Digital Policy Hub — Working Paper

Assessing Satellite Internet Potential in Rural Kenya

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About the Hub

The Digital Policy Hub at CIGI is a collaborative space for emerging scholars and innovative thinkers from the social, natural and applied sciences. It provides opportunities for undergraduate and graduate students and post-doctoral and visiting fellows to share and develop research on the rapid evolution and governance of transformative technologies. The Hub is founded on transdisciplinary approaches that seek to increase understanding of the socio-economic and technological impacts of digitalization and improve the quality and relevance of related research. Core research areas include data, economy and society; artificial intelligence; outer space; digitalization, security and democracy; and the environment and natural resources.

The Digital Policy Hub working papers are the product of research related to the Hub's identified themes prepared by participants during their fellowship.

Partners

Thank you to Mitacs for its partnership and support of Digital Policy Hub fellows through the Accelerate program. We would also like to acknowledge the many universities, governments and private sector partners for their involvement allowing CIGI to offer this holistic research environment.

About CIGI

The Centre for International Governance Innovation (CIGI) is an independent, non-partisan think tank whose peer-reviewed research and trusted analysis influence policy makers to innovate. Our global network of multidisciplinary researchers and strategic partnerships provide policy solutions for the digital era with one goal: to improve people's lives everywhere. Headquartered in Waterloo, Canada, CIGI has received support from the Government of Canada, the Government of Ontario and founder Jim Balsillie.

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Key Points

- The use of affordable low-Earth orbit (LEO) satellites has the potential to support the United Nations' Sustainable Development Goal Target 9c (global access to affordable internet by 2020) by expanding information and communication technology (ICT) access in developing nations such as Kenya, thereby potentially reducing the digital divide. Research is crucial for informing policies related to the adoption of innovative technologies and the expansion of internet access in rural areas.

- This working paper explores the intricate factors affecting the adoption and diffusion of satellite internet technologies in Sub-Saharan Africa (SSA), specifically in Kenya. With a digital divide focus, this paper seeks to understand why rural Kenyans, who constitute 75 per cent of the population, prefer older, less cost-effective broadband technologies over newer, more affordable satellite internet options. The need for implementing low-cost satellite internet in Kenya is assessed.

- Digital technology is a pivotal instrument for SSA's advancement. Despite this technology's expansion in Kenya, the country is still deficient in coherent initiatives, unequivocal policy frameworks and robust technological governance essential for sustaining development.

- The Fourth Industrial Revolution is driving the need for high-capacity wireless ICT services globally, with satellite internet offering a cost-effective solution, particularly in developing nations' rural areas. Kenya needs robust policy frameworks to support and maintain the technologies of the Fourth Industrial Revolution.

- Impeded by limited ICT infrastructure, nascent policy mechanisms and affordable access to sufficient electricity, the diffusion and adoption of low-cost satellite internet in Kenya remains limited, constraining its population's access to economical, advanced technological innovation, which is critical to the country's economic and social development.

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Outline of the Issue

Affordable satellite internet is crucial for digital inclusivity and socio-economic growth in Kenya's burgeoning digital economy during the Fourth Industrial Revolution (Ponge 2016). Research is vital for SSA's transformation, particularly cross-continental scholarly collaborations to address local needs and promote global digital unity (Hedt-Gauthier et al. 2019). The success of mobile health initiatives in the region highlights the impact of such technology-centric research (Reddy et al. 2021). Amon Nsengimana et al. (2023) demonstrate that smartphone consultations save time and money, reduce facility burden and improve health-care access in Rwanda.

To diminish the digital gaps in economically challenged Kenyan and SSA communities, it is crucial to investigate accessible internet options (Sambuli 2016). Low-cost satellite internet is pivotal for fostering digital inclusivity and socio-economic growth in Kenya, with the capacity to narrow gender and rural-urban disparities by integrating remote populations into the digital economy (Ponge 2016; Duque et al. 2005; M. A. Graydon and Parks 2020). Challenges such as infrastructure and net neutrality must be addressed (Sambuli 2016), as well as the role of government and the private sector in extending satellite internet services (E. Graydon 2020). Unequal access rates

and inadequate power infrastructure are just two obstacles to universal internet access with which SSA has to contend (Houngbonon and Le Quentrec 2020).

