

Assessment of last-mile connectivity interventions in Uganda



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Acknowledgements

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The research was undertaken by ITU Expert Alex Nkuyahaga under the framework of the project and its deliverables. Technical input, feedback and guidance have been provided by ITU and the Ministry of ICT and National Guidance project team members and experts in government ministries, agencies, institutions, and across Uganda's digital ecosystem.

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Foreword



It is with great pleasure that I present the **Assessment of last-mile connectivity interventions in Uganda**, a report that marks a significant step forward in Uganda's ongoing efforts to bridge the digital divide and ensure that no Ugandan is left behind in the digital era. This assignment, conducted under the Technical Assistance and Training to Uganda on National ICT Development Strategy project, is both timely and crucial as we strive to achieve our vision of a digitally enabled society that contributes to sustainable economic growth and national development.

As we continue our journey toward Digital Uganda, the Government of Uganda has placed ICT at the heart of its development agenda. With the adoption of the Digital Transformation Roadmap and the strategic objectives outlined in the Third National Development Plan (NDP III), we are determined to harness the full potential of technology in transforming key sectors such as education, health, agriculture, and governance. Our ultimate goal is to ensure that all Ugandans, regardless of their location, have access to the benefits of digital services, fostering inclusivity and opening new opportunities for economic participation.

Last-mile connectivity is a critical element of this vision. While Uganda has made great strides in expanding its ICT infrastructure, many rural and remote areas still face significant barriers in accessing reliable and affordable internet. This report provides a thorough evaluation of our ongoing efforts to expand connectivity in these underserved regions, highlighting both the successes and the challenges we face in achieving true inclusivity.

I recognize the critical role that ICT infrastructure plays in the broader development agenda. Expanding broadband access is not only a technological challenge but also a political priority. Our commitment to affordable, accessible, and reliable internet for all Ugandans remains unwavering. The findings of this report will play a key role in shaping our policies, informing future investments, and strengthening the regulatory environment to support the growth of the ICT sector.

I would like to take this opportunity to express my gratitude to the International Telecommunication Union (ITU), the Global Development and South-South Cooperation Fund (GDSSCF), and all other partners for their continued support and collaboration in this important endeavor. This study would not have been possible without their valuable expertise and commitment to Uganda's ICT development.

In conclusion, this report is a critical tool for guiding Uganda's digital transformation. It provides a clear roadmap for addressing the challenges of last-mile connectivity and ensuring that all Ugandans are able to fully participate in the digital economy. Together, we will continue to build a digitally inclusive Uganda, one that empowers every citizen to access the opportunities of the future.

A handwritten signature in black ink, appearing to read 'Baryomunsi', with a long, sweeping flourish extending upwards and to the right.

Hon. Dr. Chris Baryomunsi
Minister of ICT and National Guidance

Foreword



It is my pleasure to present this report under the project 'Technical Assistance and Training to Uganda on National ICT Development Strategy', a collaboration between the Government of Uganda and the International Telecommunication Union, supported by the Global Development and South-South Cooperation Fund and ITU's ICT Development Fund.

Through carefully co-crafted interventions in support of the country's vision to transform Uganda into a digitally enabled society that is innovative, productive and competitive, the project has applied a three-pronged approach focusing on the development of policy recommendations, enabling capacity development, and the implementation of pilot projects.

In recent years, Uganda has witnessed tremendous growth in its digital economy, reflecting broader trends across the Africa region and globally. The increased access to digital technologies, new opportunities that connectivity has brought, and the surge in digital services are fueling rapid advancements on how citizens engage with one another and with vital government services. These developments also bring new challenges, requiring policy-makers and regulators to rethink strategically and build enabling policy and regulatory frameworks that are future-ready and adaptable to this ever-changing landscape. Moreover, digital skills remain essential for citizens to meaningfully participate in the digital space and for professionals to fully leverage the potential of digital technologies in addressing socio-economic challenges. This has been a critical aspect of the implementation of the policy interventions within this project.

Co-created and initiated in support of Uganda's ambitious digital transformation journey, this project stands as an example of how focused and meaningful partnerships can lead to impactful change. We have witnessed the results of the policy interventions and the impact of the significant capacity development in the country. I believe the efforts will continue to impact Uganda's transformation for years to come.

I encourage ITU Member States across Africa and globally as well as development partners to join forces and invest in digital transformation for social and economic growth. The Telecommunication Development Bureau stands ready to continue supporting countries on their digital transformation journeys with impactful project implementation and partnerships that are essential for achieving universal and meaningful connectivity and digital transformation for all.

A handwritten signature in black ink, appearing to read 'Dr. Cosmas Luckyson Zavazava'.

Dr Cosmas Luckyson Zavazava
Director of the Telecommunication Development Bureau
International Telecommunication Union

Foreword



On behalf of the Ministry of ICT and National Guidance, I take this opportunity to express our profound gratitude to all those who played a pivotal role in the successful completion of this report, **Assessment of last-mile connectivity interventions in Uganda**. This work is a significant milestone in our collective effort to bridge the digital divide and ensure equitable access to ICT services for all Ugandans.

The findings of this assessment underscore the importance of innovative and sustainable solutions to address the connectivity gaps in Uganda. From community-driven models like Research and Education Network for Uganda (RENU), BOSCO Uganda, and the Rural Connectivity Broadband Network (RCBN), we see that locally tailored solutions can have a transformative impact. These models not only provide essential services but also empower communities to take ownership of their digital infrastructure. The insights gained from this study will be instrumental in guiding the government's next steps to replicate and scale these successful initiatives across the country.

Special thanks go to the International Telecommunication Union (ITU) and the Global Development and South-South Cooperation Fund (GDSSCF), for their unwavering support and commitment to Uganda's digital transformation journey. Your partnership has not only enriched this assignment with global expertise but also underscored the importance of collaboration in achieving our shared vision.

I must also highlight the invaluable contributions of the Ministry's technical officers Eng. Geoffrey Agoi, Irene Karungi Sekitoleko, Doreen Gift Bujjingo, Peter Ogule, and Timothy Wamale, who dedicated their time, expertise, and unwavering commitment to this assignment. Your guidance, attention to detail, and provision of accurate and timely information were instrumental in ensuring that this report reflects the realities and aspirations of Uganda's ICT sector.

I also extend my heartfelt appreciation to the team of experts and key stakeholders including our agencies who devoted their time, knowledge, and resources to make this report a reality. Your efforts in conducting thorough assessments, gathering insightful data, and developing practical recommendations have given us a solid foundation for actionable interventions.

This report is not just a technical document, it is a tool that will guide the Ministry and its partners as we implement targeted solutions to improve last-mile connectivity. It speaks to the heart of Uganda's development agenda by supporting sectors like education, health, agriculture, and governance. The recommendations within will play a key role in unlocking the potential of ICT to transform lives, create jobs, and drive sustainable economic growth.

Lastly, I acknowledge the leadership and vision of Hon. Dr. Chris Baryomunsi, the Minister of ICT and National Guidance, whose dedication to Uganda's digital future continues to inspire us all. Together, let us commit to ensuring that the insights from this report are fully implemented, so that no Ugandan is left behind in this digital era.



Dr. Amina Zawedde (PhD)
Permanent Secretary
Ministry of ICT and National Guidance
Government of Uganda

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Abbreviations

APC	Association for Progressive Communications
APN	access point name
BOSCO	Battery Operated Systems for Community Outreach
DAP	Digital Ambassadors Program
ERA	Electricity Regulatory Authority
GEO	geosynchronous equatorial orbit
GSMA	Global System for Mobile Communications Association
ICT	information and communication technology
IEEE	Institute of Electrical and Electronics Engineers
ISM	industrial, scientific and medical
ISP	Internet service provider
ITU	International Telecommunication Union
LEO	low-Earth orbit
LRA	Lord's Resistance Army
LTE	long-term evolution
MEO	medium-Earth orbit
MNO	mobile network operator
MTN	Mobile Telecommunications Network
NaaS	network as a service
NBI	national backbone infrastructure
NDP III	Third National Development Plan
NGO	non-governmental organization
NITA-U	National Information Technology Authority Uganda
NSA	non-State actor
PoP	point of presence
PPP	public-private partnership
RCBN	Rural Broadband Connectivity Model
RCDF	Rural Communications Development Fund

(continued)

RENU	Research and Education Network for Uganda
SWOT	strengths, weaknesses, opportunities and threats
TowerCo	tower company
TVWS	TV white space
UCC	Uganda Communications Commission
UCUSAF	Uganda Communications Universal Service and Access Fund
UNCDF	United Nations Capital Development Fund
UNICEF	United Nations Children’s Fund
UTCL	Uganda Telecommunications Corporation Limited
VAT	value-added tax
VSAT	very small aperture terminal
Wi-Fi	Wireless Fidelity
WUGNET	Women of Uganda Network

Executive summary

This study on the assessment of last-mile connectivity interventions in Uganda's information and communication technology (ICT) sector provides a comprehensive evaluation of the current state of connectivity projects, examines their ecosystems and proposes sustainable strategies for improvement. Ensuring inclusive connectivity is vital for bridging the digital divide and fostering equitable access to digital resources, which is crucial for Uganda's socio-economic development.

Uganda has established a strong foundation for digital transformation, supported by an enabling regulatory framework, successful public-private partnerships (PPPs) and the emergence of innovative community network models. The country's Digital Transformation Roadmap, which is part of Uganda Vision 2040, is designed to strengthen the fundamentals of the economy by leveraging opportunities within the ICT sector. The Third National Development Plan (NDP III) also prioritizes ICT as a critical sector capable of enhancing livelihoods, generating employment and boosting economic output, for both export and import substitution.

Despite these advances, Uganda's position on global indices reveals areas needing significant improvement. The Global ICT Development Index rates Uganda below the African average in nationwide telephone penetration, while the Global Connectivity Index ranks the country at 77 out of 79 profiled nations. Although Internet penetration stands at an average of 43 per cent, limited infrastructure in many regions remains a barrier. However, the steady growth in registered Internet users, now exceeding 20 million, indicates that Internet usage is on the rise. The National Broadband Policy of 2018 further underscores the role of broadband in socio-economic transformation, emphasizing the need for infrastructure development to achieve affordability, digital inclusion and connectivity for all Ugandans.

The study employed a mixed-methods approach, integrating qualitative and quantitative data collection with extensive desk reviews, stakeholder engagements and field assessments. This comprehensive approach provided a thorough understanding of the various last-mile connectivity projects and their ecosystems across Uganda. The analysis identified key stakeholders and implementers involved in last-mile connectivity, examining the diverse models and approaches used in these projects. The study assessed the usage, challenges, successes, sustainability and gaps within these projects, providing a detailed understanding of Uganda's connectivity landscape.

Successful community network models – such as the Research and Education Network for Uganda (RENU), the Battery Operated Systems for Community Outreach (BOSCO) Uganda and the Rural Communications Broadband Network (RCBN) – have emerged as good examples of how community-driven initiatives can bridge the digital divide. RENU focuses on collaboration among research and education institutions, ensuring reliable Internet access and high-quality network services. BOSCO Uganda, particularly noteworthy for its work in Northern Uganda, has used innovative wireless technology and deep community engagement to provide critical communication infrastructure during and after times of conflict. Its initiatives, such as the bamboo tower project, have empowered local communities to independently manage and sustain ICT centres, creating self-sustaining ecosystems within underserved areas. The RCBN

model emphasizes community involvement, tailoring network designs to meet specific local needs, which has proven effective in expanding connectivity to marginalized regions.

Despite these successes, significant disparities persist between urban and rural areas. Urban centres generally have access to high-speed Internet, while many remote villages lack even basic connectivity infrastructure, hindering economic growth and social development. The study highlighted the need for innovative solutions to bridge this digital divide, including leveraging alternative technologies such as satellite Internet and TV white space (TVWS) to overcome geographical barriers and extend services to hard-to-reach areas.

Investment in last-mile connectivity remains a critical challenge, particularly in economically unviable regions such as north-eastern, south-western and parts of northern Uganda. These areas face high poverty rates, low population density and rugged terrain, making traditional infrastructure investments costly and financially unsustainable. Operators are hesitant to invest in these regions due to the low revenue potential and high operational costs, further exacerbating the urban-rural divide. The identification of these economically unviable regions is crucial for prioritizing resources and tailoring interventions that address specific challenges.

1 Introduction

1.1 Preamble

The Uganda Ministry of ICT and National Guidance and the International Telecommunication Union (ITU), supported by the South-South Cooperation Assistance Fund, are implementing the “Technical assistance and training to Uganda on National ICT development strategy” project.¹ The objective of the project is to contribute to a strengthened ICT policy and regulatory environment to enable Uganda to continue its transformation into a digitally enabled society that is innovative and competitive and, further to that, support the development of the ICT sector in Uganda, contribute to its economic development and the reduction of poverty, while providing support to poverty alleviation activities in various forms. The project is framed under the Digital Transformation Programme in NDP III. Through its interventions, the project seeks to assist in the development of Internet connectivity, especially in rural areas, and the resiliency of such networks, and boost related opportunities to contribute to sustainable social economic development. The project also seeks to assist the Government of Uganda to review and strengthen the enabling ICT policy and regulatory environment and contribute to making ICT services affordable and accessible for all Ugandans.

The project is being delivered under the following three components, which are mutually reinforcing:

- Component 1 – Policy and strategy recommendations;
- Component 2 – Cross-cutting capacity development;
- Component 3 – Design and implementation of pilot projects and use cases to support the recommendations.

It is under Component 1 that the assessment of the last-mile connectivity interventions in Uganda is being premised.

Uganda’s last-mile connectivity projects hold the key to unlocking the full potential of the nation’s digital transformation. These initiatives directly address the critical gap in Internet access for remote and underserved communities. This report highlights how these projects align with the core objectives of the Digital Uganda Vision, NDP III and the Digital Transformation Roadmap. By extending the reach of the Internet backbone, last-mile connectivity directly supports the “Digital Infrastructure and Connectivity” pillar of the Digital Uganda Vision, fostering development across all sectors. These projects further resonate with the NDP III ambitions, as outlined in the Digital Transformation Programme Implementation Action Plan.

The Digital Transformation Roadmap (2023) identifies expanding broadband access as a critical element. Last-mile connectivity efforts pave the way for e-services, empower digital participation across various sectors, and lay the groundwork for future technologies envisioned in the roadmap, such as artificial intelligence and the Internet of Things.

The most suitable technology for a particular project will depend on factors such as cost and terrain, with optical fibre, wireless solutions and even satellites all being potential options.

¹ Available at www.itu.int/en/ITU-D/Regional-Presence/Africa/Pages/projects/2023/uganda-digital-transformation.aspx.

1.2 Background

Uganda has made significant strides in expanding its ICT infrastructure, contributing to the country's socio-economic development. One critical facet of this development is the enhancement of last-mile connectivity, the final leg of the telecommunication networks, which delivers Internet access to end users. By June 2023, Uganda had witnessed a 6 per cent surge in active 90-day mobile Internet subscriptions, reaching 12.5 million, up from 11.8 million at the end of March 2023.² This indicates that mobile Internet is the primary driver, constituting 45 of every 100 Internet connections with a minimum of 90 days of activity. In aggregate terms, this elevates total Internet connections to 27.7 million subscriptions. A notable increase in Internet penetration, these subscriptions result in an Internet national penetration rate of 61 connections for every 100 Ugandans. Despite these advancements, challenges have persisted in ensuring equitable and reliable last-mile connectivity, particularly in rural and remote areas. The existing landscape reflects a blend of achievements and obstacles, showcasing both the potential for transformative impact and the necessity for targeted interventions.

Key achievements

- Expansion of 3G and 4G networks: Urban centres and major towns in Uganda have experienced improved Internet connectivity with the deployment and expansion of 3G and 4G networks by telecommunication providers.
- Increased mobile phone penetration: The widespread adoption of mobile phones has played a crucial role in extending Internet access to a broader segment of the population, enabling a range of services, from mobile banking to information access.
- Government initiatives: The government has undertaken initiatives to enhance last-mile connectivity, recognizing the pivotal role of the Internet in fostering economic growth, education and e-governance.

Challenges

- Rural connectivity gaps: Despite progress in urban areas, rural and remote regions continue to face challenges in accessing reliable and affordable Internet services, limiting opportunities for socio-economic development.
- Infrastructure limitations: Insufficient ICT infrastructure, including inadequate fibre-optic networks and power supply constraints, poses barriers to seamless connectivity expansion, particularly in underserved areas.
- Affordability: This remains a hurdle for many Ugandans, limiting their ability to access and utilize Internet services effectively. While mobile broadband is economically accessible in absolute terms, it may not be financially viable in relative terms. Uganda is positioned as the 12th most cost-effective country, out of 54 countries in Africa, for 300 MB and 1 GB monthly usage. However, expressed in terms of gross national income per capita, Uganda only ranks 27th and 28th respectively. For 20GB monthly usage, 28 countries in Africa had more affordable packages.
- Broadband adoption: This is low despite good broadband coverage and relatively fast download speeds. Various factors point to affordability as one of the main obstacles to wider broadband adoption.

² Uganda Communications Commission (UCC) Market Performance Report 4Q FY 2022/23 (April – June 2023).

The way forward

The ongoing efforts to assess Internet last-mile connectivity in Uganda aim to identify gaps, evaluate the effectiveness of existing interventions, and propose strategies for improvement. The collaborative engagement of stakeholders – including government entities, private sector players and civil society – is crucial in shaping a comprehensive and inclusive approach to address these challenges.

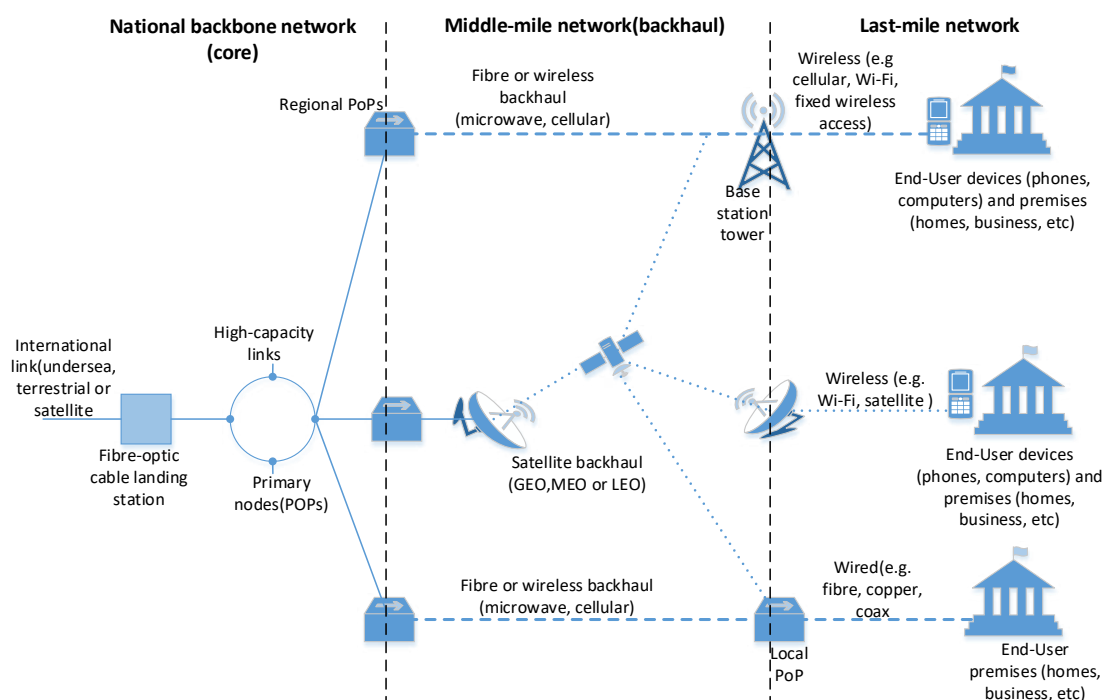
This assessment, therefore, is positioned as a vital step towards fostering a digitally connected Uganda, where every citizen can harness the benefits of the Internet for education, health care, entrepreneurship and overall socio-economic advancement. The outcomes of this assessment will guide future interventions, policies and investments to ensure that last-mile connectivity becomes a catalyst for inclusive development across the nation.

