developed economies, large-scale systematic investment in transportation infrastructure is particularly challenging. Indeed, in the poorest parts of rural Africa, there has been practically no investment in roads, electricity, or conventional fixed-line telecommunications. Under these circumstances, it has proven logistically difficult to lay down physical cables over significant distances to provide standard fixed-line telecommunications. Wireless technologies have proven to be crucial in this environment. The need for connectivity fosters innovation in the deployment of wireless mechanisms to reach customer premises. Wireless networks now operate within major African urban centres and in smaller towns, connecting homes and businesses to the internet. Overall, these wireless overlays are responsible for the significant growth in Africa's internet ecosystem.

8. The Role of Education in Addressing the Digital Divide

Education has an important role to play in achieving digital inclusion. Governments, international organizations, and other development actors in Africa can help by supporting digital literacy programs, particularly those designed in partnership with local communities. The spread of digital technology has important implications for how we live, work, and govern ourselves. In many wealthier countries, opportunities for civic participation, employment, and personal and professional development have grown alongside the increase in internet connectivity. Unfortunately, these gains are not shared by everyone. Large groups of people, particularly those marginalized and disadvantaged, continue to be left out. As a result, scholars, policymakers, and international

institutions increasingly talk about the global "digital divide" - the gap between those who are empowered and those who are disempowered by digital technology.

The educational system can play a pivotal role in addressing the digital divide. By educating and empowering citizens - not just in computer and internet use, but also in the fundamental attitudes of fairness, equity, and justice - schools, colleges, and universities can guide people to make use of digital opportunities and minimize digital harms. Schools in Africa and elsewhere in the Global South have played a key role in fighting hunger, increasing access to water and sanitation, and reducing the environmental impact of industrial activity. There is an opportunity for Africa to be bold and adventurous - to think out of the box, if you will - about digital technology and what it is for. How might education transform both the online world and the offline world? What are the limits of digital technology - and how could better data infrastructure address them? As many African countries draft education policies and national cybersecurity strategies, the next section of this report looks in detail at the strategies, guiding principles, and potential pitfalls of digital literacy.

8.1. Digital Literacy Programs

A growing body of academic research provides evidence on the impact of digital literacy programs and other educational interventions aimed at building digital competencies to aid digital inclusion in general and youth in specific. Some of the best evidence comes from trials in the US. Recent reviews of the literature highlight a variety of important findings, most notably that impact is best seen when interventions are complementary. Youth who are experiencing the greatest digital skills lack are the greatest beneficiaries of digital literacy teachers and classrooms. Additionally, those with the lowest pre-existing cognitive skills respond best to digital literacy interventions.

In many developed countries, and a growing number of ACP countries, internet use is almost universal in the youth population, which, in turn, is greater for older people. Some of these reports are designed to inform national digital strategies, and others are to meet the specific priorities of funders. Thus, many may emphasize and highlight deficits. In general, then, a large proportion of Africans, and 100% of young people in the capital cities of Ethiopia, Mozambique, Rwanda,

and Sierra Leone are excluded from the benefits of the internet. This is concerning, given that digital literacy is increasingly seen widely as essential to full participation in all areas of development. Full participation offers individuals social empowerment. Meshram found that while people's (generally low) income status is an important factor in limiting internet use, other factors must also be considered in order to enhance digital equity.

9. Challenges and Opportunities in Enhancing Connectivity

In summary:

A) In enhancing connectivity, African countries face significant challenges. Technical and logistical challenges include the geographic and demographic conditions of individual African countries, such as high levels of urbanization, low population density, large rural areas, and a large proportion of the population living in remote communities. Similarly, rough terrain and rivers naturally hinder the roll-out of physical infrastructure. On principle, underinvestment and outdated strategies of investment and regulation may contribute to obstacles in infrastructure roll-out. Other challenges are linked to regulation, policy, and governance, either at the national level or in terms of regional differences. These barriers relate to funding limitations, technical limitations, limited infrastructure and knowledge, market limitations and urges to expand, policy incentives, local socio-economic and political actors and institutions, access to and use of modern media, promotion of local and independent content, indigenous innovation, change in administration and management, the importance of political will, and lastly the connection between communication and other utilities. There are also several opportunities for African countries to enhance connectivity. These opportunities will be discussed, inter alia, in the light of off-grid electrification, the digital economy, financing options, cybersecurity, and semi-cost sharing arrangements.

Though the extension of the optic fibre network in Africa improves physical connectivity, it does not enable universal connectivity. Wireless access has to be shared not only from the network point of view, but physical costs are also divided among the users. Yet, the roll-out of wireless connectivity bears specific challenges.

It could help cities grow by improving connectivity in poor suburbs or rural areas, or it could take away population from mid-sized towns. This danger could be avoided by concentrating rather on Universal Design principles, and on-demand rural solutions, such as satellite internet. Financing: New and more innovative financing models that appeal to both commercial and non-commercial investors are available. With the dropping prices of ICT equipment, some countries have dedicated a part of their financial resources for the development and upgrade of ICT infrastructure. Moreover, there is a lot of capacity building and interesting project opportunities to explore in this area, e.g. off-grid electrification schemes, internet pilots, ICT strategy development and implementation, OTTs, community networks, and internet exchange points.