Amid the Fourth Industrial Revolution unfolding globally, SSA nations, such as Kenya, need robust policies to lead technological innovation, including embracing artificial intelligence, automation and the Internet of Things (Schwab 2016, 2017; Schwab and Davis 2018). The country's, as well as the wider region's, preparedness for these digital, physical and biological technologies is of crucial importance. Prioritizing education and research through affordable internet access is essential for Africa to benefit from the Fourth Industrial Revolution (Naudé 2017).

Research into affordable satellite internet is key to bridging the digital divide in Kenya, where most people live in rural areas (Kenya National Bureau of Statistics 2019; Wamuyu 2017). Enhancing ICT access for communities could transform health care via telemedicine (Moahi 1999) and improve information access, as shown by increased rates of vaccination for cervical cancer (World Health Organization 2016). Continued development of cost-effective internet is crucial for Kenya's social and health progress (Getachew et al. 2023).

Introduction

LEO satellites, positioned 160 to 2,000 km above the Earth, offer a cost-effective, high-speed internet solution by providing wide coverage and low latency or transmission delay. This is ideal for areas with limited infrastructure, such as rural Kenya, in that its adoption could potentially bypass expensive broadband set-ups (Handley 2018). The proximity of these satellites to Earth ensures reduced latency and diminished costs for both satellite production and deployment (Radu, Nanni and Shahin 2024), enabling pervasive internet access (Federal Communications Commission 2020).

An estimated four billion people worldwide still lack reliable access to the internet, with the majority of this number concentrated in developing countries. Without a significant expansion of the satellite internet industry, bringing with it a grand vision of social and economic growth through connectivity, this internet technology could fail to reach the communities that need it most, as Matthew A. Graydon and Lisa Parks (2020) argue.

This working paper contends that merely expanding ICT usage in the developing world without fostering local production perpetuates technological dependency; a balanced e-strategy that integrates both production and utilization is essential. In this regard, South-South cooperation holds promise, particularly the proposed establishment of an e-South Framework Agreement that aims to promote digital innovation in developing regions through resource efficiency, economies of scale and risk reducing and benefit sharing (Malatji 2024).

This paper delves into the paradox of the digital technology landscape in Kenya and SSA, examining the region's technological dependency due to the widespread and persistent preference for traditional broadband internet over cost-efficient satellite internet, and illuminating the critical aspects of the Kenyan rural-urban digital divide. It goes beyond exploring Kenya's digital transformation trajectory in the Fourth Industrial Revolution and attempts to assess how economic, organizational, political, social and cultural factors interact to influence technology adoption and policy outcomes using a robust analytical framework developed by Bitange Ndemo and Tim Weiss (2017). There are strategies that could assist developing countries such as Kenya in investing

and implementing cost-effective satellite internet technology, and this paper argues that this technology has the potential to bridge the digital divide across genders, socio-economic groups and geographic populations (rural and urban), bringing social and economic growth through connectivity as well as expanding access to education, finance, e-government services, health care, agriculture, tourism and trade in Kenyan rural communities.

Analytical Framework Used in This Study

SSA's digital transformation is intricate, requiring not just high adoption rates for digital technology, but also supportive economic, organizational, political, social and cultural ecosystems (Mokgohloa et al. 2022). Cultural heritage in particular has a profound impact on how technology is assimilated and utilized across the continent (Jacobs et al. 2008). The failure to address these multi-factor challenges and the failure of exisiting policies to prioritize technological innovation are two reasons why ICT development challenges persist in SSA (Ndemo and Weiss 2017).