The last mile is one of the components of a typical telecommunication network (Figure 1). The three main components of a telecommunication network are defined as follows:

- Last-mile or access network: This is the part of the network that is accessed and connects end-user devices, typically smartphones, laptops, tablets, computers and other Internet-enabled devices.³
- Middle-mile network or backhaul: This is the distribution network that connects the national backbone to a point in an outer locality/geographic area for broader distribution out to the last-mile network.
- National backbone (or core) network: This connects international Internet traffic (usually through undersea or terrestrial fibre-optic cables) via submarine cable landing stations (or terrestrial gateways for land borders) to the national high-speed, high-capacity backbone network connecting the country's bigger cities and major population centres. A country's core network provides the first layer of overall network redundancy in case there are breaks between core network points of presence (PoPs) and data centres.

³ ITU (2020). The Last-mile Internet Connectivity Solutions Guide: Sustainable Connectivity Options for Unconnected Sites. Geneva. Licence: CC BY-NC-SA 3.0 IGO.

Figure 1: Telecommunication network components supporting last-mile interventions in developing countries



Source: ITU

Notes: It should be noted that Figure 1 is not exhaustive and some segments are interchangeable, particularly in the last mile. In a few country cases, satellite continues to be the main, or only, source of international connectivity.

1.3 Purpose and scope

The intent of this study was to evaluate the most suitable mix of last-mile connectivity technologies, and to explore options on how the Government of Uganda could engage the private sector, community networks and other relevant stakeholders on viable opportunities for collaborations such as investment, deployment, operations or management of digital connectivity infrastructure on the last mile.

The study was also commissioned to contribute towards the Government of Uganda’s efforts through the Uganda Digital Acceleration Project – GovNet and plans on the last-mile connectivity, among others, to expand public Wi-Fi offering, with primary focus on locations where women and other marginalized communities can safely and securely access the Internet and allied digital services, such as public markets, and ensure that ministries, departments and agencies are well connected, so that e-services can be used at the local level by citizens and businesses.⁴

⁴ The World Bank (2020). “Project appraisal document on a proposed credit in the amount of SDR 98.8 million (US\$140 million equivalent)”. Available at <https://documents1.worldbank.org/curated/en/473041622944887337/pdf/Uganda-Digital-Acceleration-Project.pdf>

1.4 Assignment deliverables

The following were the key deliverables of the assignment:

- Inception report:
 - Research, information-gathering and data collection;
 - Desk review and sampled field project assessments to understand last-mile connectivity projects and their ecosystems;
- Qualitative/quantitative data collection tools and database of collected data;
- A comprehensive analysis of last-mile connectivity ecosystem and projects in Uganda (implementers and stakeholders, models/approaches, usage, challenges/success, sustainability, gaps, etc.);
- A comprehensive report of the framework and alternative approaches to sustainability (including recommendations, strategies for sustainability and project ideas for remote connectivity using alternative technologies);
- Datasets of economically unviable areas in Uganda;
- A report on investment opportunities for last-mile connectivity;
- A framework for non-State actors (NSAs) to collaborate with stakeholders;
- Recommendations for the collaboration of NSAs with the government;
- Final report, presentation slides and policy brief.

1.5 Methodology

A participatory, consultative and evidence-based approach was used to conduct the study, as detailed below.

a. Desk review

A comprehensive desk-based review of relevant documents was carried out. The documents reviewed included the ITU Last Mile Connectivity Toolkit and related reference material on last-mile connectivity projects and enabling regulation; and material specific to the Ugandan context, such as the National Broadband Survey and ICT Infrastructure Blueprint, National Broadband Policy (2018), the existing literature on legal and regulatory framework for ICTs in Uganda, and regional and international best practices on last-mile connectivity interventions. The desk review enabled understanding of the current situation, identification of gaps and challenges, and understanding of global standards and of practices from other countries.

b. Stakeholder consultation and field visits

Key stakeholders involved within the digital infrastructure ecosystem of Uganda – specifically the critical players in last-mile connectivity both private and public, community networks, industry associations, academia and research institutions, among others – were identified and engaged. The stakeholder consultation was done through key informant interviews and by way of a survey. The stakeholder consultations and field visits helped identify and map Ugandan stakeholders that were supporting or were needed to support NSAs in their last-mile projects to ensure sustainability. The stakeholder consultation also helped gather diverse perspectives, opinions, experiences, expectations, needs and suggestions from different actors in the digital

infrastructure ecosystem. Tools applied in stakeholder engagement followed best practices set out by ITU.

As part of a joint stakeholder engagement effort, field visits were also conducted. These visits were pivotal in allowing stakeholders to physically assess a selected last-mile connectivity project, engage directly with stakeholders, and carry out guided interviews. The on-site evaluation provided valuable insights into the existing infrastructure, community involvement and technology used, enabling a more comprehensive understanding of the project impact and challenges. The direct interaction with the stakeholders facilitated a deeper exploration of key issues, which would have been difficult to capture through remote means alone. The key aspects that were examined during the field visits included infrastructure, community involvement and technology used.

c. Analysis and synthesis

Data collected from the desk review, stakeholder consultations, survey and field visits were analysed and synthesized using appropriate tools and techniques. The analysis resulted in an assessment of the strengths, weaknesses, opportunities and threats (SWOT) of the current last-mile connectivity, as well as in the identification of key issues, actual usage, challenges, gaps and priorities; evaluation of alternative options; identification and documentation of investment opportunities for last-mile connectivity; formulation of sustainability recommendations; and development of alternative sustainability strategies, among others.

d. Validation

Findings, conclusions and recommendations were validated with ITU and the Ministry of ICT and National Guidance, through a stakeholder's validation workshop, as requested by the Ministry, in addition to the regular engagements.

e. Report preparation

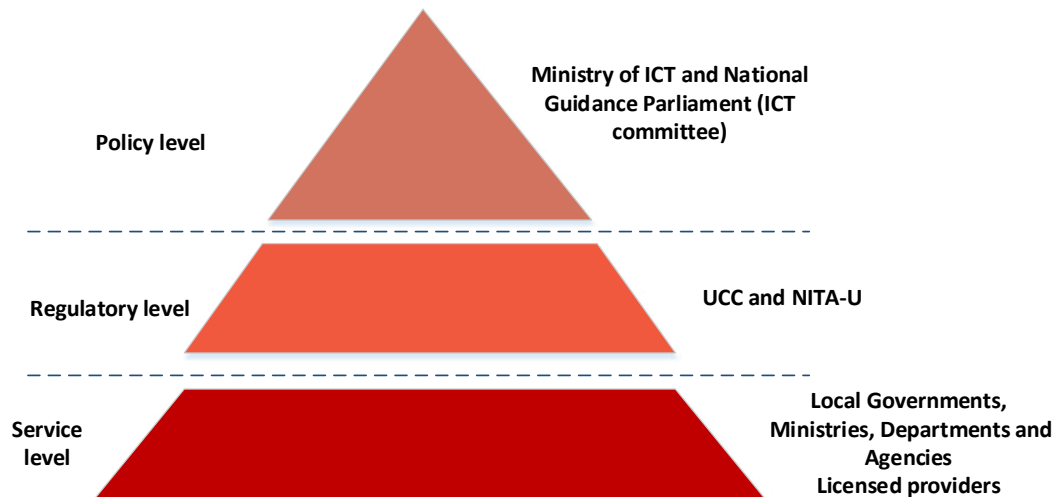
A draft report was prepared and submitted. Comments were solicited and incorporated into this final report.

2 Last-mile connectivity ecosystem in Uganda

2.1 Institutional and regulatory framework

The ICT sector in Uganda is comprised of three functional levels, as highlighted in Figure 2. At the top or policy level is the Ministry of ICT and National Guidance, which oversees the sector and provides the necessary policy framework to guide implementation. In the middle or regulatory level, the Ministry was supported by regulatory agencies that included the Uganda Communications Commission (UCC), regulating the telecommunication sector and also responsible for management of the Rural Communications Development Fund (RCDF), now known as the Uganda Communications Universal Service and Access Fund (UCUSAF); and the National Information Technology Authority Uganda (NITA-U), regulating the ICT sector and also responsible for the roll-out and operation of the National Backbone and e-Government Infrastructure.⁵ The lower level – the service level – includes service providers who are predominantly private sector-licensed.

Figure 2: Functional levels of the ICT sector in Uganda



Source: ITU

Beyond the policy framework, a robust legal and regulatory framework underpins the ICT ecosystem in Uganda. Key instruments include:

- The Uganda Communications Act, 1997: This Act establishes the Uganda Communications Commission (UCC) and defines its regulatory powers over the telecommunication sector. It also sets the foundation for competition and universal service access.
- Attendant Regulations to the Uganda Communications Act: These regulations provide further details on specific aspects of the Act, such as licensing procedures, spectrum management and consumer protection.
- Other relevant legal frameworks: Additional laws may impact the ICT sector, such as the Data Protection and Privacy Act, 2019, or the Electronic Transactions Act, 2008.

⁵ The state of the ICT sector in Uganda

The regulatory level is comprised of agencies that ensure adherence to the legal and policy frameworks:

- UCC: Regulates the telecommunication sector, manages UCUSAF, formerly known as RCDF, and promotes competition and consumer protection.
- NITA-U: Regulates the ICT sector, oversees the roll-out and operation of the National Backbone and e-Government Infrastructure, and promotes ICT adoption and innovation.

The lower level, the service level, includes service providers that are predominantly private sector licensed entities. These include telecommunication operators, mobile network operators (MNOs), Internet service providers (ISPs) and last-mile connectivity providers (both public and private).

In September 2018, the National Broadband Policy was adopted, under which a new licensing framework for the industry was developed, which finally came into force in July 2020. The overall objectives are to harmonize and regulate the planning and development of broadband infrastructure, define the appropriate technology mix, enable universal connectivity, and reform the licensing framework to improve quality of service in the industry and meet the overall national policy goals and aspirations.⁶ Private operators were required to use any broadband infrastructure that the government had constructed, including terrestrial microwave, satellite and optical fibre.

The resultant effects of not having regulated/coordinated infrastructure development and an appropriate technology mix were:

- Lack of connectivity for all (limited connectivity), as operators mostly focused on optical fibre without exploring other forms of connectivity, and only chose to develop and deploy infrastructure where it was commercially viable.
- High cost of Internet services, as operators' pricing was influenced by investments in infrastructure.
- Underutilization of the national backbone infrastructure (NBI), which only connected government establishments and therefore could not effectively influence the market.
- Poor or slow Internet speeds occasioned by infrastructure bottlenecks, which resulted in poor quality of service.

2.2 The state of last-mile connectivity in Uganda

According to latest ITU Facts and Figures report, Internet connectivity was barely making a dent in the digital divide, as low-income countries continued to be left behind despite Internet connectivity and usage being on the rise.⁷ The report stated that not only were fewer people online in low-income countries, but those who were connected used less data. This meant that Internet users in low-income countries, such as Uganda, were not achieving the full potential of connectivity or realizing the benefits of digital transformation.

⁶ National Broadband Policy, 2018.

⁷ Measuring digital development Facts and Figures 2023, <https://www.itu.int/en/mediacentre/Pages/PR-2023-11-27-facts-and-figures-measuring-digital-development.aspx>.

a. Service and infrastructure providers

There were over 30 licensed service and infrastructure providers that constituted the last-mile connectivity ecosystem. The ecosystem is dominated by MNOs and other ISPs, and infrastructure providers, as shown in Table 1.

Table 1: Sampled last-mile connectivity stakeholders in Uganda, April 2024

Service providers			Infrastructure providers			Community networks
MNO	Mobile Virtual Network Operator	ISP	Fibre	Tower company	Data centre	
MTN Uganda	K2 Telecom	Roke Telkom	CSquared	American Tower Corporation	Raxio	Office of the United Nations High
Airtel Uganda		Liquid	Bandwidth and Cloud Services	TOA (Ubuntu)	NITA-U	BOSCO
Lycamobile		Echotel Uganda	Seacom			Access Plus
UTCL		Gilat Telecom	NITA-U			RENU
Smile		Blue Crane	Uganda Electricity Transmission Company Limited			
		Wanainchi Group (Zuku)				
		Canalbox				
		Sprint Uganda				
		Hamilton Telecom				
		United Wireless				

At the time of this study, last-mile connectivity in Uganda was typically being delivered with cellular mobile network technology, and fixed wired and fixed wireless terrestrial technologies.

b. Regulation and licensing

MNOs and other ISPs are licensed by UCC, the industry regulator. Additionally, UCC also regulates and licenses infrastructure providers such as tower companies, fibre backhaul infrastructure providers and satellite backhaul providers.

Before 2022, MNOs and ISPs used free and unlicensed industrial, scientific and medical (ISM) bands (2.4GHz and 5GHz). These were used mainly for point-to-point and point-to-multiple-points

fixed wireless last-mile connectivity. However, in April 2022 UCC issued guidelines on the utilization of the 5GHz ISM band, which effectively licensed Block C (5725 - 5850MHz). All operations in this frequency range have since required radio-frequency spectrum authorization and associated spectrum fees.⁸ This development was likely to hamper efforts to broaden last-mile connectivity in Uganda by further driving up the already high costs of last-mile connectivity interventions in the rural and remote unserved and underserved areas, further widening the digital divide.

In June 2023, UCC successfully awarded spectrum to two of the country’s mobile operators, MTN and Airtel, in the crucial 700 MHz, 800 MHz, 2.3 GHz, 2.6 GHz and 3.5 GHz bands, assigning at least 100 MHz per operator in mid-bands for 5G. Five operators participated in the competitive multiband award process, launched in May 2023.

Table 2: UCC new mobile broadband spectrum assignments in June 2023

Band	Assignment
700 MHz	20 MHz (MTN)
800 MHz	20 MHz (Airtel)
2.3 GHz	100 MHz (MTN)
2.6 GHz	20 MHz (MTN)
3.5 GHz	100 MHz (Airtel)

The new licences also came with coverage obligations that were geographical, instead of population-based, with the aim to bridge the rural-urban gap. Currently, in Uganda, 77 per cent of the population is covered by 3G and 31 per cent by 4G, while 53 per cent of the country’s geography is covered by 3G and 24 per cent by 4G.⁹ Prioritizing geographical coverage obligations was seen to impose significant financial burdens on mobile network operators, impacting service affordability. Also, requiring geographical coverage obligations could divert resources away from areas where the demand for mobile services is higher and where a larger population could benefit from higher investments. In Uganda, around 74 per cent of the population lives in rural areas,¹⁰ which is well above the average of 54 per cent for sub-Saharan Africa – making it particularly challenging for MNOs to cover all parts of the country, and even more important to have low bands available.

⁸ UCC (2022). “Guidelines for the utilisation of the 5GHZ band for wireless access networks in Uganda”. Available at www.ucc.co.ug/wp-content/uploads/2023/10/UCC-Guidelines-for-the-Use-of-5GHz-Band-in-Uganda.pdf.

⁹ GSMA (2023). “Spectrum assignment moves Uganda closer to national broadband targets”. 24 July. Available at www.gsma.com/spectrum/spectrum-assignment-moves-uganda-closer-to-national-broadband-targets/.

¹⁰ World Bank Group (n.d.). “Rural population (% of total population) - Sub-Saharan Africa”. Available at <https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=ZG>.

2.3 Current landscape

Rural and remote areas in Uganda often lack adequate Internet infrastructure, relying primarily on mobile networks for connectivity. However, network coverage is often sparse and unreliable in these regions, hindering access to essential services such as education, health care and economic opportunities. Limited electricity supply and low levels of digital literacy further exacerbate the digital divide in these areas.

As of early 2023, Uganda had made significant progress in expanding Internet penetration. The country had witnessed an increase in mobile Internet usage, with more than 24.6 per cent of the population having access to the Internet.¹¹ However, the majority of Internet users are concentrated in urban areas, leaving rural regions underserved.

As of the latest data, Uganda's population is approximately 49.9 million people. Around 28.6 per cent of Ugandans live in urban areas, which translates to approximately 13.9 million people. The majority, 71.4 per cent, resides in rural regions.¹² This is well above the average of 54 per cent for sub-Saharan Africa – making it particularly challenging for MNOs to cover all parts of the country, and even more important to have low bands available.

The spectrum licensing in Uganda holds coverage obligations that are geographical, instead of population-based, with the aim to bridge the rural-urban gap.

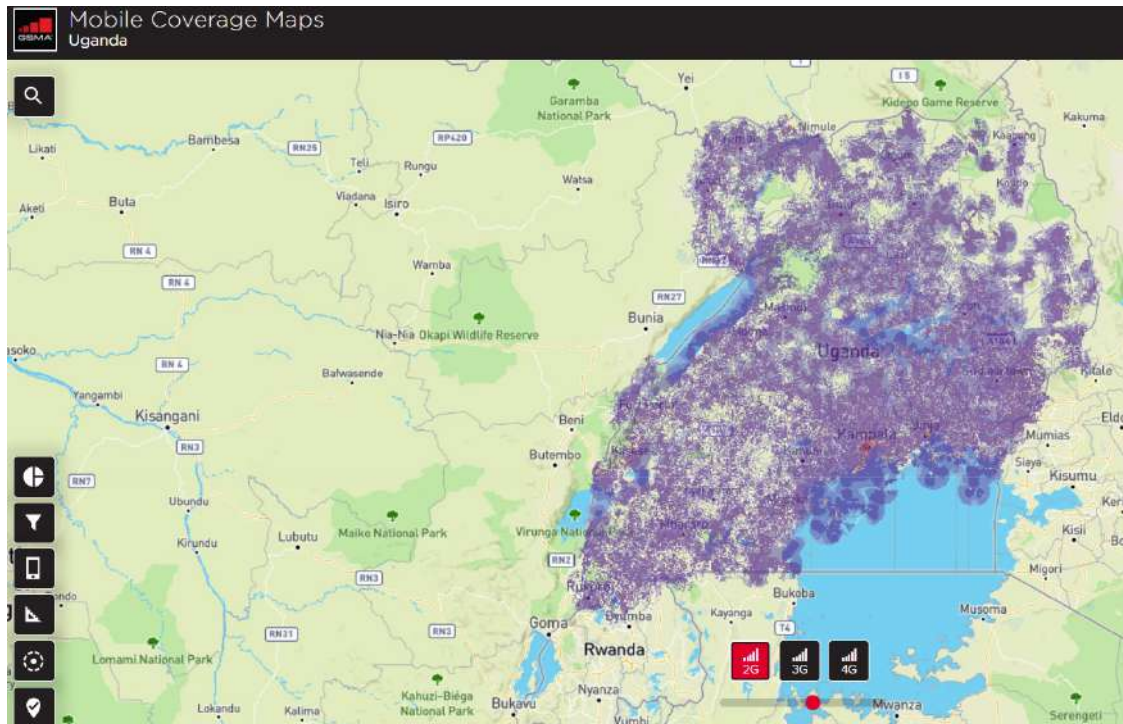
The coverage gap (citizens not covered by any mobile broadband signal) has been steadily declining. According to Global System for Mobile Communications Association (GSMA) research, this stood at 9 per cent as of 2021, representing a 23 per cent reduction from 2017. On the other hand, broadband adoption is not keeping up with this trend, resulting in a high usage gap (citizens living within mobile broadband coverage, but not utilizing it) of 69 per cent as of 2021.¹³ Addressing the main barriers to mobile broadband adoption, including affordability and digital skills, should be a priority for stakeholders to realize the potential of mobile connectivity to drive economic growth and development. Coverage obligations, therefore, need to factor in the urgency of addressing these barriers to increase the adoption of mobile services in Uganda.