9.1. Cybersecurity Concerns

The rapid proliferation of digital operations and improvements is transforming how people reside and work. Activities undertaken digitally have a variety of implications. Data sharing, financial management, commerce, and remote work possibilities are abundant. Critical communication requirements are also being met. Evolving Internet usage is now a growing target for immoral purposes such as deliberate criminal exercise, unauthorized espionage, and active hostility. Digital connectivity is no different from any other form of linkage. Secure interconnectivity is a critical enabler. Since connectivity is an active requirement for keeping an economy running well, communications should be secured by using cybersecurity to avoid and repel negligence or deliberate harm.

Today's interconnected networks, mobility, and big data in Africa are both natural habitats for cryptomalia, which typically includes phishing, viruses, denial of service, disconnection, and impersonation. Users who misunderstand fundamental technological protections fall prey to cryptomalware. Cryptomalware introduces more accessibility, increases congestion, and offers operators control. Any legal attention is highly valued by workers. A distributed denial of service automatically triggers a complete network outage. Central and commercial assets, particularly in Africa, may be hijacked and held for ransom until a ransom is secured. Since 2007, recorded security violation reports in Africa rose by 44%. There has been a direct impact on the network, its principle, and its responsive citizens. Up to 85% of African citizens feel insecure using the internet appropriately according to recorded weights. The locations of African cyber

offences, victims, and itself are also subjects to an expanding list of problems for Good Governance, Security, Privacy, and Confidentiality. Policymakers appear to be satisfied with computer, data control, and protection laws, which lead to periodic updates of legislation.

9.2. Innovative Financing Models

The DigI project's major emphasis is placed on innovative financing for sustainable connectivity initiatives in Africa. At present, approximately 2.5 billion people are still without access to basic internet services through conventional mobile broadband technologies. This is because mobile network operators (MNOs) do not consider investment in broadband infrastructure in population-scarce areas cost-justified. In the discussion of possible funding opportunities, the African society-based approaches to sustainable digital inclusion in general and those focusing on inter alia digital literacy, infrastructure rollout, and accessibility are among the most topical. The partnerships which promote business information-efficiency inclusive models and solutions that improve the socio-economic impact of universal digital service provision and usage are also being considered as potential financing mechanisms for easily accessible and highly active POPs.

African-based ICT4D and universal service fund (USF) alternatives, such as peer-to-peer community aggregation using innovative technology, search to reduce infrastructure expenditure per user, via access to other "free" or "highly subsidized" local government-created or partially "public" resources such as rights of way, energy, equipment, etc. The term "public infrastructure" was initially used to describe infrastructures such as roads, education, lighting, energy, and telecommunications, many of which are viewed as "public" due to their externally evaluated societal impact rather than their ownership status. More than just the social impact value of incorporating all dis/ability, indigenous, and especially African people into digital society for equity purposes, the access social upliftment society focus can facilitate private sector investment. Financing models in an African DTC.

10. Conclusion and Future Directions

6. Conclusion The realization that there is a digital 'have' and 'have-nots' has been long recognized, with the concept of the 'digital divide' shifting over time to the 'broadband gap' and now 'connectivity' gap. Our study confirms that there is a

persistent digital divide in access and adoption. In this chapter, we merge three data sources and use shared frequencies of administrative units and network proxies for network presence to map the digital divide. The results confirm that a marked digital divide persists in Africa. Digital access and adoption are in part driven by economic welfare, levels of education, gender, urbanicity, and administrative hierarchies, but about a quarter of digital difference is rooted in geographical specificity through varying attributes in terrestrial topology and availability. This is not only a matter of privacy and freedom of expression, but deeply consequential in overall development measured by life satisfaction. Solutions to digital inequality must be multidimensional, addressing social demographics and improving the technological environment.

6.1. Future Directions Fighting the digital divide, this essay suggests, should form part of, and not be viewed in isolation from broader funding projects. African states need to attract the right investments into the development of internet infrastructure. Whereas there is a need to create a supportive policy and institutional framework, and create incentives for out-of-pocket tech-vending to vulnerable poorer regions, governments also need to commission, in both urban and rural settings, the development of community venues and e-centres, as practically demonstrated in a number of local initiatives in the North Western Region of Cameroon. Our review of documents and internet sites of a few of these e-development projects or LICS does indeed indicate that they mainly target or benefit rural or, to a lesser extent, hard-to-reach urban poor communities. While this recommendation recognizes that ownership and stake in e-development projects and related processes and decision-making matter, feasible financing mechanisms (one that with time will promote sustainability) should be sought. What apparently appears to be subsidized services or pricing in e-commercial and social advantage, injection of public monies, struggling with capacity through training and retraining policies in addition to massive e-education, use of ICT or admission to ICT and partnering for the provision of e-tutorial and offshore learning materials could likely help de-emphasize or cancel out any differences in digital adoption. Overall, we maintain that it is not only the ability or affordability to have a computer that matters, much depends on reaping the value of accessibility ICTs provide.