The research methodology used in this study is a five-lenses analytical framework proposed by scholars Ndemo and Weiss (2017), who assess how economic, organizational, political, social and cultural factors interact to influence technology adoption and policy outcomes. This framework applies a multi-faceted approach toward understanding digital technology adoption rates in SSA.

Economically, Ndemo and Weiss's framework probes how digital technology fosters market opportunities and productivity; organizationally, it examines institutional and business adaptations to maximize digital benefits; politically, it considers the impact of regulations on digital technology's spread and equitable distribution; socially, it focuses on how digital tools reshape norms and behaviours, with an aim to bridge rather than widen divides; and culturally, it explores the importance of respecting and integrating local customs, enhancing rather than disrupting traditional practices, in order to ensure digital adoption (Ndemo and Weiss 2017; Rossini et al. 2021). This framework also explores the innovation environments that support digital technology growth, including the role of education in creating a skilled workforce, the availability of investment for technology start-ups and the need for a nurturing entrepreneurial ecosystem. By adopting this five-lenses framework, this paper aims to generate insight into the dynamics of digital technology in Kenya, informing strategies toward a digitally inclusive development pathway in the future.

Kenya's digital transformation, like that of the rest of SSA, has been a subject of increasing interest due to its potential impact on various sectors, including health care, the economy and the social and political participation of citizens. However, given the complex and multi-faceted nature of this transformation, a comprehensive analysis must acknowledge the broad array of factors influencing and being influenced by digital technology. Therefore, Ndemo and Weiss's analytical framework is a critical tool used in this paper to achieve a holistic evaluation by incorporating economic, organizational, political, social and cultural perspectives. Ndemo and Weiss also emphasize that digital technology alone does not guarantee development opportunities; they advocate for systemic transformation as the key driver of progress, pointing out the collaborative influence of context, including both institutional and human actors, on outcomes.

Obstacles to Kenya's Adoption of Innovative Digital Technology

Since the 1970s, technology has been recognized as vital for SSA's growth; however, effective policies and management to harness the Fourth Industrial Revolution have been lacking (Vitta 1990). SSA requires targeted research to meet its unique technological and socio-economic challenges within the Fourth Industrial Revolution framework, particularly the need for policy support for emerging technologies (Mamphiswana and Bekele 2020; Ogbaji and Wapmuk 2022). Open governance and collaborative efforts are essential for service delivery innovations (Maina and Otieno 2024), while African universities must also prepare individuals for this era of new technology by addressing both incipient career opportunities and the risk of job losses due to automation (Mbithi et al. 2021; Ndagi 2018).

Kenya's digitalization, which began in 2000, has advanced economic development and innovation, though disparities between urban and rural areas persist due to challenges such as high internet costs (Yohanis et al. 2019). Despite ICT advancements across various sectors and digital literacy programs being implemented in schools, remote areas still face significant hurdles; a lack of digital literacy in teacher training and high levels of poverty undermine the capacity to sustain ICT initiatives, in spite of the COVID-19 pandemic further emphasizing ICT's important role in national development (Awuor and Rambim 2022; Abuya, Mochama and Makworo 2020; Lusweti and Odoyo 2022).

Kenya's technological revolution has greatly impacted enterprise, politics and banking, yet the digital divide remains, with rural areas lagging behind in terms of internet access and digital device availability despite initiatives to increase broadband penetration (Bett, Ngala and Kiruhi 2020; Musau 2022; Kipkoech 2022; Townsend et al. 2013; Whitacre and Mills 2007; Ashmore, Farrington and Skerratt 2017; Price, Deville and Ashmore 2021). Kenya's small and medium-sized enterprises in manufacturing confront high costs, funding scarcity and technical skills deficits (N. K. Mwangi, Njiraini and Waweru 2023; Mohamed et al. 2018). Challenges for digital transformation in SSA span economic, market-based and socio-technical factors (Achieng and Malatji 2022; Jaguga and Kwobah 2020). Further, the lack of digital platforms that offer multimodal interfaces and native language support poses barriers (Daramola 2022; Doat, Negarandeh and Hasanpour 2019), while rural dwellers struggle with access issues tied to affordability, distance and time (Ocholla 2007; Masaba and Mmusi-Phetoe 2020).