¹¹ Data Reportal (2023). "Digital 2023: Uganda". 14 February. Available at <https://datareportal.com/reports/digital-2023-uganda>.

¹² WorldOMeter (n.d.). "Uganda Population (Live)". Available at www.worldometers.info/world-population/uganda-population/.

¹³ GSMA (2023). "Spectrum assignment moves Uganda closer to national broadband targets". 24 July. Available at www.gsma.com/spectrum/spectrum-assignment-moves-uganda-closer-to-national-broadband-targets/.

Figure 3: Mobile networks coverage footprint map for Uganda



Source: GSMA

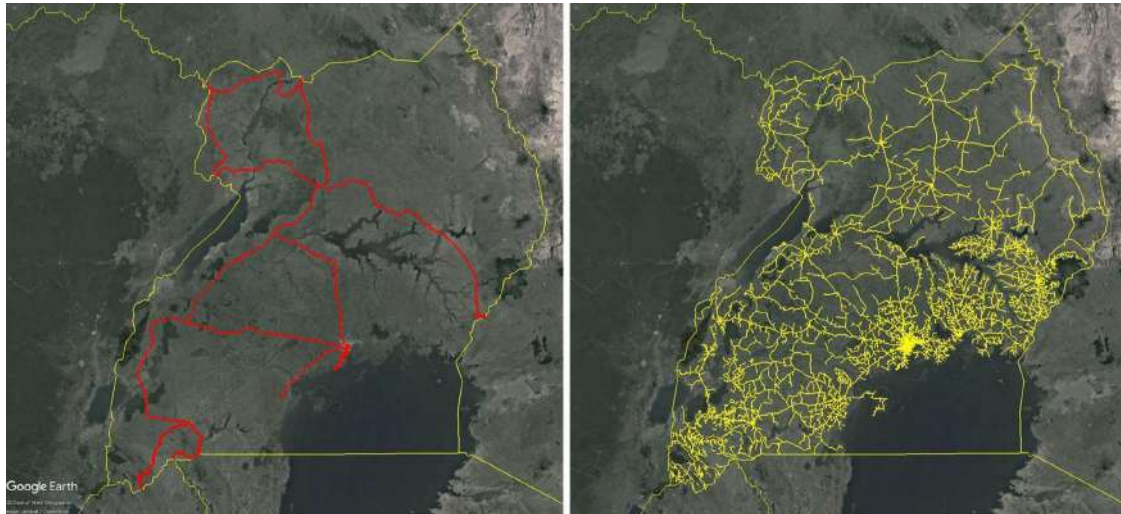
Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by ITU.

Taking all operators together, Uganda has around 4 000 telecommunication towers. Theoretically, approximately 6 200 low-band sites would be required to provide 90 per cent coverage of Uganda's landmass of 241 038 km², assuming each site covers an area of 35 km².

Prioritizing geographical coverage obligations can impose significant financial burdens on mobile network operators, impacting service affordability. Also, requiring geographical coverage obligations may divert resources away from areas where the demand for mobile services is higher, and where a larger population can benefit from higher investments.

On the other hand, by focusing on population coverage, operators are encouraged to deploy in areas where people reside, work and commute – the areas where service provision is needed. By concentrating on regions where more people can benefit from the services, operators can achieve economies of scale, optimize network performance, prioritize investments and reduce costs.

Figure 4: Maps of Uganda comparing the extent of the total fibre footprint (shown in red) and power lines (shown in yellow)



Sources: EnergyData.info, ITU.int, UCC.co.ug, Google Earth¹⁴

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by ITU.

Uganda's infrastructure landscape is rapidly developing, with several initiatives aimed at expanding reliable Internet access to rural and remote areas, thus bridging the digital divide. The NBI Project and the Last Mile Connectivity Project are two significant endeavours driving the expansion.

The NBI Project is designed to enhance connectivity primarily for government institutions and departments. It comprises multiple phases aimed at extending robust connectivity infrastructure across various regions of Uganda. Phase I connected key towns, including Entebbe, Mukono, Jinja, Bombo and Kampala, encompassing 27 ministries and government departments. Fibre-optic cables were then laid across towns including Busia, Tororo, Mbale, Gulu and Mbarara, covering a total distance of just over 1 400 km in Phase II. The NBI was then extended to additional towns, including Masaka, Mutukula border post, Mbarara, Kabale and Katuna border post, further expanding the network reach in Phase III.

In addition, the government initiated the Last Mile Connectivity Project to extend the NBI to an additional 700 sites across 58 districts, facilitating connectivity in previously underserved areas. Approximately 732 km of fibre-optic cable is being deployed as part of this effort, complementing the NBI infrastructure.

To deepen connectivity nationwide, the Last Mile Connectivity Project leverages fibre-optic cables and microwave networks to extend reliable Internet access to communities in remote and rural areas. The laying of approximately 732 km of fibre-optic cable underscores the commitment to enhancing connectivity infrastructure across Uganda. Microwave networks play a pivotal role in connecting remote areas where laying fibre-optic cables may be challenging or cost-prohibitive. These networks serve as vital bridges, ensuring that even the most isolated communities can access Internet services.¹⁵

¹⁴ Engineering at Meta (2020). "Making aerial fiber deployment faster and more efficient". 13 July. Available at <https://engineering.fb.com/2020/07/13/connectivity/aerial-fiber-deployment/>.

¹⁵ NITA-U (n.d.). "National Backbone Infrastructure Project (NBI/EGI)". Available at www.nita.go.ug/projects-service-portfolio/national-backbone-infrastructure-project-nbiegi.

Figure 5: Existing national backbone infrastructure and future planned expansions under Uganda Digital Acceleration Program (UDAP) and phase 5



Source: NITA-U

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by ITU.

NITA-U is implementing the Last Mile Connectivity Project under which 732 km of fibre-optic cable are to be laid to extend the NBI to an additional 700 sites across 58 districts. At the end of the project, the NBI will cover over 3 156 km across 97 districts, connecting over 1 069 ministries, departments and agencies, local governments and target user groups.¹⁶

Mapping initiatives showcase the current coverage areas and highlight the envisioned reach of connectivity infrastructure, offering a visual representation of Uganda’s evolving digital landscape. Uganda’s commitment to expanding and strengthening connectivity infrastructure

¹⁶ NITA-U (2016). “Deepened Nationwide Connectivity”. 21 December. Available at <https://nita.go.ug/deepened-nationwide-connectivity>.

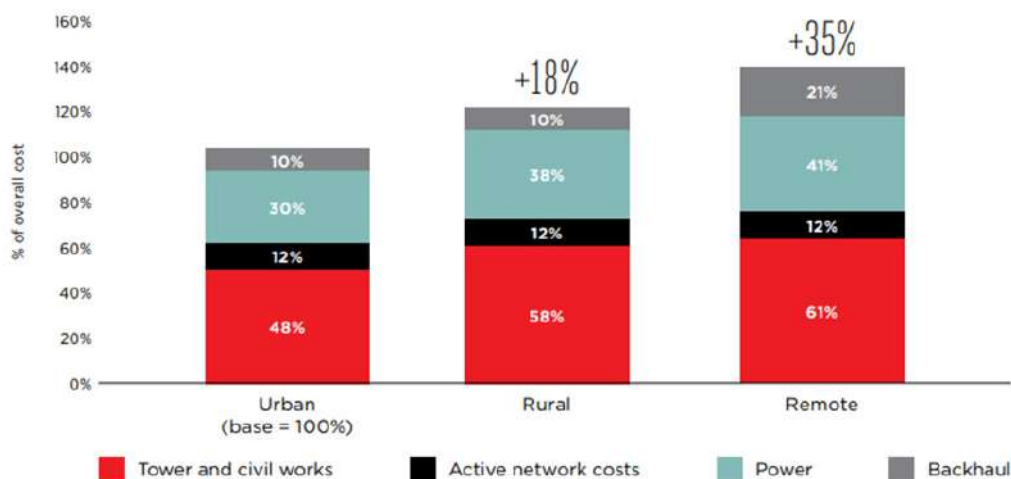
aims to create a more inclusive digital ecosystem, empowering individuals and communities with access to opportunities, information and resources essential for socio-economic development.

2.4 Challenges

2.4.1 Infrastructure costs

The high cost of deploying and operating last-mile connectivity infrastructure in rural and remote areas poses a significant barrier to investment. Investors need to consider innovative financing models and risk-sharing mechanisms to make projects financially viable. GSMA notes, as illustrated in Figure 6, that the average additional annual cost of mobile coverage sites was 18 per cent more in rural sites than in urban sites, and 35 per cent more in remote sites in 2019, driven by additional costs in backhaul, power and tower/civil works.¹⁷

Figure 6: Annualized cost of mobile coverage sites in rural and remote locations (relative to urban), by major component



All figures are GSMA generalised benchmarks, taken from GSMA Intelligence data.

Source: GSMA

In Uganda, despite various initiatives aimed at improving Internet access in rural areas, there are still many challenges that hinder progress. Previous efforts have failed to adequately address the underlying issues effectively. One of the primary reasons for the limited success is the high capital expenditure requirements for setting up and the high operational expenditures of running infrastructure in rural regions in relation to very low revenues, which make it an unviable and unsustainable business. This has impeded efforts to improve connectivity and extend network coverage.

2.4.2 Operational challenges

Maintaining and operating last-mile connectivity infrastructure in remote locations can be challenging due to limited access to grid power, inaccessible road networks, harsh environmental conditions and security concerns.

¹⁷ GSMA: Closing the Coverage Gap.

Beyond the high cost, maintaining and operating last-mile connectivity infrastructure in rural and remote locations in Uganda faces several operational challenges. Here are some key ones:

- **Geographical dispersion and difficult terrain:** Rural areas often have scattered populations spread across vast distances. This makes it difficult and expensive to physically reach locations and maintain infrastructure. Rugged terrain, dense vegetation and harsh weather conditions can further complicate maintenance efforts.
- **Limited power supply:** Reliable electricity is often scarce in remote areas. This can hinder the operation of base stations and other network equipment, requiring alternative power sources such as generators or solar panels, which add complexity and maintenance needs.
- **Technical skills shortage:** Skilled technicians may be unavailable or unwilling to relocate to remote areas. This can lead to delays in resolving technical issues and maintaining optimal network performance.
- **Security and vandalism:** Theft of cables, vandalism of equipment and damage caused by wildlife are more significant risks in remote locations with lower population density and limited surveillance.
- **Low revenue potential:** Due to lower population density and lower average revenue per user, rural areas may not generate enough income to justify the investment in network infrastructure. This can create a disincentive for private companies to expand services.
- **Limited awareness and adoption:** Rural communities might not fully understand the benefits of connectivity or have the resources to afford Internet access. This can hinder user adoption and limit the overall impact of the infrastructure. Implementing robust maintenance and security protocols is essential to ensure the sustainability of investments.

2.4.3 Policy and regulatory environment

Regulatory hurdles and bureaucratic processes can impede investment in last-mile connectivity projects. Streamlining regulatory frameworks, clarifying licensing requirements and providing incentives for private sector participation can facilitate sustainable investments in underserved areas.

The blanket regulation for rural, urban and remote areas refers to a single set of rules applied across all locations, regardless of their specific characteristics. This approach can be problematic for several reasons:

- **Ignoring contextual differences:**
 - **Needs:** Rural areas might need regulations focused on infrastructure development and access, while urban areas might prioritize traffic management or waste disposal. Remote locations might have unique environmental concerns.
 - **Capabilities:** Remote areas might not have the resources or infrastructure to comply with regulations designed for urban settings.
- **Inefficiency and unfairness:**
 - **Cost:** One-size-fits-all rules can be unnecessarily expensive for rural or remote areas, where the same level of compliance might not be achievable or even necessary.
 - **Effectiveness:** Regulations designed for densely populated areas might be ineffective or irrelevant in sparsely populated rural settings.
- **Potential for stifling innovation:**
 - Blanket regulations might hinder the development of tailored solutions needed for specific challenges in rural or remote areas.

Despite regulatory efforts to address the communication challenges in rural and remote locations through the UCUSAF subsidy model (partnering with TowerCo Africa to construct 63 telecommunication masts and constructing 12 Wi-Fi hotspots at border locations, 22 3G sites and 80 2G sites), this one-time subsidy model has fallen short of addressing the sustainability issue. Operational costs of communication services to rural and remote areas remain high with very low revenues barely meeting costs.

One of the other challenges is the imposition of licensing fees and the recent move by the regulator, UCC, particularly for spectrum upper band, such as the 5.8GHz ISM band. These fees are detrimental to the business operations of ISPs. This requires them to pay for this licence for them to use, since they have already invested in the equipment. It discourages investment in extending connectivity to rural and remote areas, where profitability is lower due to lower population density.

2.5 Key stakeholder profiles

The stakeholders in the last-mile connectivity ecosystem play a pivotal role as enablers, facilitators and end users. The stakeholders that were interviewed were categorized by the key roles they play in the last-mile connectivity ecosystem as shown and profiled in Table 3:

- Public sector: Ministries (Ministry of ICT and National Guidance), regulatory bodies (UCC and NITA-U) and government agencies.
- Private sector: Telecommunication operators (MTN, Airtel, Lycamobile and UTCL), ISPs and infrastructure providers (tower companies and fibre-optic providers).
- Community networks: RCBN, BOSCO and RENU.
- Civil society organizations: Non-governmental organizations (NGOs) focused on ICT access, and rural development.
- Academia and research institutions: Universities with ICT programmes and research centres focusing on telecommunications, such as RENU.
- International organizations: World Bank, GSMA and ITU.

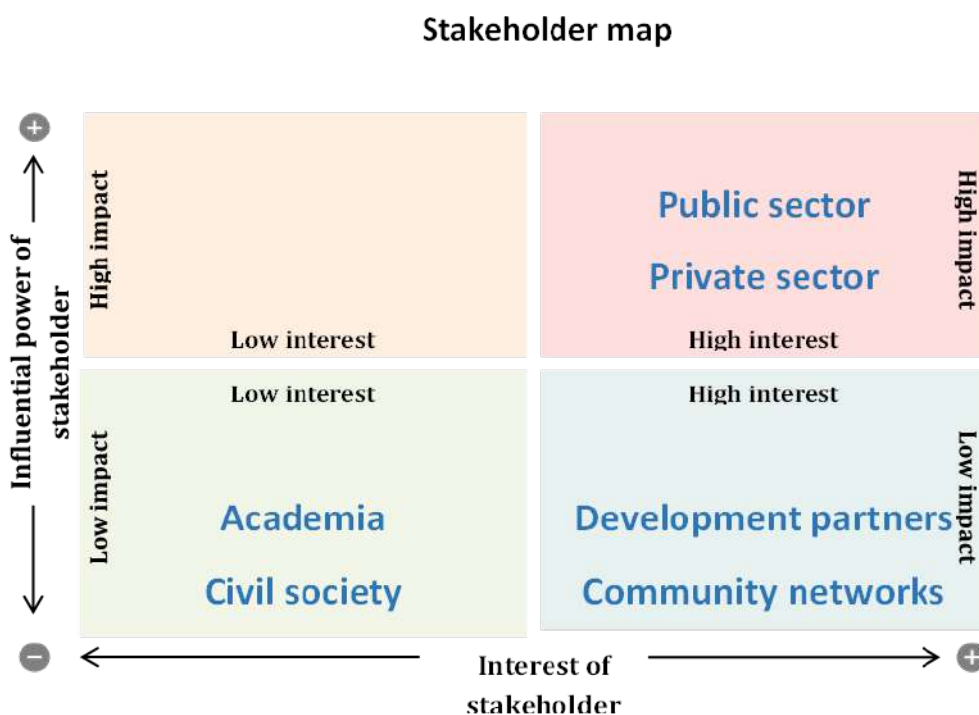
Table 3: Stakeholder profiles

Classification	Stakeholders	Interest	Influence	Potential role in the study
Public sector	Ministries (Ministry of ICT and National Guidance), regulatory bodies (UCC, NITA-U), government agencies	High	High	Provide insights on policy and regulation of last-mile connectivity interventions
Private sector	Telecommunication operators (MTN, Airtel, Lycamobile, UTCL), ISPs, Infrastructure providers (tower companies, fibre-optic providers)	High	High	Provide perspectives and insights on last-mile connectivity interventions, models/ approaches, actual usage, gaps, challenges and success

Table 3: Stakeholder profiles (continued)

Classification	Stakeholders	Interest	Influence	Potential role in the study
Community networks	RCBN, BOSCO, RENU	High	Low	Provide perspectives and insights from a community networks position on last-mile connectivity interventions in rural and remote locations in Uganda
Development partners	United Nations Capital Development Fund (UNCDF), Office of the United Nations High Commissioner for Refugees, the United States Agency for International Development, United Nations Children’s Fund (UNICEF)	High	Low	Provide development partners’ input on promoting sustainable and community-led interventions for last-mile connectivity in Uganda
Civil society organizations	NGOs focused on ICT access, rural development, e.g. Hello World	Low	Low	Offer NGO perspective
Academia and research institutions	Universities with ICT programmes, research centres focusing on telecommunications, e.g. RENU	Low	Low	Offer perspective from academia

Figure 7: Stakeholder map



Source: ITU

3 Study results and findings

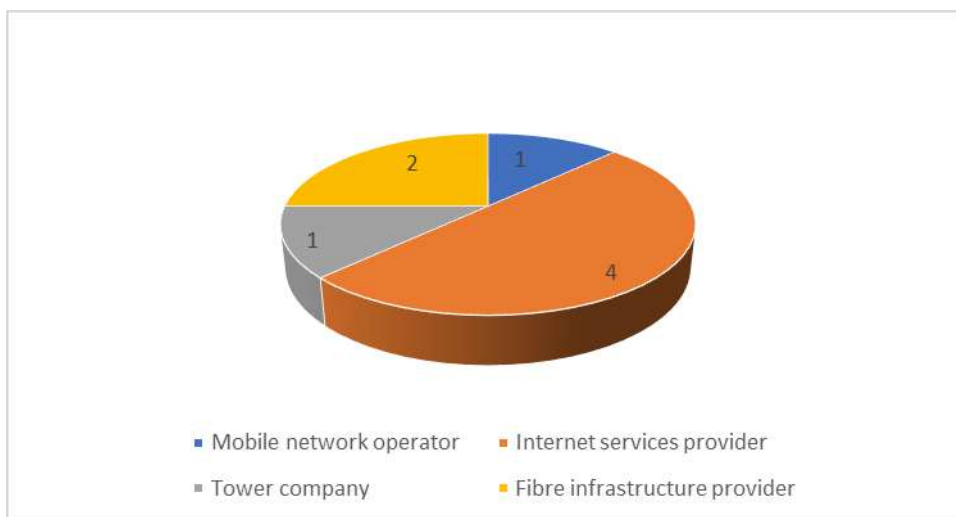
Data for this study were collected through survey questionnaires and followed up with key informant interviews with the stakeholders to get their valuable insights on last-mile connectivity interventions in Uganda. The respective data sets of the survey and key informant interviews are in the Annexes section of this report. Below are findings from survey questionnaires and key informant interviews.

3.1 Survey results

3.1.1 Profile of respondents

All respondents were licensed by UCC, primarily holding infrastructure and service provision licences for last-mile connectivity delivery. The majority, i.e. four of the respondents, were ISPs, while two were fibre infrastructure providers. One was from an MNO and one was from a tower company (TowerCo), as illustrated in Figure 8.

Figure 8: Survey respondent profiles



Source: ITU

3.1.2 Key findings

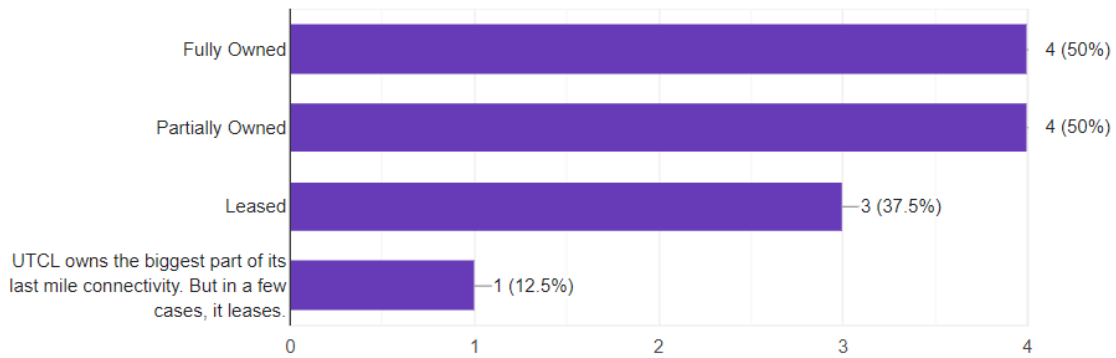
a. Technologies

In terms of mobile broadband cellular technologies, 3G and 4G were the predominant choices among respondents, with fibre-optic cable and fixed wireless access as the most widely used last-mile connectivity technologies, followed by very small aperture terminal (VSAT).

b. Infrastructure ownership

Four of the respondents fully owned their infrastructure. Four respondents partially owned their infrastructure, while three leased their infrastructure. One respondent, UTCL, utilized a mixed approach depending on the area.

Figure 9: Infrastructure ownership

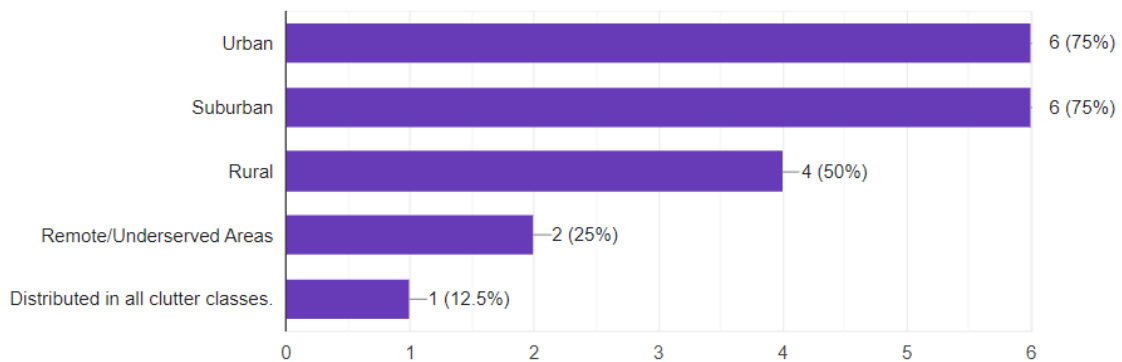


Source: ITU

c. Coverage

Geographically, out of the eight respondents, six had their last-mile connectivity cover urban areas. Six covered suburban areas. Only four covered rural areas, while only two covered remote/underserved areas. The majority of respondents had last-mile infrastructure coverage in urban and suburban areas. Remote and underserved areas had the least coverage.

Figure 10: Coverage

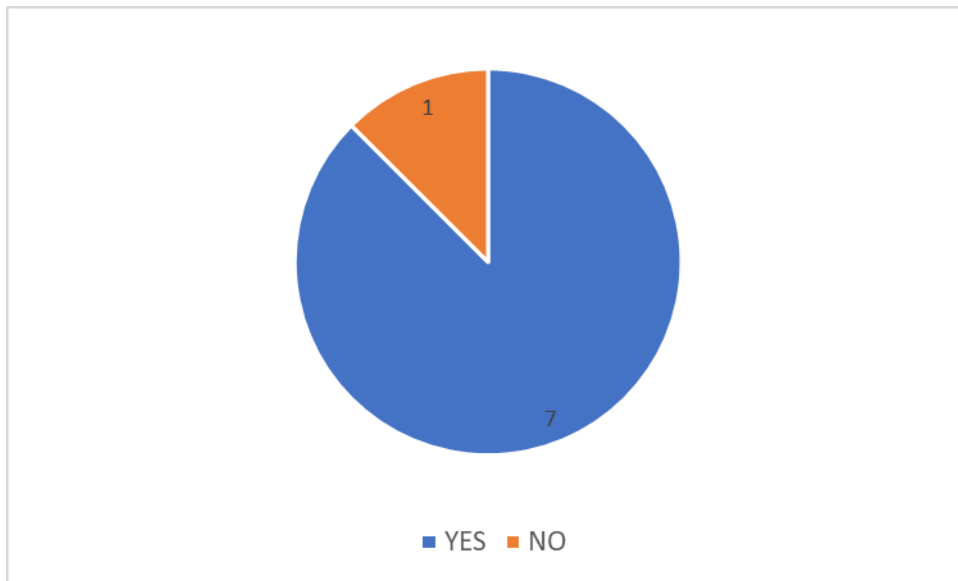


Source: ITU

d. Collaboration

There was a strong willingness to collaborate among service and infrastructure providers, with all expressing interest in partnerships, as shown in Figure 11.

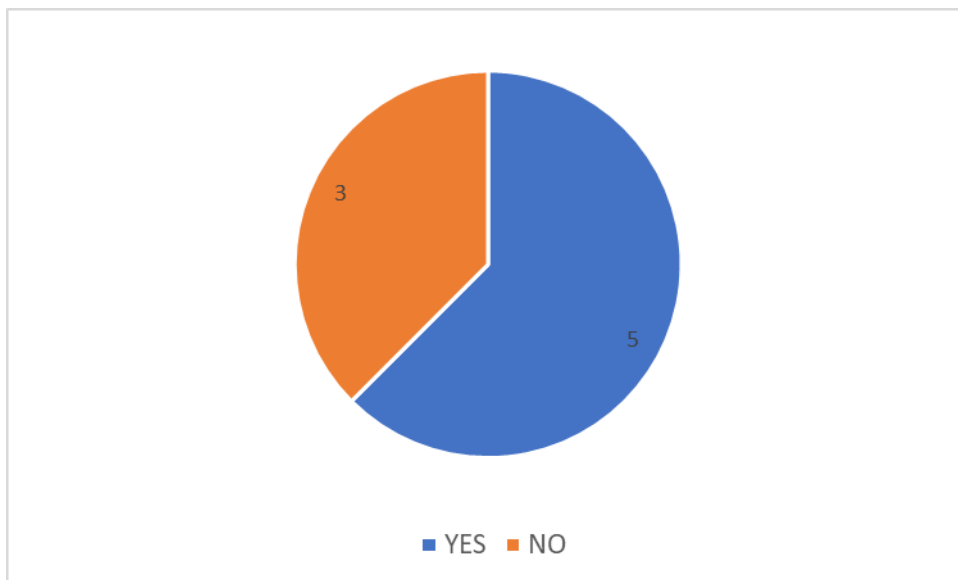
Figure 11: Involvement and willingness to collaborate with other providers



Source: ITU

Similarly, all respondents were open to working with non-State actors such as NGOs and development partners. Collaborations with government agencies such as NITA-U were highlighted, along with partnerships with NGOs and development partners such as the United States Agency for International Development. However, only five of the respondents indicated existing collaborations with government.

Figure 12: Involvement and willingness to collaborate with government

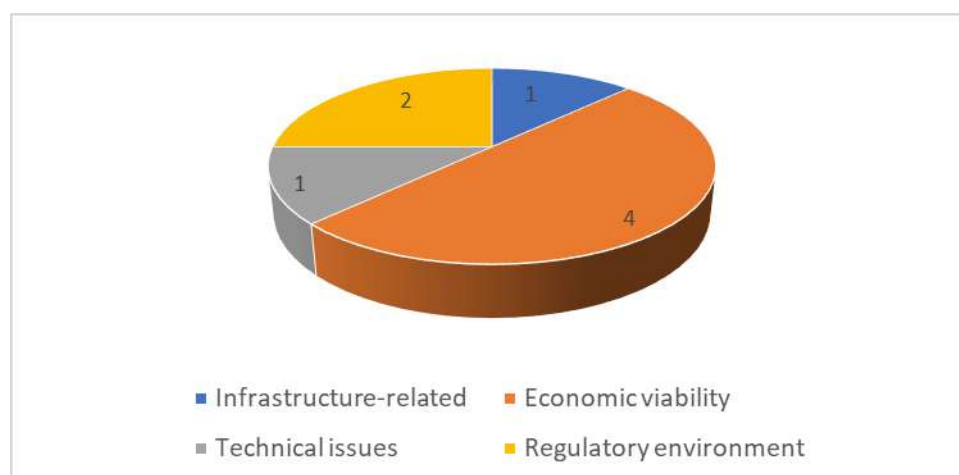


Source: ITU

e. Challenges

Four of the respondents cited economic viability concerns as their main challenges. Two respondents indicated regulatory environment constraints as their main challenges. One respondent indicated their main challenges as infrastructure-related, while one respondent cited technical issues.

Figure 13: Graph of challenges highlighted by respondents



Source: ITU

3.1.3 Suggestions by survey respondents

The respondents proposed the following recommendations to address challenges cited:

- Streamline regulations: Establish working groups with permitting agencies to address delays and improve efficiency. Consider sensitization programmes to tackle corruption within the permitting process.
- Promote PPPs: Encourage collaboration between government and private entities to incentivize last-mile infrastructure development in underserved areas.
- Develop infrastructure: Explore initiatives such as including ducts for optical fibre in public infrastructure projects and facilitate partnerships between ISPs and power companies for utilizing existing power lines.
- Manage spectrum: Review and enforce licensing frameworks to ensure proper spectrum allocation and minimize interference.
- Undertake affordability initiatives: Explore strategies to address affordability challenges, such as regulating last-mile pricing or implementing government subsidies.
- Raise public awareness: Raise awareness among communities about the benefits and uses of last-mile connectivity services to increase demand and adoption.

3.1.4 Summary of survey findings

The survey highlighted a diverse landscape of last-mile connectivity interventions in Uganda, with stakeholders facing both common challenges and varied opportunities for collaboration and improvement. Addressing these challenges through strategic partnerships, regulatory interventions and infrastructure investments can significantly enhance the accessibility and effectiveness of last-mile connectivity initiatives in rural and remote areas, ultimately contributing to Uganda’s digital transformation and socio-economic development. The successful deployment of last-mile connectivity solutions in Uganda requires a multipronged approach that addresses regulatory hurdles, fosters collaboration and promotes investment in infrastructure development, particularly in underserved areas.

3.2 Stakeholder interview findings

The stakeholder interviews were conducted to collect a wide array of perspectives from key players, such as MNOs, ISPs, community networks, regulators and development partners.

3.2.1 Mobile network operator perspective

Three MNOs - Lycamobile, UTCL and Airtel Uganda - were interviewed regarding last-mile connectivity interventions in Uganda, with a focus on rural and remote areas. Some of the findings are below:

- a. Coverage gap and underlying issues
 - High capital expenditure and operational expenditure: This makes it costly for extending services to rural and remote areas with lower population density and revenue potential.
 - Infrastructure bottlenecks: There is a lack of extensive fibre infrastructure and duplication in urban areas. Additionally, the power supply is unreliable in remote areas, and there are poor road networks and terrain obstacles. The highlands especially further complicate connectivity efforts.
 - Challenges with infrastructure sharing: While MNOs acknowledged the potential of infrastructure-sharing, limited implementation suggested a need for stronger policies and incentives to encourage collaboration.
- b. Financial and regulatory barriers
 - Unsustainable business models: Existing models prioritized profitability, making them unsuitable for low-revenue rural areas.
 - High licensing costs: The high cost of licences discouraged investment, especially for smaller service providers. The phasing out of free spectrum bands such as the 5GHz ISM band further restricted investment options.
 - Inadequate UCUSAF support: The current structure of UCUSAF does not address the sustainability issue of network deployments in low-revenue remote areas.
 - Regulatory approvals: Obtaining permits was a tedious process. Infrastructure development in game parks is often obstructed due to outright rejections or excessively drawn-out procedures.
 - Technology adoption: New technologies often caught regulators off guard, leading to delays in adoption.
- c. Opportunities
 - Community network initiatives: The success stories of RENU and Hello World, and collaborations with MyUG, demonstrated the potential of community networks to bridge the gap in underserved areas.
 - Technological advancements: New technologies such as dual-beam antennas offered improved coverage efficiency, potentially reducing the number of infrastructure installations needed. Additionally, fixed wireless technologies using 4G and 5G networks provided high-speed Internet at lower costs, making it more accessible in rural areas.
 - Reaching underserved areas: Airtel Uganda planned to bridge the digital divide by extending its network coverage, particularly in rural and semi-rural areas, in order to empower communities and stimulate economic activity.

- Promoting education: There were initiatives such as the partnership with UNICEF to provide educational resources which could significantly enhance learning opportunities, especially for students in remote locations.
- Empowering youth: Partnerships such as with Absa Ready-to-Work programme and skilling initiatives in public libraries were seen to equip young people with essential ICT skills, improving their employability.
- Supporting agriculture: EzyAgric collaboration offered farmers access to vital agricultural information through Unstructured Supplementary Service Data (USSD) codes, enhancing agricultural practices and productivity.
- Promoting health care: Partnerships such as the Airtel Kabaka Birthday Run raised awareness and supported critical health-care services in Uganda.
- Smartphone penetration: Collaborations with smartphone manufacturers and financial institutions were accelerating smartphone adoption, a crucial tool for digital inclusion.

d. Challenges and potential solutions

- Economically unviable areas: Airtel acknowledged that 30 per cent of Uganda's geographical area presented economic challenges for network expansion. Potential solutions included:
 - Government subsidies: Government intervention with subsidies or financial support could incentivize infrastructure development in these areas. This could involve targeted subsidies for network operators, tax breaks for infrastructure development, or establishing universal service funds to bridge the financial gap.
 - Alternative technologies: Exploring cost-effective solutions such as satellite technology could be crucial for reaching remote locations. However, satellite technology had its own limitations, such as higher latency and potential weather interference. Investigating advancements in low-Earth orbit (LEO) satellite constellations could offer promising solutions for broader coverage at a more affordable cost.
- Infrastructure hurdles: MNOs acknowledged challenges such as inadequate power supply, road networks and geographical barriers that hindered network expansion. Solutions included:
 - Public-private partnerships (PPPs): Collaboration with government agencies and private companies could facilitate infrastructure development. PPPs could leverage the resources and expertise of both sectors to overcome these hurdles. The government could contribute land, permits and regulatory streamlining, while private companies could provide the capital and technical expertise for infrastructure development.
 - Strategic partnerships: Partnering with existing tower companies and exploring innovative solutions, such as utilizing existing infrastructure (schools, hospitals and public buildings), could optimize network expansion. This could reduce the need for building new towers, minimizing costs and environmental impact.
- Regulatory delays: Obtaining permits from various authorities – such as the National Environment Management Authority, Civil Aviation Authority and local bodies – was often time-consuming and obstructed progress. Airtel suggested:
 - Streamlined processes: Streamlining the permit issuing process and establishing clearer guidelines could expedite network deployment. Regulatory bodies could collaborate with network operators to develop standardized applications and transparent approval timelines.
 - Collaborative advocacy: Collaborating with the government and regulatory bodies to raise awareness about the importance of connectivity for development

was considered crucial. Airtel Uganda, along with other stakeholders in the telecommunication industry, could advocate for policies that promote network expansion and bridge the digital divide. This could involve conducting joint awareness campaigns, providing data on the socio-economic benefits of connectivity, and proposing regulatory reforms to expedite the permitting process.

- Community resistance: Myths and concerns regarding infrastructure development required targeted efforts to address them. Solutions included:
 - Community engagement: Actively engaging communities, educating them about the benefits of connectivity and addressing their concerns would foster collaboration. Airtel Uganda's outreach programmes were observed to be a positive step in this direction. Community meetings, demonstrations of the benefits of connectivity and partnering with local leaders would help address community concerns and build trust.
 - Awareness campaigns: Launching awareness campaigns through various channels such as social media, radio broadcasts and partnerships with local authorities would dispel myths and build trust. These campaigns would showcase real-life examples of how connectivity improved lives in other communities, address health concerns related to base stations with scientific evidence and emphasize the economic and educational opportunities that connectivity brings.
- Security concerns: Security issues in border areas posed a challenge. Potential solutions include:
 - Collaboration with security forces: Collaboration with security agencies to ensure safe infrastructure development and network operation would be critical. Airtel Uganda proposed to work with local law enforcement and security forces to identify high-risk areas and develop strategies for mitigating security threats.
 - Focus on sustainable solutions: Investing in robust and secure infrastructure would minimize potential security risks. This could involve using tamper-proof materials for towers and equipment, implementing remote monitoring systems, and partnering with security providers for surveillance and threat detection.

3.2.2 ISPs and fibre infrastructure provider perspective

Below is an analysis of interview responses from Seacom, Sombha Solutions, Liquid Intelligent Technologies, Bandwidth and Cloud Services, NITA-U, Roke Telkom and CSquared on last-mile connectivity interventions in Uganda.

- a. Coverage gap and underlying issues
 - Urban focus: The interviews revealed a prioritization of urban areas by most ISPs and fibre providers due to:
 - Financial constraints: The high cost of deploying infrastructure in rural areas with lower population density and potential revenue discouraged investment.
 - Infrastructure challenges: The lack of existing fibre infrastructure, unreliable power supplies and geographical difficulties in remote regions further hindered expansion.
 - NBI coverage limitations: While NITA-U NBI offered some backbone connectivity, significant gaps, particularly in the north-eastern region, remained unaddressed. This limited the effectiveness of last-mile extension efforts.
 - Business model disparity: The focus on business-to-business models by providers such as CSquared created a gap in direct consumer engagement, especially for

underserved rural communities. This approach prioritized high-value customers over broader societal goals of digital inclusion.

b. Challenges in MNO collaboration

- Cost and technology barriers: Collaboration with MNOs faced hurdles due to:
 - High costs: The high cost of establishing connections and potential incompatibility between technologies used by ISPs and MNOs made collaboration less financially attractive.
 - Uneconomical expansion: Extending services to sparsely populated areas was commercially viable for MNOs, hindering their willingness to collaborate.
 - Failed co-building initiatives: NITA-U experience with a failed co-building project with Airtel Uganda highlighted the challenges of translating collaboration plans into reality.

c. Community networks and support

- Value recognition: Several providers acknowledged the potential of community networks such as RENU and community-based initiatives such as Hello World in bridging the connectivity gap in underserved areas. These initiatives offered alternative models for reaching remote communities.
- Limited support mechanisms: While there was some support for community networks (e.g. Roke Telkom>Hello World and RENU), challenges remained:
 - Infrastructure limitations: Community networks often lacked the resources to build their own infrastructure, hindering their reach and scalability.
 - Unclear regulatory landscape: The regulatory environment for community networks seemed not be well-defined, creating uncertainty and hindering growth.

d. Regulatory challenges and bottlenecks

- High licensing costs: The high cost of obtaining licenses discouraged investment, especially for smaller ISPs, limiting competition and potentially hindering innovation in the sector.
- Spectrum scarcity: The phasing out of free bands such as the 5GHz ISM band and potential licensing of the 6GHz band raised concerns about increased spectrum costs, further restricting options for affordable connectivity solutions.
- UCUSAF imbalance: UCUSAF was perceived as inclined towards larger MNOs due to its bidding structure. This disadvantages smaller ISPs and fibre-optic providers who could be better suited for deploying infrastructure in underserved areas.