In Kenya, where expensive bandwidth is severely limiting satellite-based internet penetration, e-learning is failing and poor populations are being made to pay excessively for services (Kibuku, Ochieng and Wausi 2020; Ndung'u, Waema and Mitullah 2012). LEO satellite internet technology offers low-latency, high-speed global internet in SSA. Combined with 5G and 6G networks, it enables emerging technologies such as precision farming and smart cities, crucial for SSA's economic growth (Lalbakhsh et al. 2022). While mobile internet has been successful in low-income urban areas (Wamuyu 2017; Sambuli 2016), satellite initiatives in rural areas have proven to be cost-intensive (Hansson et al. 2007; Abdelsalam et al. 2018).

Kenya's varied and remote geography complicates the logistics of satellite internet infrastructure, with poor road networks and unreliable power supplies hindering installation, maintenance and consistent connectivity. The scarcity of technical expertise for the specialized installation and maintenance of satellite internet

limits support, particularly in rural areas lacking skilled workers. Successful satellite internet adoption in Kenya may necessitate policy and regulatory reforms, including adjustments in licensing, spectrum allocation and integration with existing terrestrial networks (Migiro 2006; Mohamed et al. 2018).

Rural areas in Kenya face significant digital disparities due to inadequate high-speed internet infrastructure, in contrast to the more connected urban regions (Salemink, Strijker and Bosworth 2017). This issue is exacerbated for women, who are disproportionately affected by the gender digital gap, which hinders their access to technology's full array of benefits. Women in developing regions, especially in SSA, face significant digital disparities, with limited access to technology restricting their educational, health and professional opportunities. Inadequate digital literacy among female student teachers and insufficient research on skills development worsen this divide. Moreover, e-health solutions often fail to address women's specific needs, and economic constraints in impoverished communities further reduce access to the internet and digital devices, perpetuating the digital gender gap (Squicciarini 2018; Olukunle 2009; Taner 2018; Antonio and Tuffley 2014). Such inequities are a major concern for digital policy and e-governance, as they obstruct socio-economic progress (Kwakwa 2023; Ponge 2016).

Low-cost satellite internet emerges as a promising solution to bridge this divide, offering an affordable means to expand information and technology access (Ate and Talabi 2012). However, its success hinges on several factors: a comprehensive national broadband strategy, improved digital literacy, reduced taxes and tariffs on satellite services and equipment, and strong public-private collaborations (Oyelaran-Oyeyinka and Lal 2005).

The Impact of the Fourth Industrial Revolution on Kenya and SSA

Kenya and the broader SSA region stand at a pivotal juncture, poised to engage with the transformative potential of the Fourth Industrial Revolution. This era presents unparalleled opportunities for enhancing living standards and promoting sustainable development through job creation and skill development (Kibe, Kwanya and Nyagowa 2023). The Fourth Industrial Revolution has catalyzed efficiencies within business processes, particularly in logistics, heralding a new paradigm in operational optimization (Nagy et al. 2018).

However, the socio-economic distortions and tensions brought about by digitalization and automation necessitate a re-evaluation of career paths, as certain roles become obsolete and new ones emerge (Hirschi 2018). Consequently, the education sector must anticipate and adapt to the evolving technological landscape, equipping the workforce with the requisite skills to perform in these emerging roles (Mudzar and Chew 2022; Ally 2019). In particular, the integration of advanced technologies in agriculture lags in SSA, signalling an urgent need for innovation in this critical sector. It is imperative that states within the region, including Kenya, adopt a strategic and incremental approach to the assimilation of the Fourth Industrial Revolution's technologies in order to navigate this transition effectively.