3.2.3 Community networks perspective

Below is an analysis of the responses provided by RENU (a research and education network), RCBN (a rural community network) and BOSCO Uganda.

a. Community involvement

- RENU: Operated as a hybrid model, involving member institutions in decision-making and financing while collaborating with service providers for deployment.
- RCBN: Actively engaged local stakeholders from conception, including district leaders, authorities, NGOs and youth, fostering community ownership.

- BOSCO Uganda:
 - Community members identified needs and recommendation for locations for connectivity centres.
 - Community most times provided space for ICT centres and contributed to their construction.
 - Some community members volunteered technical support and basic maintenance.
 - Community leaders, including religious figures, played a crucial role in endorsing and supporting the project.
- b. Successful initiatives
 - RENU: Highlighted its role in providing secure Wi-Fi hotspots for members, federated research access and cloud services. Additionally, it showcased how connectivity helped a previously unconnected school participate in national conferences and online workshops.
 - RCBN: Emphasized how a farmer group benefitted by accessing online information and applications through the network, demonstrating the broader impact of connectivity in rural areas.
 - BOSCO Uganda:
 - This programme, established during the Lord's Resistance Army (LRA) conflict in 2007, provided Voice over Internet Protocol (VoIP) and Internet access to affected communities. Utilizing wireless technologies and community partnerships, it established 54 computer centres across 13 districts. This initiative highlighted the power of community-driven solutions in challenging circumstances.
 - PPPs: A pilot scheme in Ntoroko and Rubanda districts showcased the potential of collaboration between the government and private sector. By leveraging resources and expertise, PPPs would accelerate last-mile connectivity deployment.
- c. Empowering communities
 - RENU: Offered a robust capacity-building programme for member institutions' ICT staff, equipping them with network management skills.
 - RCBN: Planned to expand training initiatives, establish a knowledge-sharing platform and provide basic troubleshooting techniques to partners, fostering self-reliance.
 - BOSCO Uganda:
 - Community needs assessment: Prior to establishing ICT centres, needs assessments identified suitable locations and encouraged community participation. This fostered a sense of ownership and ensured the project aligned with community priorities.
 - Capacity building: Representatives underwent training in leadership, management and digital literacy skills. This empowered them to manage centres and train others, fostering long-term sustainability.
 - Community management: Communities contributed financially, provided space and handled security for ICT centres. This fostered a sense of ownership and responsibility for maintaining connectivity solutions.
- d. Challenges
 - RENU: Identified the high cost of fibre-optic infrastructure and limited NBI reach as key hurdles in its operation.
 - RCBN: Acknowledged challenges in:

- Technical expertise: Acquiring equipment and maintaining infrastructure.
- Adoption: Encouraging community acceptance and understanding the value of connectivity.
- Device access: Limited affordability of devices for accessing the network.
- Energy dependence: Reliance on stable electricity for network operations.
- BOSCO Uganda:
 - High Internet costs relative to income levels, posing accessibility challenges.
 - Addressing basic needs in communities recovering from prolonged conflicts.
 - Limited availability and timely supply of equipment in Uganda's market.
 - Overwhelming demand for services, leading to capacity constraints.
 - The absence of partnerships and resource-sharing opportunities to expand coverage effectively.
- e. Innovative solutions
 - RENU: Leveraged a private access point name (APN) solution to connect remote members to the high-speed network.
 - RCBN:
 - Power: Implemented solar systems to ensure reliable power for equipment and user devices.
 - Capacity building: Conducted training sessions to empower locals with basic troubleshooting skills.
 - Application development: Was building a platform with local applications to enhance user engagement and potentially generate revenue.
 - BOSCO Uganda:
 - Wireless technologies: Utilized point-to-point, 2.5G and even 5G technologies, and the battery-operated system programme demonstrated innovative approaches to overcome infrastructure limitations in remote areas.
 - Bamboo tower project: This pilot project explores the potential of using bamboo towers for Internet connectivity, potentially a first in Africa. This innovative approach could offer a cost-effective and sustainable solution for remote areas.
- f. Collaboration and expansion
 - RENU: Aimed to connect Kalangala Island to the mainland with a high-speed fibre-optic cable. It actively collaborated with:
 - Local and international players in education.
 - Service providers, institutions and NGOs to expand its reach, including the Women of Uganda Network (WUGNET), UCC and NITA-U.
 - RCBN:
 - Partnered with entities such as Radio Apac to leverage tower infrastructure.
 - Collaborated with local radio stations in Oyam and Moroto.
 - Worked with the College of Gender and WUGNET to promote inclusivity and expand impact.
 - Sought to partner with regional universities such as Lira University.

- BOSCO Uganda:
 - Collaboration with religious leaders: Partnered with religious leaders to facilitate the establishment of ICT centres within existing infrastructure such as schools and hospitals. This leveraged existing resources and built trust within communities.
 - Trainer of trainers programme: Trained community members as trainers to empower them to share knowledge independently, promoting long-term sustainability and wider digital literacy.
 - Local government support: Local governments provided equipment, covered subscription fees, and conducted awareness campaigns, fostering collaboration and ensuring programme effectiveness.
- g. Sustainability
 - RENU: Primarily relied on grants but explored developing local applications to generate revenue and foster user engagement.
 - RCBN:
 - Actively sought continued support from funders and explored grant opportunities.
 - Utilized a temporary TV white space (TVWS) licence to reduce spectrum costs.
 - Investigated local application development for long-term financial sustainability.
 - BOSCO Uganda:
 - Was implementing monthly subscription fees to cover operational costs.
 - Offered various packages and services, including subsidized 3-in-1 printers.
 - Established Village Savings and Loan Associations to support centre sustainability.
 - Partnered with local governments for equipment provision and subscription subsidies.
 - Trained community members as trainers to ensure knowledge transfer and self-reliance.
 - Collaborated with Association for Progressive Communication (APC), an international network of civil society organizations, and initiated a pilot project using a bamboo tower, which would be the first of its kind in Uganda and Africa. At the time of the study, one tower was already operational, marking a significant step towards addressing connectivity challenges.
- h. Key takeaways

Key takeaways from the engagements with community networks include similarities and differences in the approaches taken to service delivery, the audience they target, chosen infrastructure and the sustainability considerations.

Table 4: Key takeaways from interviews with community networks

Approaches	RENU, BOSCO Uganda and RCBN demonstrated successful models for community-driven last-mile connectivity in Uganda, but with different approaches: <ul style="list-style-type: none"> • RENU: Focuses on education and research institutions, leveraging partnerships and existing infrastructure. • RCBN: Targets rural communities with limited access, emphasizing capacity building and local ownership. • BOSCO Uganda: <ul style="list-style-type: none"> ○ Community participation and ownership are critical for the success of last-mile connectivity initiatives. ○ Innovative solutions can overcome infrastructure limitations in remote areas. ○ Collaboration between government, the private sector and local communities fosters a multipronged approach to bridging the digital divide. ○ Building digital literacy alongside infrastructure development is essential for maximizing the impact of connectivity programmes. 		
Similarities	<ul style="list-style-type: none"> • These networks acknowledged the importance of community involvement and capacity building. • They faced similar challenges, such as affordability, device access and power dependence. • All these networks explored innovative solutions and partnerships to overcome these challenges. • They all prioritized long-term financial and operational sustainability. 		
Differences			
Feature	Bosco Uganda (battery-operated systems)	RENU	RCBN
Target audience	Conflict-affected and remote communities	Member institutions (schools, hospitals)	Local communities (grassroots level)
Infrastructure approach	Wireless technologies (existing infrastructure)	Leveraged existing infrastructure and partnerships	Used TVWS technology
Sustainability focus	Community contributions and partnerships	Explored private partnerships	Internal application development

The enquiries showcased how community networks could effectively address last-mile connectivity gaps in Uganda. Their diverse models, emphasis on community engagement and innovative solutions provided valuable insights for policy-makers and other stakeholders seeking to expand Internet access in underserved regions.

3.2.4 Development partner perspectives

Below is an analysis of UNCDF interview responses regarding its support and funding mechanisms, capacity-building efforts and recommendations for successful last-mile connectivity interventions in Uganda.

- a. Support and funding mechanisms
 - Collaboration with MNOs: UNCDF worked with MNOs such as MTN and Airtel to leverage existing infrastructure, such as towers, for last-mile connectivity projects. They provided incentives through:

- Guarantees: Mitigated risk for MNOs by offering guarantees on potential revenue streams.
- Grants: Funded initiatives such as digitalizing agriculture and connecting refugee camps.
- Innovation grants: Encouraged the development of user-friendly solutions for the last mile through grants awarded to businesses.
- b. Capacity building
 - Focus on user capabilities: UNCDF acknowledged the gap between affordability and user ability to utilize digital solutions.
 - Investment in training: It prioritized capacity building for local communities and stakeholders on using technology effectively.
 - Encouraging user-friendly design: They advised partners in fintech and other sectors to develop user-friendly technologies for wider adoption.
- c. Sustainability and community-led interventions
 - Private sector partnerships: UNCDF emphasized sustainable interventions through private sector models.
 - Rural value chain approach: It advocated for leveraging existing rural value chains and anchor partners within those chains for last-mile projects.
 - Human-centred design: It promoted building solutions with rural communities through iterative processes to ensure they address local needs.
- d. **Success stories and measuring impact**
 - UNCDF highlighted successful interventions from other regions, i.e.:
 - Device financing: The Copia model in Kenya for device financing through the Universal Service Fund.
 - Infrastructure sharing: The concept of infrastructure sharing in Uganda to avoid duplication of efforts.
 - Device access initiatives: Rwanda's focus on increasing access to devices.
 - Digital literacy programmes: The "Digital Ambassador" programme in Rwanda for promoting digital literacy.
 - Impact measurement strategy: UNCDF measured the impact of its interventions through:
 - Usage rates: Monitoring how many people used the provided solutions and what services they accessed digitally.
 - Community impact: Assessing the impact on rural community livelihoods and how digital solutions contributed to positive changes.
 - Transformative outcomes: Evaluating how interventions contributed to improving lives within rural communities.
- e. Conclusion

UNCDF played a crucial role in promoting sustainable and community-led interventions for last-mile connectivity in Uganda. Its focus on partnerships, user-centred design and capacity building provided a valuable blueprint for other development partners and stakeholders working in this space. Its recommendations regarding device affordability, digital literacy and

infrastructure investment offered practical insights for policy-makers aiming to bridge the digital divide in Uganda.

3.3 SWOT analysis of last-mile connectivity in Uganda based on stakeholder responses

A SWOT analysis was conducted on last-mile connectivity projects in Uganda, which highlighted the multifaceted landscape of last-mile connectivity in that country. While there were promising community-driven models, government initiatives and development partner support, significant challenges remained. Addressing infrastructure gaps, regulatory hurdles, device affordability and digital literacy skills is crucial. Fostering collaboration among stakeholders, embracing new technologies and prioritizing underserved areas will contribute to a more inclusive and sustainable approach to bridging the digital divide in Uganda.

Table 5 shares details on the SWOT analysis of last-mile connectivity in Uganda.

Table 5: SWOT analysis of last-mile connectivity in Uganda

Strengths	Weaknesses
<ul style="list-style-type: none"> • Enabling regulatory framework: UCC framework provided a foundation for UCUSAF funding, spectrum allocation strategies, infrastructure sharing guidelines, and community licensing. • Collaboration efforts: Stakeholders collaborated through UCC engagement frameworks, NITA-U partnerships with MNOs, memoranda of understanding with sister agencies, and initiatives such as community networks. • Community networks: RENU, BOSCO Uganda and RCBN showcased successful models for community-driven connectivity with a focus on capacity building and local ownership. • PPPs: NITA-U collaboration with MNOs for leveraging existing infrastructure demonstrated a potential model for efficient expansion. • Development partner support: UNCDF involvement with MNOs in digitalizing agriculture and refugee camps offered valuable experience in fostering innovation for underserved areas. • Government initiatives: The National Broadband Policy and NBI roll-out demonstrated government commitment to infrastructure expansion. 	<ul style="list-style-type: none"> • Limited NBI coverage: NITA-U target of 80 per cent coverage in five years left a significant gap in rural areas, hindering last-mile extension. • Focus on urban areas: Most ISPs and fibre-optic providers prioritized urban areas due to financial constraints and infrastructure challenges in remote regions. • High licensing costs: The high cost of obtaining licenses discouraged investment, particularly for smaller ISPs, limiting competition and potentially hindering innovation. • Spectrum scarcity: The phasing out of free bands and potential licensing of the 6GHz band could increase spectrum costs, restricting options for affordable connectivity solutions. • UCUSAF imbalance: The current UCUSAF structure may favour larger MNOs over smaller ISPs and fibre-optic providers who might be better suited for deploying infrastructure in underserved areas. • Limited collaboration: Challenges existed in MNO-ISP collaboration due to cost concerns and technology incompatibility. • Device affordability and data costs: The high cost of devices and data remained a significant barrier for user adoption in underserved areas. • Digital literacy gap: Limited digital literacy skills among the population hindered their ability to fully utilize connectivity solutions.

Table 5: SWOT analysis of last-mile connectivity in Uganda (continued)

Opportunities	Threats
<ul style="list-style-type: none"> • Targeted government investment: Investment in infrastructure alongside road construction projects to reduce deployment costs and incentivize private sector participation in extending services to underserved areas. • Revisiting licensing regimes: Exploring utilizing free spectrum bands and re-evaluating the 6GHz band licensing to promote wider access and reduce costs for ISPs. • Financial incentives for underserved areas: Implementing tax breaks, subsidies or grants for projects focused on expanding connectivity in underserved regions. • Revitalize UCUSAF: Restructuring UCUSAF to ensure fairer distribution of benefits and include fibre-optic infrastructure providers alongside MNOs. • Collaboration and knowledge sharing: Encouraging collaboration among MNOs, ISPs and community networks through workshops, funding opportunities and streamlined regulatory processes. • Embrace new technologies: Exploring and incentivizing adoption of sustainable technologies such as dual-beam antennas and fixed wireless solutions for potentially lower deployment costs compared with traditional fibre-optic infrastructure. • Community network growth and support: Exploring research opportunities on scaling successful community network models with government support. • Digital literacy programmes: Implementing nationwide programmes to equip communities with the skills necessary to utilize technology effectively. • Bamboo tower: Using bamboo towers, which potentially lowers the operational capital expenditure and operational expenditure, marking a significant step forward in addressing connectivity challenges. 	<ul style="list-style-type: none"> • Insufficient funding: Limited public and private investment could hinder the pace of infrastructure development and service expansion. • Regulatory uncertainty: Unclear or restrictive regulations could discourage investment and innovation in the last-mile connectivity sector. • Technological disparity: Rapid technological advancements could exacerbate the digital divide if underserved communities lack access to the latest solutions. • Sustainability challenges: Ensuring financial and operational sustainability for community networks and other last-mile initiatives beyond initial funding remains a challenge. • Regulatory approvals: Inefficiencies in obtaining permits; infrastructure development in game parks is often obstructed due to outright rejections or excessively drawn-out procedures. • Community opposition: Existing prevalent myths, such as the belief that infrastructure causes cancer or affects animal reproduction, lead to resistance. • Security concerns: Uganda’s border areas, particularly those shared with the Democratic Republic of the Congo and South Sudan, are increasingly vulnerable to security threats.

4 Framework and alternative approaches to sustainable last-mile connectivity

4.1 Alternative technologies for remote connectivity

To address the problem of digital inequality in Uganda, it is important to take a comprehensive approach that focuses on providing sustainable last-mile connectivity. This involves a combination of policy-making, innovative technological solutions and community engagement, to ensure that the initiative is successful in the long run. While traditional methods of deploying fibre-optic cables are essential for high-bandwidth applications, they can be very expensive and pose significant challenges in remote areas. However, by combining traditional and alternative technologies, it is possible to create a more holistic solution that addresses the needs of the community. Moving beyond traditional infrastructure, several alternative technologies hold immense potential for extending connectivity to underserved areas.

4.1.1 TV white space

TV white space (TVWS) technology offers a game-changer for delivering broadband access in Uganda's remote regions. TVWS refers to the unused frequencies or gaps in the VHF and UHF spectrum that can provide wireless Internet services.¹⁸ The complex problems in rural areas caused the gap in telecommunication infrastructure between urban and rural areas, so that technological solutions that fit with the rural characteristics are required. Based on the literature, TVWS is an appropriate technology alternative for rural conditions.¹⁹ Unlike traditional fibre-optic cables, which can be prohibitively expensive to deploy in sparsely populated areas, TVWS leverages unused frequencies in the television spectrum. This innovative approach presents several advantages:

- TVWS infrastructure is becoming increasingly popular as a cost-effective and efficient solution for providing Internet connectivity to underserved communities, especially in remote areas with limited existing infrastructure.²⁰ Compared with fibre-optic cables, TVWS deployment requires less investment, making it a more financially viable option for community-based projects or initiatives led by NGOs and development partners. The lower upfront costs associated with TVWS deployment can be particularly beneficial for rural regions where resources are scarce.²¹
- TVWS signals boast superior propagation characteristics compared with Wi-Fi, allowing them to travel longer distances and cover vast swathes of rural terrain with fewer base stations needed.²² This translates into significant cost savings and simplifies network set-up, particularly in geographically dispersed communities with challenging topography. Remember those old TV antennas with rabbit ears that could pull in channels even in remote locations? TVWS uses a similar technology, operating on UHF signals just like those old channels. This gives TVWS a key advantage over Wi-Fi - it can reach much further distances and overcome obstacles that would normally disrupt a Wi-Fi signal. This makes

¹⁸ EverythingRF (2020). "What is TV White Space?" 10 June. Available at www.everythingrf.com/community/what-is-tv-white-space.

¹⁹ EverythingRF (2020). "What is TV White Space?" 10 June. Available at www.everythingrf.com/community/what-is-tv-white-space.

²⁰ GSMA (2013). "TV White Space". Available at www.gsma.com/spectrum/wp-content/uploads/2013/04/GSMA-Policy-Position-on-TV-white-space.pdf.

²¹ ITU (2020). "TV White Spaces". 14 June. Available at <https://cocreate.itu.int/post/3353900>.

²² ITWeb (2019). "TV white space overcomes WiFi limitations". 7 October. Available at www.itweb.co.za/article/tv-white-space-overcomes-wifi-limitations/KPNG8v8d9oxv4mWd.

TVWS a valuable tool for bringing Internet access to areas where traditional Wi-Fi falls short.²³

- Furthermore, TVWS signals can effectively penetrate obstacles such as buildings and foliage, ensuring reliable connectivity even in areas with dense vegetation or challenging topography. This penetration capability is crucial for reaching remote villages nestled amid hills or valleys, or scattered settlements which are often out of reach of traditional line-of-sight technologies such as microwave or satellite.²⁴
- The relatively simpler infrastructure of TVWS, compared with fibre-optic cable networks or traditional cellular towers, allows for faster deployment. This expedited deployment process is particularly advantageous in bridging the digital divide, as it enables quicker connection of remote communities to the vast resources and opportunities available online. The rapid roll-out of TVWS infrastructure can also be instrumental in emergency response situations, facilitating critical coordination efforts between relief organizations, government agencies and local communities.²⁵

The TV white space Ugandan context

The Rural Communications Broadband Model (RCBN) has successfully demonstrated the viability of TVWS in Uganda through pilot projects. Their experience highlights the potential of this technology to bridge the digital divide in the following ways:

- Reaching underserved regions: TVWS can extend broadband access to remote villages and communities that would otherwise be left behind by traditional infrastructure projects. This can have a transformative impact on these regions by opening doors to a world of opportunities. With Internet connectivity, residents of these communities can access educational resources and online learning platforms, improving their educational attainment and career prospects. They can connect with health-care providers and access vital medical information online, leading to better health outcomes. Additionally, TVWS can empower these communities by enabling them to participate in the digital economy. Farmers can connect with online marketplaces to sell their produce more effectively, and local artisans can showcase their products to a wider audience. This can stimulate economic growth in these regions and create new income-generating opportunities.
- Empowering rural communities: Connectivity empowers rural communities by enabling a multitude of benefits that can improve their quality of life and livelihoods. Access to information allows farmers to stay updated on weather forecasts, market prices and best agricultural practices, leading to increased yields and improved farm management. Educational resources empower students to learn beyond the limitations of local schools and access a wider range of educational materials. Health-care services can be significantly enhanced through telemedicine, allowing remote communities to connect with doctors and specialists for consultations, diagnoses and even remote surgeries. E-commerce platforms open doors for rural entrepreneurs to sell their products to a national or even global audience, bypassing traditional middlemen and increasing their profit margins. Financial inclusion can be accelerated through mobile banking and digital payment systems, enabling easier access to financial services, remittances and credit facilities. Government services can be delivered more efficiently online, reducing the need for travel and paperwork for rural residents. Communication and social networking platforms connect families and friends who are geographically dispersed, fostering stronger social ties and reducing feelings of isolation.²⁶

²³ 6Harmonics (n.d.). "Why TV White Space?" Available at <https://6harmonics.ca/why-tvws/#:~:text=TV%20white%20space%20operates%20on,Wi%2DFi%20spectrum%20wireless%20broadband>.

²⁴ ITWeb (2019). "TV white space overcomes WiFi limitations". 7 October. Available at www.itweb.co.za/article/tv-white-space-overcomes-wifi-limitations/KPNG8v8d9oxv4mwD.

²⁵ GSMA (2013). "TV White Space". Available at www.gsma.com/spectrum/wp-content/uploads/2013/04/GSMA-Policy-Position-on-TV-white-space.pdf.

²⁶ ITU (2020). "TV White Spaces". 14 June. Available at <https://cocreate.itu.int/post/3353900>.

- Boosting economic development: Broadband access can stimulate economic growth in rural areas by facilitating agricultural innovation, attracting investment and creating new job opportunities.

Challenges and considerations

a. Signal interference

One of the greatest challenges with TVWS is signal interference. This can be addressed by a number of considerations:

- Efficient management of the television spectrum is of utmost importance to ensure that TVWS signals do not interfere with existing television broadcasts in Uganda. This requires a cooperative approach between various stakeholders, including the Uganda Communications Commission (UCC), which is the country's regulatory body responsible for spectrum allocation and management. UCC can play a pivotal role in creating a clear and effective regulatory framework for TVWS deployment, which must establish guidelines for spectrum sharing between TVWS users and existing television broadcasters, ensuring that both can operate without causing interference. On a positive note, UCC has facilitated the development of a dynamic spectrum allocation system that allows for flexible and efficient use of the available spectrum. In Uganda, TVWS technology for Internet access can only operate within the designated UHF television broadcasting band, ranging from 470 to 694 MHz. To prevent interference, channels are limited to a maximum bandwidth of 8 MHz, though combining multiple channels (aggregation) can provide higher bandwidth if needed. Additionally, a geolocation database can be used to ensure TVWS operations don't disrupt existing licensed services.²⁷
- Collaboration with television broadcasters is vital to ensure that their existing operations are not disrupted by TVWS deployments. Open communication and technical coordination between TVWS operators and broadcasters can help identify potential interference issues and develop mitigation strategies. This may involve establishing buffer zones around television broadcasting towers or utilizing geolocation databases to prevent TVWS signals from interfering with broadcast reception in areas with active television usage.²⁸
- TVWS equipment manufacturers also have an essential role to play in mitigating spectrum interference. They can ensure that their devices adhere to established technical standards and incorporate features that enable dynamic spectrum allocation. Additionally, they can develop equipment that can detect and avoid using frequencies that are already in use by television broadcasters.

b. Limited supply of TVWS equipment

The wider adoption of TVWS in Uganda depends on the availability of affordable TVWS equipment. Currently, only a limited number of vendors manufacture TVWS devices, and the upfront costs can be a barrier for local communities. Several initiatives can be explored to address this challenge:

- The Government of Uganda can play a crucial role in promoting the adoption of TVWS technology. To achieve this, it can consider partnering with international development agencies to secure bulk discounts on TVWS equipment.²⁹ By doing so, the cost of acquiring TVWS equipment will be reduced, making it more affordable for individuals

²⁷ UCC (2019). "Standard for tv white spaces access and use in Uganda". November. Available at www.ucc.co.ug/wp-content/uploads/2023/10/UCC-TVWS-standards.pdf.

²⁸ Available at dissertations.mak.ac.ug/handle/20.500.12281/7242.

²⁹ Amparo Canaveras (2012). "The Impact of the TV White Space Unlicensed Spectrum on the Wireless Industry Competition". September. Available at <http://dspace.mit.edu/bitstream/handle/1721.1/100358/931086911-MIT.pdf?sequence=1>.

and organizations to purchase and use TVWS devices. Furthermore, the government can facilitate the establishment of local TVWS equipment manufacturing or assembly facilities. This will not only reduce the cost of TVWS equipment, but also create job opportunities and contribute to the transfer of technology.

- Collaboration between government agencies and private companies can leverage private sector expertise and resources to make TVWS equipment more affordable. This can involve private companies investing in TVWS equipment deployment in exchange for tax breaks or subsidies. Additionally, public-private consortiums can work together to develop innovative financing models for TVWS projects, such as leasing or pay-as-you-go schemes. Such partnerships can help to make TVWS equipment more accessible and cost-effective, especially for low-income earners.^{30, 31}
- Encouraging the development and adoption of open-source TVWS equipment designs can reduce reliance on proprietary technologies and lead to more affordable alternatives. This approach can foster innovation and competition in the TVWS industry, leading to better quality and more affordable TVWS equipment.
- To ensure the sustainability of TVWS projects, it is necessary to train local communities on TVWS technology and its utilization. This capacity building should encompass several aspects, including equipping community members with the technical skills to install, maintain and troubleshoot TVWS equipment. This can be achieved through training workshops conducted by government agencies, NGOs, or private companies with expertise in TVWS technology.
- In addition to technical skills, digital literacy is essential to maximize the benefits of connectivity. Training programmes should focus on teaching users how to navigate the Internet safely and effectively, access online resources and utilize digital tools for communication, education and economic empowerment. Encouraging local content creation in languages and formats relevant to the community can further incentivize Internet adoption and ensure the network is used to its full potential. Workshops and training sessions can equip community members with the skills to develop websites, create digital content and participate in the online ecosystem. Overall, these measures can help to promote the adoption of TVWS technology and enhance digital literacy and skills among local communities in Uganda.

4.1.2 Satellite connectivity

For geographically isolated communities nestled in mountainous regions or vast plains, traditional terrestrial connectivity solutions such as fibre-optic cables often prove impractical and prohibitively expensive. However, advancements in satellite technology are opening doors for these remote areas, offering a glimmer of hope in bridging the digital divide.³² Satellite Internet technology offers a unique advantage - it can deliver broadband access virtually anywhere on Earth. Unlike terrestrial infrastructure that requires physical cables or towers within range, satellites orbit the planet, beaming Internet signals directly to user terminals on the ground.³³

³⁰ Many Possibilities (2020). "Saving TVWS". 8 March. Available at <https://manypossibilities.net/2022/03/saving-tvws/>.

³¹ Nominet (2016). "Getting started with TV White Space - Part 1: Initial Considerations". 1 September. Available at www.nominet.uk/getting-started-tv-white-space/.

³² Ernst and Young (2021). "Satellite connectivity: Combatting the digital divide to unlock long-term value". Available at https://assets.ey.com/content/dam/ey-sites/ey-com/en_uk/topics/tmt/ey-8-ey-satellite-connectivity.pdf?download.

³³ Satellite Internet (2024). "What Is Satellite Internet?" 7 March. Available at www.satelliteInternet.com/resources/what-is-satellite-Internet/.

This makes it particularly valuable for Internet connectivity, especially for the following unserved and underserved areas in Uganda.

- Geographically isolated communities: Mountain ranges such as the Rwenzoris or the Virunga Massifs, vast deserts such as the Karamoja region, sprawling savannahs in northern Uganda and scattered island communities in Lake Victoria – these are just some examples of the geographically diverse landscapes that pose significant challenges for traditional terrestrial Internet infrastructure. Satellite technology transcends these geographical barriers, offering a lifeline to these remote populations. Satellite Internet bridges these geographical divides, empowering remote communities to participate in the digital age and unlock a world of opportunities.³⁴
- Challenging terrain: Deploying fibre-optic cables or microwave towers often requires navigating rugged terrain with dense vegetation, deep valleys and extreme weather conditions. Uganda’s mountainous regions are characterized by steep slopes, deep gorges and unpredictable weather patterns, making it difficult to lay fibre-optic cables. However, with satellite Internet, remote highland communities can still enjoy reliable connectivity. The dense vegetation in Uganda’s lush rainforests and woodlands can also pose a challenge to terrestrial signals, causing attenuation or complete blockage. Fortunately, satellite Internet offers a viable solution, enabling these island communities to connect to the digital world and participate in the global information economy.^{35, 36, 37}

Challenges and considerations

Satellite Internet has had a mixed reputation in the past, with issues such as high latency and data caps making it a less appealing option for many users. However, recent advancements in satellite technology have brought about significant changes that make it a more viable choice for remote communities. The introduction of low-Earth orbit (LEO) satellites, which are placed in lower orbits, offers reduced latency, making them suitable for real-time applications such as videoconferencing or online gaming. Furthermore, satellite technology has seen improvements in available bandwidth, which allows for faster download and upload speeds. This means that users can enjoy a wider range of online activities. As the technology matures and competition intensifies, the cost of satellite Internet is also gradually decreasing, making it more financially accessible to underserved communities.³⁸ Despite cost reductions, satellite Internet may still be more expensive than terrestrial options in certain areas. This necessitates innovative financing models such as government subsidies, targeted NGO programmes or PPPs to make it more accessible. Additionally, data usage limitations can be a concern for users in areas with limited or no alternative connectivity options. It is important to explore flexible data plans or prioritize essential applications such as education and health care to help mitigate this challenge.³⁹

³⁴ Satellite Internet (2024). “Pros and Cons of Satellite Internet Service”. 10 January. Available at www.satelliteinternet.com/resources/satellite-Internet-pros-and-cons/.

³⁵ <https://utilitiesone.com/bridging-the-digital-divide-satellites-for-global-Internet-access>

³⁶ Shapehost (2024). “Satellite Internet: Bridging the Digital Divide in Remote Areas”. 23 January. Available at <https://shape.host/resources/satellite-Internet-bridging-the-digital-divide-in-remote-areas>.

³⁷ ResearchGate (2024). “Bridging the Digital Divide”. September. Available at www.researchgate.net/publication/373620797_Bridging_the_Digital_Divide.

³⁸ ResearchGate (2023). “The Advancements and Future of Satellite Internet Technology”. December. Available at www.researchgate.net/publication/376989265_The_Advancements_and_Future_of_Satellite_Internet_Technology.

³⁹ ITU News Magazine (2019). “Evolving satellite communications: ITU’s role in a brave new world”. No. 2. Available at www.itu.int/en/itu/news/Documents/2019/2019-02/2019_ITUNews02-en.pdf.

A collaborative approach in satellite

Despite the various challenges that come with it, the potential advantages of satellite Internet for remote communities in Uganda are immense and diverse. For instance, students can now access online learning resources, connect with educators from different parts of the world, and participate in virtual classrooms. In health care, telemedicine applications have made it possible for remote consultations with doctors, specialists and other health-care providers, thus improving access to vital medical services. Moreover, connectivity has empowered local businesses to participate in the digital economy, access online markets and connect with potential customers globally, thereby fostering economic development. Furthermore, satellite Internet has played a crucial role in bridging the digital divide, enabling remote communities to connect with family and friends, access information and participate in the online world, thus promoting social inclusion.⁴⁰ To ensure that satellite Internet has the greatest possible impact, multiple stakeholders need to collaborate effectively. This involves bringing together a range of individuals and organizations with different expertise, interests and perspectives, and working together to identify and address any challenges that may arise. This can be achieved as discussed below.

- Government: The government can play a critical role in narrowing the digital divide in Uganda's remote regions by implementing policies that enable satellite Internet providers to obtain licences more easily. The government can also explore options for subsidizing satellite Internet services in underserved communities, thereby increasing their accessibility and affordability. Another approach is to facilitate PPPs that accelerate infrastructure development and service delivery.
- Development partners, such as NGOs, can contribute by providing financial and technical assistance to local communities to purchase and install satellite equipment. They can also build capacity through training programmes on using and maintaining satellite Internet and promote digital literacy to ensure that communities can make the most of available online resources.
- Satellite Internet companies can also play a critical role by developing innovative financing models that make their services more accessible in rural areas. They can offer flexible data plans catering to the specific needs of remote communities, and partner with local organizations to facilitate on-the-ground support and training.

Satellite Internet presents a promising solution for bridging the digital divide in Uganda's remote regions. By addressing affordability concerns, fostering collaboration among stakeholders and focusing on capacity building, this technology can unlock a world of opportunities for geographically isolated communities, empowering them to participate in the digital age and chart a path toward a brighter future.

4.1.3 Mesh networks

The quest for universal Internet access in Uganda faces a significant challenge in remote areas. Traditional infrastructure solutions such as fibre-optic cables can be prohibitively expensive due to sparse populations and challenging terrain. A mesh network is defined as a type of local area network (LAN) topology, where multiple devices or nodes are connected in a non-hierarchical manner, so that they can coexist, cooperate and provide comprehensive network coverage to

⁴⁰ Uniting Aviation (2021). "A collaborative approach for the Ground and Satellite Augmentation Systems Task Force". 20 January. Available at <https://unitingaviation.com/regions/asia-pacific/a-collaborative-approach-for-the-ground-and-satellite-augmentation-systems-task-force/>.

a wider area than what is possible by a single router.^{41, 42} This new wave of technology – mesh networks – offers a glimmer of hope. These innovative networks, consisting of interconnected devices that relay signals, present a decentralized and potentially transformative approach to bridging the digital divide.⁴³ Unlike traditional networks with a central hub, mesh networks function as a distributed system. Individual devices within the network, known as nodes, act as both routers and receivers, relaying signals to each other and extending the overall reach of the network. Imagine a village nestled amid rolling hills, where each household possesses a mesh node. These nodes work together, weaving a web of connectivity that blankets the entire community, ensuring Internet access for everyone.⁴⁴

The benefits of mesh networks are highlighted below:

- Mesh networks are a type of decentralized architecture that offers a high degree of resiliency against outages. By distributing processing power and information storage across multiple nodes, they eliminate the risk of a single point of failure that could bring down the entire system. This means that if one node goes down, the network can automatically reroute traffic through other available nodes, keeping connectivity uninterrupted for users.
- Mesh networks are also highly scalable, allowing for gradual and cost-effective expansion as new nodes are added to the system. This makes them an ideal solution for communities with evolving connectivity demands, as they can be tailored to meet specific needs.
- In addition to their scalability and resiliency, mesh networks are also highly cost-effective. Unlike traditional infrastructure projects, they require minimal investment in physical cables or towers. By leveraging existing infrastructure such as electricity grids, nodes can be powered without incurring additional operational costs.^{45, 46}
- Mesh networks are highly adaptable, making them well suited to the diverse terrain of Uganda. Nodes can be strategically placed to overcome obstacles in the environment or provide stronger signal strength in specific areas. This flexibility allows mesh networks to cater to the unique needs of each community, from densely populated rural settlements to sparsely scattered villages.⁴⁷

Mesh networks Ugandan context

ISPs have pointed out that mesh networks hold enormous potential in addressing the connectivity challenges faced by remote villages, underserved urban areas and disaster-stricken regions.

In remote villages, where geographical isolation and inadequate infrastructure are common, mesh networks provide a cost-effective and scalable solution. By utilizing the existing community resources – such as schools, health centres or community centres – mesh nodes can be set up,

⁴¹ Spiceworks (2022). "What Is a Mesh Network? Meaning, Types Working, and Applications in 2022". 12 August. Available at www.spiceworks.com/tech/networking/articles/what-is-mesh-network/.

⁴² TechTarget (n.d.). "Wireless mesh network (WMN)". Available at www.techtarget.com/searchnetworking/definition/wireless-mesh-network.

⁴³ IEEE Xplore (2011). "A Survey of Network Design Problems and Joint Design Approaches in Wireless Mesh Networks". Volume 13, Issue 3, third quarter. Available at <https://ieeexplore.ieee.org/abstract/document/5497855>.

⁴⁴ Google Support (n.d.). "What is a mesh network?" Available at <https://support.google.com/googlenest/answer/7182746?hl=en>.

⁴⁵ Spiceworks (2022). "What Is a Mesh Network? Meaning, Types Working, and Applications in 2022". 12 August. Available at www.spiceworks.com/tech/networking/articles/what-is-mesh-network/.

⁴⁶ TechTarget (n.d.). "Wireless mesh network (WMN)". Available at www.techtarget.com/searchnetworking/definition/wireless-mesh-network.

⁴⁷ Google Support (n.d.). "What is a mesh network?" Available at <https://support.google.com/googlenest/answer/7182746?hl=en>.

thus extending connectivity to surrounding households and businesses. For instance, a school in a remote village can be transformed into a connectivity hub, empowering students with access to online learning resources and enabling teachers to connect with educational tools and platforms

In densely populated but underserved urban slums and peri-urban areas, mesh networks can be deployed on existing structures such as electricity poles or rooftops, establishing a community-driven network that provides residents with affordable Internet access. This fosters social inclusion, empowers residents through online entrepreneurship opportunities, and opens doors to e-government services and telemedicine applications.

The decentralized nature of mesh networks makes them particularly valuable in disaster response scenarios. In areas hit by natural disasters that damage traditional infrastructure, mesh networks can be rapidly deployed to establish temporary communication channels between relief organizations, government agencies and affected communities. This facilitates critical coordination efforts in emergencies, ensuring timely delivery of aid and fostering a faster recovery process.

Building a sustainable mesh network ecosystem

To ensure the maximum impact of mesh networks in Uganda, several vital considerations need to be considered.