Kenya's Internet and Mobile Penetration Trajectory

Kenya, a leader in African mobile penetration rates alongside Egypt and Nigeria, exhibits robust internet and mobile usage, with more than 59 million possessing at least one mobile device (8.9 percent of the population possesses multiple devices) and 21.75 million individuals having internet access, including 11 million social media users (Communications Authority of Kenya 2021). The surge in mobile penetration has spurred economic growth and entrepreneurship, further bolstered by the adoption of advanced telecommunications technologies such as 4G and 5G (Nturibi et al. 2023; Aicha 2023; Ministry of ICT, Innovation and Youth Affairs 2022).

In Kenya, satellite internet has advanced the health-care (Ngongo et al. 2019) and banking sectors, as well as aided in the spread of agricultural information (Kiplang'at 1999) and driven mobile banking such as M-PESA (Kharono et al. 2022). Amid the COVID-19 pandemic, satellite broadband has been crucial for enabling remote learning. In 2019, iMlango launched an e-learning platform and delivered ICT equipment to Kilifi and Makueni counties in Kenya, using Avanti's HYLAS 2 satellite. In South Africa's uMzinyathi district, Khula Education, with MorClick and YahClick, provides internet connectivity to schools for USD$49 per school. In Ghana and parts of West Africa, the Joy Learning channel offers free educational content via the MultiTV platform, supported by SES's Astra-2F satellite. Additionally, MultiChoice Africa provided free Udemy online courses to DSTv customers until July 2020 (Njeri 2021).

Yet Kenya's adoption of satellite internet technology in agriculture lags, with minimal user engagement (Maumbe and Okello 2010), despite the promise that ICT represents for small-scale farmer marketing (Moyi 2019). Kenya's strides in digital connectivity make it a technological vanguard in Africa, with profound implications for its economy and essential services.

Digital technology diffusion is key to transforming societies and industries, yet Kenya and SSA face hurdles in embracing these changes. Resistance to new technology such as satellite internet due to a reliance on traditional broadband impedes e-governance, especially in low-connectivity rural areas (Mugeni, Wanyembi and Wafula 2012). Broadband adoption is further stymied by personal factors such as users' lack of confidence in and knowledge of this new satellite technology (Mbarika 2002). The slow uptake is the result of customer resistance, organizational uncertainties and complex social systems, impacting firms' growth and their competitive edge (Talwar et al. 2020; Shibeika and Harty 2015; Mugo and Macharia 2020).

Opportunities for Satellite Internet Adoption in Kenya Vis-à-Vis Competition

Satellite internet providers in Kenya face a formidable competitor in existing broadband providers, who represent an entrenched alternative with their established infrastructure and market presence (Ndemo 2020). However, the high costs and limited coverage of broadband might make low-cost satellite internet a more attractive option for underserved areas — if regulatory and infrastructure challenges can be overcome (Mutula and van Brakel 2006).

The competition between established broadband providers and emerging satellite internet services in Kenya has two sides. Bitange Ndemo (2020) illuminates the significant competition posed by traditional broadband companies due to existing infrastructure and presence in the market. Conversely, Stephen Mutula and

Pieter van Brakel (2006) demonstrate that the prohibitive costs and geographic limitations inherent to broadband could tilt the scales in favour of cost-efficient satellite internet in regions that are currently underserved, contingent upon overcoming regulatory and infrastructural hurdles. Gloria Iyawa et al. (2020) emphasize the transformative influence of digitalization on health care across the African continent, suggesting that affordable satellite internet could surmount extant barriers of accessibility and extend connectivity to marginalized locales.

The invention of mobile money platforms such as M-PESA in Kenya has fuelled the rise of similar inventions across Africa, leading to improved living conditions for micro-entrepreneurs (Asamoah, Takieddine and Amedofu 2019), reduced transaction costs and increased efficient financial transfers (Alhassan and Koaudio 2019). M-PESA's 70 percent market penetration in Kenya has fostered a robust ecosystem for financial services, inspiring new business models and start-ups. This integration of mobile money with financial institutions creates opportunities for satellite internet providers to offer digital financial services to a wider audience (Kendall et al. 2011; Natile 2016). This scenario creates a significant niche market for satellite internet service providers, since mitigation of the barriers to broadband internet infrastructure deployment remains unattainable.