- One of the most crucial is **community engagement**. For a successful mesh network deployment, it is essential to involve the residents in the planning, installation and maintenance of the network. This approach fosters a sense of ownership and ensures long-term sustainability. Community members can be equipped with the necessary skills through training programmes to manage the network, troubleshoot issues and contribute to its ongoing development.
- Another important aspect is **capacity building**. Building digital literacy within communities is essential for the effective utilization of mesh networks. This includes training on safe browsing practices, accessing online resources and utilizing digital tools for communication, education and economic empowerment. By promoting digital skills among the people, they can take full advantage of the network capabilities and harness its potential for their benefit.
- Encouraging the **development of local content** in languages and formats relevant to the communities is another vital consideration. It can further incentivize Internet adoption and ensure the network is used to its full potential. Workshops and training sessions can equip community members with the skills to create websites and digital content, and actively participate in the online ecosystem. This approach can help to bridge the digital divide and ensure that everyone can benefit from the advantages of mesh networking.
- One of the most effective ways to accelerate the deployment of mesh networks in underserved regions is through the **collaboration** between government agencies, ISPs and private sector entities. Such partnerships can leverage the collective expertise, resources and innovative financing models to make mesh networks more accessible in remote areas. The government, for instance, can provide tax breaks or subsidies to incentivize private sector investment in mesh network projects. On the other hand, public-private consortiums can develop innovative financing mechanisms, such as pay-as-you-go models or microloans, to enable communities to acquire mesh node devices.
- **Continuous research and development** in mesh technology hold the promise of further improving its capabilities. For instance, advancements in antenna technology and signal modulation techniques can significantly extend the range of individual mesh nodes, enabling them to cover larger areas, ultimately reducing the overall number of nodes

needed for a network. Furthermore, robust encryption protocols and user authentication mechanisms are crucial for ensuring the security of mesh networks and protecting user data. Advancements in these areas can build trust and encourage wider adoption. Additionally, self-healing capabilities of mesh networks, which enable them to detect and reroute traffic around malfunctioning nodes, can be further enhanced, leading to even more reliable and resilient network performance.^{48, 49}

4.1.4 Network as a service

Another potential solution to the challenges of last-mile connectivity interventions in Uganda is the use of network as a service (NaaS) models. NaaS being a cloud-based network infrastructure delivery model where a third-party provider delivers network services and infrastructure over the Internet, on-demand and pay-per-use basis can be used to provide Internet access to underserved communities in Uganda in several ways, including community networks, mobile networks, fixed wireless and satellite. There are several potential benefits to using NaaS, including reduced costs, as the service provider is responsible for infrastructure and maintenance, reducing the financial burden on local communities and organizations. There is also increased scalability, as service providers can quickly increase or decrease network capacity as needed, making it an ideal solution for areas with varying population densities. NaaS can be flexible in terms of network services - including Wi-Fi, long-term evolution (LTE) and optical fibre - allowing for a range of connectivity options. Rapid deployment in NaaS is possible as the service providers have existing infrastructure and can rapidly provision new services, reducing the time and effort required to set up new networks. It can have multiple data centres and built-in redundancy, ensuring high uptime and reliability.

To implement NaaS in Uganda, several stakeholders will need to be involved, including NaaS providers, local ISPs, mobile operators, community networks and government agencies. In terms of implementation, NaaS providers will need to work closely with local ISPs, mobile operators, community networks and government agencies to ensure seamless deployment and management of services.

4.1.5 Conclusion

The optimal technology choice will depend on various factors, including geography, population density, existing infrastructure and intended applications. A thorough assessment considering these factors is crucial for project success.

4.2 Project ideas for remote connectivity

4.2.1 Project 1: Leveraging TV white space for rural broadband access

Following the success of the RCBN pilot project, the proposed initiative aims to scale up TVWS coverage and make it accessible to more underserved regions in Uganda. This would involve extending the reach of TVWS technology to areas where existing infrastructure is limited or non-existent. To ensure effective deployment, capacity building and content development,

⁴⁸ Google Support (n.d.). "What is a mesh network?" Available at <https://support.google.com/googlenest/answer/7182746?hl=en>.

⁴⁹ ResearchGate (2019). "Blockchain for economically sustainable wireless mesh networks". Available at www.researchgate.net/publication/333426100_Blockchain_for_economically_sustainable_wireless_mesh_networks.

RBCN plans to collaborate with local authorities, NGOs and community networks. Additionally, the organization intends to engage with MNOs and ISPs to establish PPPs and leverage their expertise and infrastructure for broader service delivery.

4.2.2 Project 2: Deploying mesh networks in underserved areas

The proposed initiative aims to investigate the potential of mesh networks in densely populated but underserved areas. The project would entail conducting pilot projects in strategic locations across Uganda to assess the feasibility and effectiveness of mesh networks in the local context. To achieve this objective, the project would collaborate with local communities and ISPs to identify suitable test sites. This project would promote community ownership by involving residents in network maintenance and encouraging a sense of shared responsibility. Furthermore, the project would evaluate the scalability potential of mesh networks to determine their suitability for wider deployment in underserved regions. The findings of this initiative could have significant implications for expanding Internet access to communities that are currently underserved and could help bridge the digital divide in Uganda.

4.2.3 Project 3: Integrating satellite connectivity for remote communities

The proposed project aims to address the issue of the digital divide in remote and isolated regions by focusing on four key areas. Firstly, the project will identify priority regions by collaborating with government agencies and local stakeholders to determine areas with limited or no connectivity options. Secondly, partnerships will be explored with satellite Internet providers to develop innovative financing models and ensure cost-effectiveness. Thirdly, content delivery optimization will be prioritized to minimize bandwidth usage, considering the constraints of satellite Internet speeds. Finally, the project will prioritize the development of applications such as telemedicine and e-learning, which have the potential to bring about significant positive changes in remote communities despite the limitations of bandwidth.

4.3 Consideration

To establish sustainable last-mile connectivity in Uganda, a collaborative approach is required that integrates policy, technology innovation and community engagement. The use of alternative technologies such as TVWS, mesh networks and satellite Internet can be leveraged by concerned parties to extend connectivity to remote areas and empower marginalized populations. It is imperative to prioritize infrastructure development, capacity building and community ownership to ensure long-term success. The ideas presented above can serve as a starting point for tackling the challenge of digital inclusion in Uganda. By implementing these projects and fostering a supportive ecosystem, stakeholders can bridge the digital divide and unlock the immense transformative potential of connectivity for the benefit of all Ugandans.

5 Economically unviable areas in Uganda

5.1 Introduction

Last-mile connectivity is a pressing issue in Uganda, where a staggering 71 per cent of the population resides in rural areas, according to the Uganda Bureau of Statistics (2020). The country's rugged terrain, with over 50 per cent of its land covered in hills and valleys, makes it challenging to install and maintain connectivity infrastructure such as fibre-optic cables or cell towers.⁵⁰ This has resulted in a significant urban-rural divide in terms of access to the Internet, with only 22 per cent of rural households having access to the Internet, compared with 55 per cent of urban households.⁵¹ As of 2023, there were 11.77 million Internet users in Uganda, representing an Internet penetration rate of 24.6 per cent.⁵² Despite the increase in access, inequality has increased, with women and rural dwellers experiencing increased marginalization. According to a report by the Uganda Communications Commission, mobile network coverage in Uganda increased from 44 per cent in 2015 to 74 per cent in 2020 (Uganda Communications Commission, 2020). However, there are still significant gaps in coverage, particularly in rural areas. For instance, a study by the GSMA found that while mobile network coverage has improved in Uganda, there are still around 10 million people living in areas with no mobile network coverage (GSMA, 2020).

5.2 Characteristics of economically unviable areas

The economic viability of connecting rural areas – mostly in north-eastern Uganda, south-western Uganda and some parts of northern Uganda – is also a concern, with an estimated 38 per cent of the population living below the poverty line.⁵³ The World Bank Uganda Economic Update report provides context for understanding Uganda's economic growth. Between 2012 and 2016, the poverty rate increased from 19.7 to 21.4 per cent, and growth averaged only 4.4 per cent, far below the National Development Plan targets of 7.2 and 6.3 per cent, respectively. This slowdown was mainly attributed to challenges for productivity growth, several shocks, private sector credit constraints and poor execution of public projects. This makes it difficult for companies to invest in connectivity infrastructure in areas with limited economic activity. Leaving the investors aside, people will tend to prioritize real basic needs such as food and water over Internet connectivity. Furthermore, reports from the Uganda National Roads Authority, 2020 and the Electricity Regulatory Authority, 2020, say that the lack of basic infrastructure – such as roads, electricity and water in some areas^{54, 55} – makes it difficult to deploy and maintain connectivity infrastructure. Government needs to prioritize offering these services as it will and influence the uptake of these last-mile connectivity intervention.

⁵⁰ Uganda Ministry of Lands, Housing and Urban Development (n.d.). Department of Surveys and Mapping. Available at <https://mlhud.go.ug/lands-managment/department-of-surveys-and-mapping/>.

⁵¹ Available at www.ubos.org/wp-content/uploads/publications/09_2021Uganda-National-Survey-Report-2019-2020.pdf.

⁵² Datareportal (2023). Digital 2023: Uganda. Available at <https://datareportal.com/reports/digital-2023-uganda>.

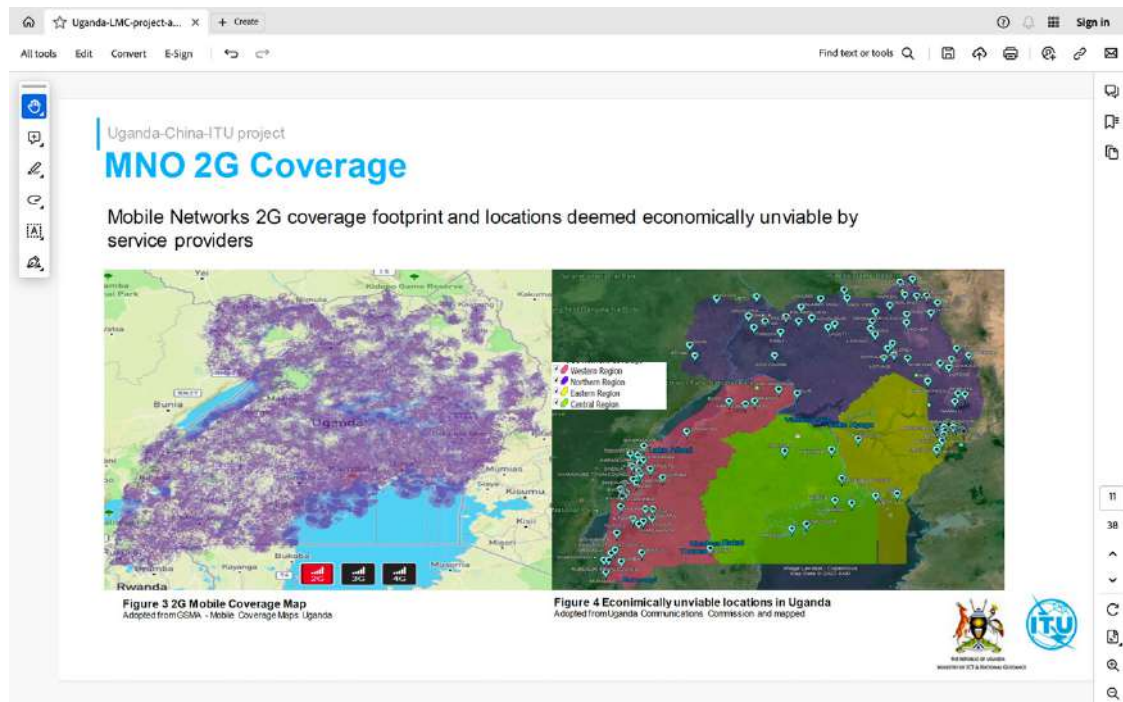
⁵³ Uganda Bureau of Statistics (2021). Uganda National Household Survey 2019/2020. Available at www.ubos.org/wp-content/uploads/publications/09_2021Uganda-National-Survey-Report-2019-2020.pdf.

⁵⁴ Uganda Electricity Regulatory Authority (n.d.). Reports. Available at www.era.go.ug/index.php/resource-centre/publications/reports.

⁵⁵ Uganda Office of the Auditor General (n.d.). Report of the auditor general on the financial statements of Uganda National Roads Authority for the financial year ended 30th June 2020. Available at www.oag.go.ug/reports/852.

5.3 Economically unviable areas

Figure 14: 2G mobile coverage map

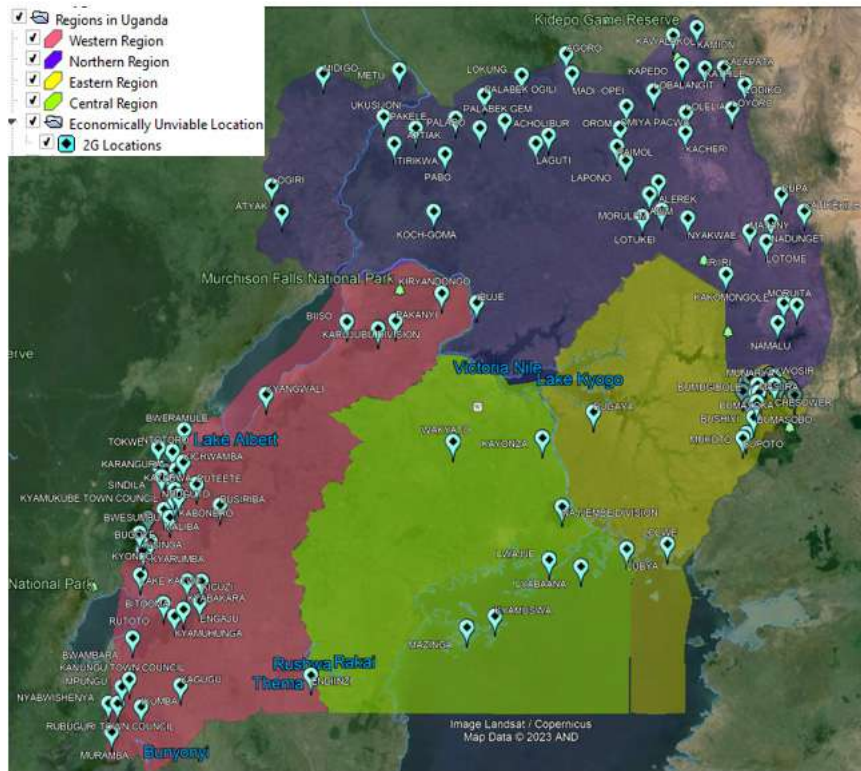


Source: Adopted from GSMA-Mobile Coverage Maps Uganda

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by ITU.

Figure 14 shows the consolidated 2G mobile network coverage maps simulation adopted from GSMA depicting coverage gaps in the northern and north-eastern regions of Uganda. There are also pockets of poor coverage in western and south-western regions of the country.

Figure 15: Economically unviable locations in Uganda with reference to 2G network coverage

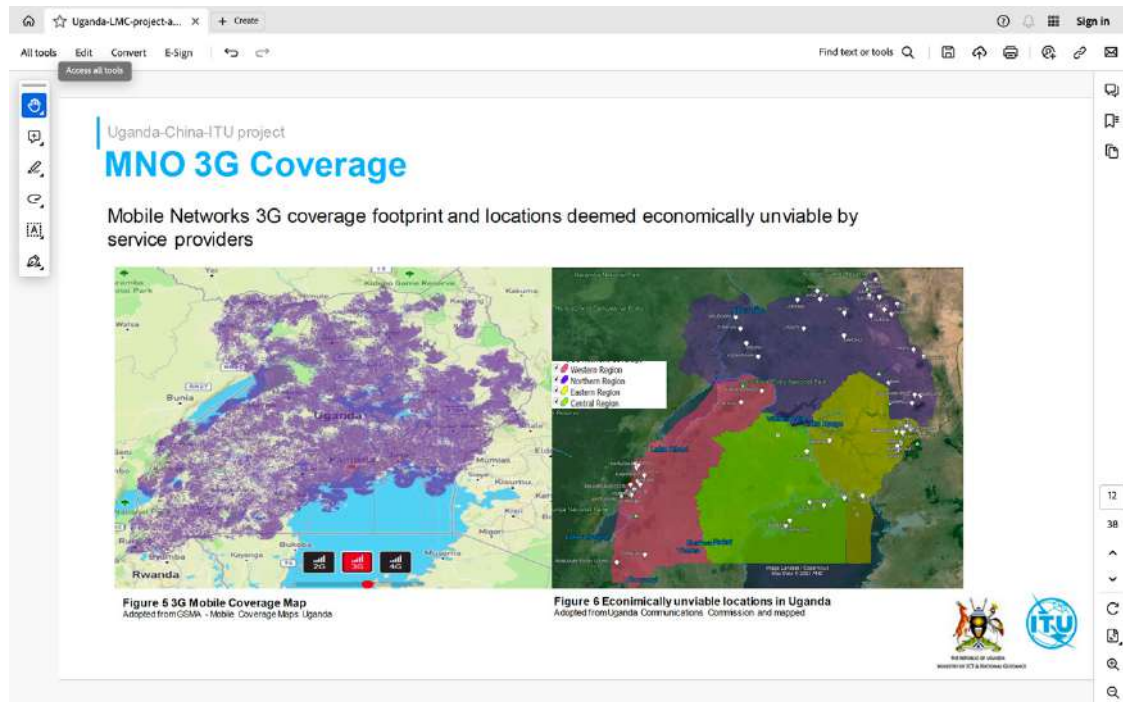


Source: Adopted from Uganda Communications Commission and mapped.

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by ITU.

Figure 15 shows the locations that have been deemed economically unviable by service providers (MNOs and ISPs). These locations are predominantly in the northern region, especially in the north-eastern Karamoja subregion. The western and south-western mountainous areas of the Mount Rwenzori mountain range and the eastern region, along with the islands in Lake Victoria, are also deemed economically unviable by the service providers.

Figure 16: 3G Mobile coverage map

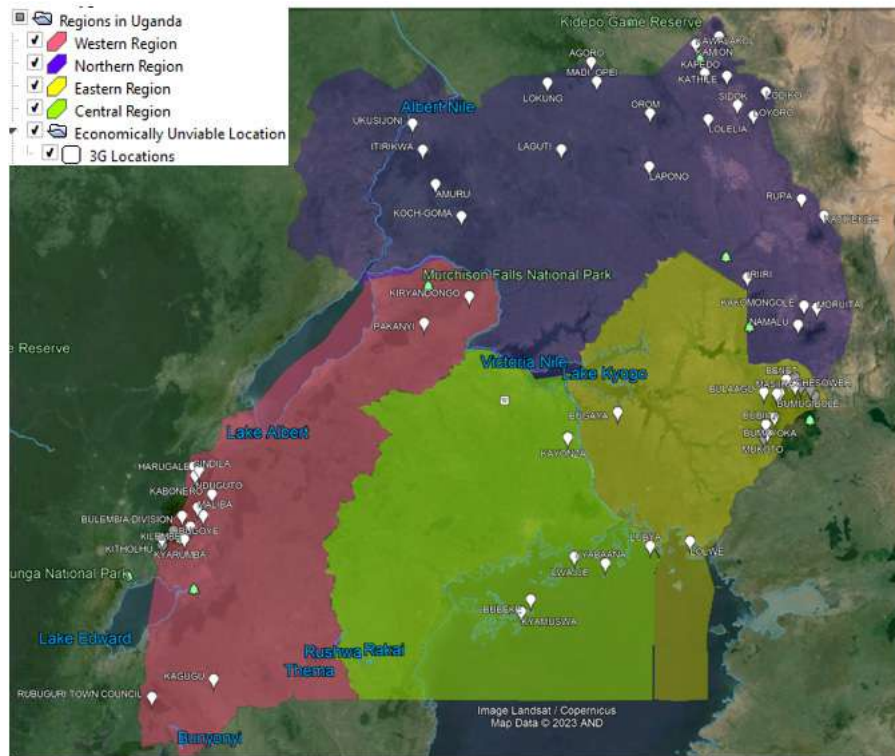


Source: Adopted from GSMA-Mobile Coverage Maps Uganda.

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by ITU.

Figure 16 shows the consolidated 3G mobile network coverage maps simulation adopted from GSMA depicting coverage gaps in the northern and north-eastern regions of Uganda. There are also pockets of poor coverage in western and south-western regions of the country.

Figure 17: Economically unviable locations in Uganda with reference to 3G network coverage



Source: Adopted from Uganda Communications Commission and mapped.

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by ITU.

Figure 17 shows the locations that have been deemed economically unviable by service providers (MNOs and ISPs). These locations are predominantly in the northern region, especially in the north-eastern Karamoja subregion. The western and south-western mountainous areas of the Mount Rwenzori mountain range and the eastern region, along with the islands in Lake Victoria, are also deemed economically unviable by the service providers.