North-South or South-South Digital Cooperation?

Globalization has accentuated the innovation divide between the Global South and high-income countries, with emerging economies seeking to enhance their innovation through global knowledge and resource flows, particularly in the digital realm. By fostering digital collaboration, technology transfer, such as solar-powered satellite internet, could accelerate from North to South, aiding SSA to tap into its abundant renewable energy resources (Aubert 2005; Williams and Woodson 2012; Kisubi et al. 2010).

Comparative Cost Analysis

Satellite internet is increasingly being considered as a more cost-effective option than fixed broadband in Kenya's rural areas, offering similar operating speeds at a fraction of the cost. This is particularly significant in cases where mobile data and satellite services are the only alternatives available due to the lack of fixed broadband infrastructure. For instance, the introduction of the American company Starlink has significantly expanded the satellite internet user base in Kenya, demonstrating its growing affordability and accessibility (Organisation for Economic Cooperation and Development 2017; Mutisi 2024). Starlink's new 50-gigabyte monthly data plan at US$10.16 in Kenya undercuts Airtel's US$23.44 plan and Safaricom's 45-gigabyte plan at US$19.53, increasing competition in the market (K. Mwangi 2024).

The development of satellite technology aims to improve connectivity and affordability in remote areas globally, playing a critical role in narrowing digital divides and improving regional economies in countries such as Kenya. Satellite technology enhances connectivity and affordability in remote areas globally, crucially narrowing digital divides and boosting regional economies, especially in countries such as Kenya. In rural regions with challenging terrains, satellite is the only viable solution, where high costs and long installation times hinder terrestrial connectivity. Increased

connectivity supports economic growth, with mobile money usage rising, allowing more Africans access to financial services and ecommerce (J.-P. Nsengimana 2022).

Recommendations

- **Policy and regulatory redesign:** Kenya must regenerate policies to lower barriers for satellite internet providers, by including simplified licensing, fair-spectrum allocation and seamless integration with existing terrestrial networks to enhance rural connectivity.

- **Digital literacy and education:** Launch nationwide campaigns for digital literacy and integrate digital skills into educational courses, to prepare the working population for both the challenges and the opportunities of the Fourth Industrial Revolution across the country to ensure uniform rural-urban development.

- **Infrastructure development incentives:** Offer tax credits and grants for satellite internet infrastructure build-out in rural Kenya, to ease the financial load for carriers and promote wider deployment of high-speed internet in underserved areas.

- **Public-private partnerships:** Encourage partnerships between the public and private sectors to take advantage of technological know-how, resources and inventive potential. Such alliances will support the dissemination of satellite internet services and the management of technical encounters and pragmatic concerns in off-track neighbourhoods.

- **Support focused on vulnerable groups:** Implement specific programs to tackle the digital gender divide, so that women and other marginalized communities have equal access to technology and training, a precondition of fair socio-economic development.

Conclusion

Satellite internet promises to mitigate Kenya's digital divide, fostering socio-economic parity and opportunity. Policy making is central to achieving equitable connectivity and addressing gender and regional digital inequities. The efforts of projects such as Starlink, which is aiming for comprehensive coverage by 2030, align with the UN's objective for African digital inclusivity. However, understanding the governance impact of the Fourth Industrial Revolution's technologies in Kenya and SSA necessitates further research to inform effective policy development.

Acknowledgements

About the Author

Frederick (Fred) Okello is a master's graduate from the Balsillie School of International Affairs and a former Digital Policy Hub fellow. At the Digital Policy Hub, his research focused on technology for development (T4D) as a tool for reducing poverty, and digital and energy inequality in Sub-Saharan Africa. His research assesses T4D as a platform for the region's digital innovation, investment and policy development, and aims to identify digital technology innovations and policies that can improve private investor regulation, market competitiveness, and the provision of financial assistance to disadvantaged customers in Sub-Saharan Africa's digital economy.

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