6 Investment prospects for extending last-mile Internet access to remote and rural areas in Uganda

6.1 Introduction

Uganda, like many countries in Africa, has experienced significant growth in Internet usage in recent years. Internet connectivity is crucial for economic development, education, health care and various other sectors in Uganda. However, the challenge of last-mile connectivity remains a significant barrier to accessing the Internet for many Ugandans, particularly those in rural areas. This section of the report describes the investment opportunities in addressing this challenge and expanding Internet last-mile connectivity infrastructure in Uganda.

6.2 Investment opportunities

6.2.1 Cross-sectoral infrastructure sharing

Infrastructure deployment for expansion of telecommunication network coverage in rural and remote areas of Uganda is capital-intensive due to the need for additional base stations and towers. Traditionally, this has involved deploying new infrastructure. However, there is an opportunity to leverage existing infrastructure for more efficient deployment.

Cross-sectoral infrastructure sharing is one approach to explore, specifically by utilizing existing power transmission towers for co-location of telecommunication equipment. This strategy has been successfully implemented in countries such as China and India, demonstrating its effectiveness in expanding telecommunication networks in underserved regions. Currently, the telecommunication and energy sectors in Uganda operate in silos, meaning they plan and deploy infrastructure independently. This siloed approach leads to inefficiencies, such as:

- Duplication of efforts: Both sectors build separate towers or lay separate lines in some areas, which increases overall expenditure and environmental impact.
- Slower broadband proliferation: The high cost of deploying new infrastructure in remote areas hinders the expansion of broadband access.

The existing infrastructure of power towers can be used instead of erecting new telecommunication towers for last-mile connectivity to save and rationalize the capital cost.

Countries such as China and India have successfully implemented cross-sectoral infrastructure sharing of power towers for telecommunication purposes.⁵⁶ These nations have demonstrated the effectiveness of leveraging existing power infrastructure to expand telecommunication networks, particularly in rural and remote areas. Uganda can learn from these case studies and emulate similar strategies to accelerate last-mile connectivity efforts. Digital and electricity networks connect consumers in similar ways. Both require wide distribution networks, yet the cost to build or extend these networks is significant. By sharing networks and working together,

⁵⁶ China Daily (2018). "Agreement allows China's telecoms, power grid to share towers". 25 April. Available at www.chinadaily.com.cn/a/201804/25/WS5ae0216ea3105cdcf651a6de.html.

these two sectors can help one another achieve access and service quality goals, while sharing the costs.⁵⁷

The benefits of cross-sectoral infrastructure sharing include:

- **Cost reduction:** Sharing power transmission towers for communication purposes helps reduce the capital expenditure associated with deploying new telecommunication towers. This cost-saving measure enables telecommunication operators to invest resources more efficiently and extend coverage to underserved areas without incurring prohibitive costs.
- **Efficient resource utilization:** By leveraging existing infrastructure, such as power towers, both the electricity and telecommunication sectors can optimize resource utilization. This approach minimizes duplication of efforts and infrastructure, leading to improved efficiency and sustainability in infrastructure deployment.
- **Enhanced service quality:** Cross-sectoral infrastructure sharing facilitates the rapid expansion of telecommunication networks, thereby improving service quality and reliability for end users in rural and remote areas. Enhanced connectivity contributes to socio-economic development by enabling access to essential services, education, health care and economic opportunities.
- **To promote cross-sectoral infrastructure sharing,** the government should conduct a thorough review of existing policies and regulatory frameworks related to power grid infrastructure sharing for telecommunication purposes. This review should identify any inadequacies or barriers that hinder collaboration between the utility and telecommunication sectors. Based on the findings, the government can then develop supportive policies and frameworks that incentivize collaboration, streamline regulatory approvals for infrastructure deployment, and establish clear guidelines for sharing power infrastructure for telecommunication purposes.

6.2.2 Submarine cable to connect islands

Last-mile connectivity to the islands of Lake Victoria among other lakes in Uganda is predominantly restricted to MNOs that backhaul their mobile base stations by microwave transmission across the lake to mainland points of presence. The performance of microwave links over water bodies is prone to service degradation. This has edged out ISPs from having the opportunity to offer their services and tap into the tourism and palm oil economic activities on the islands.

There is an opportunity for the government to invest in a submarine fibre-optic cable to link the islands to the mainland and offer an opportunity for more service providers to be able to advance last-mile connectivity to the island communities. The Government of Uganda is already deploying a similar project in the energy sector by laying a submarine power cable to extend the power grid to the island districts of Buvuma and Kalangala, an initiative the Electricity Regulatory Authority (ERA) says will significantly lower the power costs by half the power tariffs for both commercial and domestic consumers.⁵⁸ This initiative, endorsed by ERA, demonstrates the government commitment to infrastructure development for remote areas.

Additionally, reference can be drawn from Tanzania's extension of the National ICT Broadband Backbone to the Democratic Republic of the Congo by constructing submarine fibre-optic

⁵⁷ World Bank (2018). "Infrastructure sharing in energy and digital development: takeaways from cross-sectoral cooperation". 17 May. Available at <https://blogs.worldbank.org/ppps/infrastructure-sharing-energy-and-digital-development-takeaways-cross-sectoral-cooperation>.

⁵⁸ Business Times Uganda (2024). "Power Costs In Kalangala, Buvuma To Go Down As Islands Get Connected To National Power Grid". 5 February. Available at <https://businesstimesug.com/power-costs-in-kalangala-buvuma-to-go-down-as-islands-get-connected-to-national-power-grid/>.

cables across Lake Tanganyika, establishing points of presence (PoPs) for connectivity provision with the Democratic Republic of the Congo.⁵⁹

The rationale for investing in submarine cable is drawn from the following:

- **Government initiatives:** The Government of Uganda has already demonstrated its commitment to infrastructure development by deploying a submarine power cable to extend the power grid to island districts. Emulating this success in the telecommunication sector aligns with broader efforts to improve infrastructure and connectivity across the country.
- **Improved connectivity:** A submarine fibre-optic cable offers reliable and high-speed connectivity, overcoming the limitations of microwave transmission over water bodies. This infrastructure upgrade will enhance Internet access for residents, businesses and tourists on the islands, fostering economic growth and development.
- **Increased competition:** Currently, MNOs dominate island connectivity, limiting competition and innovation in service provision. Introducing a submarine cable opens up opportunities for multiple ISPs to enter the market, driving competition, improving service quality and potentially lowering costs for consumers.
- **Tourism and economic development:** The islands of Lake Victoria hold significant potential for tourism and agricultural industries such as palm oil production. Improved connectivity through a submarine cable can attract investment, facilitate e-commerce and enable access to online booking platforms, enhancing tourism and business opportunities on the islands.
- **Regional precedent:** Similar projects in the region, such as Tanzania's extension of the National ICT Broadband Backbone across Lake Tanganyika, showcase the feasibility and benefits of submarine cable deployments for enhancing connectivity to remote areas.
- **Social and economic benefits:** Improved ICT access can foster inclusive growth by promoting e-commerce, online education, telemedicine and efficient service delivery, contributing to the overall social and economic development of the country.

6.2.3 Community networks

Supporting community-led initiatives to establish and maintain local Internet networks can play a crucial role in bridging the digital divide in rural areas. Investing in capacity building, technical training and equipment provision can empower communities to deploy and manage their Internet infrastructure sustainably. Collaborating with established community networks such as RCBN RENU and BOSCO presents an opportunity to leverage innovative, impactful and sustainable models for advancing last-mile connectivity to unserved and underserved communities.

RCBN is a netLabs!UG project aimed to pilot a model for rural broadband connectivity in support of a knowledge-based economy with a focus on two sectors: agriculture and education.⁶⁰

Referencing the success of AirJaldi in India as a community-driven initiative can be beneficial. AirJaldi started as a local community operator and grew to serve a significant number of users, showcasing the effectiveness of community-driven approaches in expanding connectivity.⁶¹ Granting community operator licences with reduced fees and obligations,

⁵⁹ PIDA (n.d.). Approved project. Available at <https://pp2.au-pida.org/approved-project/entry/lnbt6/>.

⁶⁰ <http://www.netlabsug.org/website/projects/projectsingle/5>

⁶¹ AirJaldi Networks (n.d.). Profile. Available at <https://airjaldi.com/profile>.

Uganda could empower local communities to establish and oversee their networks, promoting inclusivity and sustainability in the deployment and management of Internet infrastructure.

The rationale for investing in community networks includes the following:

- Empowerment of rural communities: Community-led initiatives empower rural communities to take ownership of their connectivity solutions, fostering a sense of ownership and self-reliance. By investing in capacity building and technical training, communities acquire the skills and knowledge necessary to deploy and manage their Internet infrastructure effectively.
- Innovative and sustainable models: Community networks such as RCBN, BOSCO and RENU have demonstrated innovative and sustainable approaches to advancing last-mile connectivity. By collaborating with these networks, investors can leverage existing expertise, networks and resources to amplify the impact of investment initiatives.
- Addressing cost barriers: High costs associated with acquiring last-mile connectivity equipment and infrastructure pose significant barriers to community-led initiatives. Collaborative investments can help relieve community networks from this cost burden, enabling them to focus on network expansion and sustainability efforts.
- Local economic development: Strengthening community networks fosters local economic development by creating opportunities for entrepreneurship, education and e-commerce. Improved Internet connectivity enhances access to markets, information and services, driving economic growth and poverty reduction in rural areas.
- Social inclusion and empowerment: Access to the Internet empowers rural communities by facilitating access to educational resources, health-care information and government services. Community networks promote social inclusion and participation, bridging the digital divide and fostering community development.

6.2.4 Harnessing network-as-a-service models in Uganda

In today's interconnected world, access to reliable Internet connectivity is no longer a luxury but a necessity. However, bridging the digital divide, especially in rural and remote areas, remains a significant challenge. Traditional approaches to network deployment have often proven costly and inefficient, leaving many communities underserved. In this context, the emergence of NaaS models offers a promising solution to expand last-mile connectivity, particularly in regions like Uganda.

NaaS models represent a paradigm shift in how network infrastructure is deployed and managed. Unlike the traditional model, where MNOs and ISPs shoulder the entire burden of infrastructure investment and maintenance, NaaS providers such as Africa Mobile Networks (AMN) and NuRAN Wireless offer a collaborative approach. These providers deploy and manage network infrastructure on behalf of MNOs and ISPs, leveraging regulatory spectrum licensing agreements and geographical coverage requirements to offer cost-effective solutions tailored to underserved areas.

The benefits of NaaS models for Uganda are manifold. Firstly, they significantly reduce the investment barrier and accelerate network roll-out. By sharing the infrastructure and operational costs, MNOs and ISPs can extend their reach without incurring prohibitive upfront expenses. Moreover, the proven track record of companies such as AMN and NuRAN in deploying affordable solutions in sub-Saharan Africa instils confidence in potential partners, mitigating risk.

One of the distinguishing features of NaaS models is their revenue-sharing approach. Unlike traditional arrangements where MNOs and ISPs bear the financial burden alone, NaaS providers

offer a zero-margin guarantee, ensuring that partners do not incur losses. This mutually beneficial arrangement incentivizes providers to prioritize network performance and success, fostering a sustainable ecosystem for expanding connectivity.

In contrast, TowerCo models, another prevalent approach to infrastructure deployment, primarily focus on providing passive infrastructure. These companies build and maintain telecommunication towers, leasing space to multiple MNOs and ISPs. However, unlike NaaS providers, TowerCo models do not offer network management services or handle connectivity directly, limiting their scope of involvement.

The key differences between NaaS and TowerCo models lie in their service offerings, scope of involvement, and risk-sharing mechanisms. While NaaS providers offer a comprehensive network service encompassing infrastructure deployment, management and connectivity, TowerCo models primarily provide passive infrastructure leasing services. Additionally, NaaS providers are actively engaged in managing and operating the network, whereas TowerCo models have a more hands-off approach, focusing solely on infrastructure provision.

In conclusion, the adoption of NaaS models holds tremendous potential for enhancing last-mile connectivity in Uganda and similar regions. By leveraging collaborative partnerships, innovative business models and regulatory frameworks, NaaS providers can overcome the barriers that have traditionally impeded network expansion. As the digital landscape continues to evolve, embracing NaaS represents a significant step towards building inclusive and resilient telecommunication infrastructure that empowers communities and drives socio-economic development.

6.2.5 Digital inclusion programmes

Investing in digital literacy programmes and awareness campaigns can enhance the adoption of Internet services in rural and remote areas. Partnering with local authorities, schools and community organizations can facilitate the design and implementation of tailored interventions to address the specific needs of target communities.

Digital literacy is a crucial skill set that enables individuals to access, evaluate and use information effectively and efficiently in the digital age. In Uganda, digital literacy is essential for socio-economic development, as it contributes to bridging the digital divide, promoting digital citizenship and fostering opportunities for individuals to break cycles of poverty.

Uganda has made significant strides in promoting digital literacy through various government initiatives. The installation of ICT labs in secondary schools,⁶² the creation of an e-learning platform and the provision of digital literacy training grants for women demonstrate a strong commitment to bridging the digital divide.⁶³ The Uganda Communications Commission (UCC) has also launched the programme to enhance ICT adoption through digital literacy for rural border communities. Successful applicants are expected to partner with UCC/UCUSAF to conduct digital literacy training for community members and conduct baseline surveys on ICT usage in selected border locations. These efforts are part of the broader objective to bridge the digital

⁶² Uganda Communications Commission (n.d.). "ICT in Education Program". Available at www.ucc.co.ug/ucusaf/ict-in-education-program/.

⁶³ Telecompaper (2022). "UCC offers grants to provide digital literacy training to women through universal service fund". 26 January. Available at www.telecompaper.com/news/ucc-offers-grants-to-provide-digital-literacy-training-to-women-through-universal-service-fund--1411748.

divide, empower communities, facilitate citizen services through digital means, create learning interest, improve life skills, and enhance employment opportunities and entrepreneurship in rural areas.⁶⁴ This top-down approach focuses on improving educational quality (Sustainable Development Goal 4) and empowering women (Sustainable Development Goal 5) through digital skills development. Partnerships with NGOs and international organizations further strengthen this multifaceted approach.

However, there are areas where Uganda's digital literacy programmes can be further enhanced. While the focus on secondary schools is commendable, it potentially neglects other demographics in rural areas that could benefit greatly from digital skills. Farmers could leverage online resources for improved agricultural practices, while young children could gain access to educational opportunities beyond their immediate surroundings. The report also lacks details on the long-term sustainability of these programmes. Ensuring continued support and knowledge transfer beyond initial interventions is crucial for lasting impact.

A key weakness lies in the potential overemphasis on infrastructure provision over core skills development. While equipping schools with ICT labs and resource centres is a positive step, it is equally important to build strong digital literacy skills and encourage the creation of locally relevant content. The current focus seems tilted towards hardware rather than fostering a culture of digital fluency and content creation within communities.

Fortunately, Uganda can learn from successful models implemented elsewhere. The World Bank, in collaboration with ITU EQUALS, has launched a new programme to support digital skills development in Africa, focusing on bridging the digital gender divide. This initiative involves piloting digital literacy programmes targeting women and girls through various delivery models, including online and in-person training, mentorship support, access to digital technologies and soft skills training. The project aims to assess the effectiveness of these programmes and identify best practices for digital skills development, with a focus on empowering women and girls in the digital economy.⁶⁵

This initiative is particularly relevant in Uganda, where there is a significant gender divide in digital literacy skills. According to the UCC, women account for only 34 per cent of Internet users, compared with men, who account for 66 per cent. Bridging this divide through targeted digital literacy programmes can significantly enhance women's participation in the digital economy, contributing to socio-economic development in both rural and urban areas of Uganda.

Rwanda's Digital Ambassadors Program (DAP) is another successful model for digital literacy initiatives. Led by the Rwanda Information Society Authority, the programme aims to increase the number of digitally literate citizens and promote the use of e-services. The DAP initiative enhances access to information, Internet services, ICT infrastructure and online applications for providing services, aligning with broader objectives of socio-economic development through digital inclusion.⁶⁶

⁶⁴ ChimpReports (2022). "UCC Moves to Enhance Digital Literacy for Rural Border Communities, Calls for Partners". 21 March. Available at <https://chimpreports.com/ucc-moves-to-enhance-digital-literacy-for-rural-border-communities-calls-for-partners/>.

⁶⁵ World Bank (2021). "The World Bank in partnership with EQUALS launches new program to support digital skills development". 26 March. Available at <https://blogs.worldbank.org/en/digital-development/world-bank-partnership-equals-launches-new-program-support-digital-skills>.

⁶⁶ Rwanda Information Society Authority (2024). "Digital Ambassadors Program (DAP)". Available at [www.risa.gov.rw/projects/digital-ambassadors-program#:~:text=Status&text=The%20Digital%20Ambassadors%20Program%20\(DAP,their%20use%20of%20e%2Dservices](http://www.risa.gov.rw/projects/digital-ambassadors-program#:~:text=Status&text=The%20Digital%20Ambassadors%20Program%20(DAP,their%20use%20of%20e%2Dservices).

In rural and remote areas of Uganda, where access to digital technologies and information is limited, the DAP initiative offers a potential blueprint for implementation. The programme transforms rural communities into digitally literate and skilled communities through digital literacy training. By upskilling youth and providing work experience opportunities, the DAP initiative contributes to local community development, enhancing socio-economic development in Uganda.

The DigComp framework provides a structured approach to understanding and improving digital competence. Developed by the European Commission, the framework identifies the digital competencies necessary for individuals to thrive in the digital age. By leveraging the DigComp framework, Uganda can tailor digital literacy programmes to address specific competencies needed for socio-economic development and digital inclusion in rural and remote areas.⁶⁷

Overcoming limited Internet access remains a significant challenge in rural Uganda. Partnering with mobile network operators to provide affordable data plans or establishing public Wi-Fi hotspots in key locations could significantly improve connectivity. Additionally, exploring low-bandwidth tools and developing offline learning resources can cater to situations where Internet access is unreliable.

Developing localized training materials in Ugandan languages is another crucial step. Content that is culturally relevant and addresses the specific needs and challenges faced by rural communities will resonate more effectively with learners. This approach fosters a sense of ownership and empowers communities to take charge of their digital literacy journeys.

Building a sustainable digital literacy strategy requires a collaborative effort. Partnerships with local schools, NGOs and community leaders are essential to ensure continued programme support and knowledge transfer beyond initial interventions. By empowering these local stakeholders, Uganda can create a network of champions who can guide their communities on the path to digital inclusion.

6.2.6 Digital infrastructure for agriculture

There is a growing need for digital solutions in agriculture to improve productivity and market access for rural farmers. Investing in digital infrastructure tailored to agricultural needs – such as weather monitoring systems, market information platforms and online agricultural extension services – can have significant socio-economic impact.

Digital agriculture is transforming the agricultural sector globally, and Uganda is no exception. Like other low-developing countries, Uganda has been employing digital technology to optimize agricultural processes, improve productivity and increase income for smallholder farmers. In this analysis, we will explore the state of Uganda's digital agriculture infrastructure, compare it with other low-developing countries, and highlight some of the areas where Uganda can improve.

Uganda's digital agriculture infrastructure is relatively advanced compared with other low-developing countries. The country has a vibrant ecosystem of locally developed digital solutions, with over 200 documented ICT4Agric innovations catering to various agricultural

⁶⁷ European Commission (n.d.). "DigComp Framework". Available at https://joint-research-centre.ec.europa.eu/scientific-activities-z/education-and-training/digital-transformation-education/digital-competence-framework-citizens-digcomp/digcomp-framework_en.

needs. These solutions range from virtual call centres and e-extension services to mobile apps and market-connecting platforms. They demonstrate a deep understanding of local challenges and a commitment to tailoring technology to the Ugandan context.⁶⁸

Uganda has also embraced digital platforms and tools as a bridge between farmers and vital information. Mobile apps providing weather forecasts, pest management insights and market prices equip farmers with the knowledge necessary to make informed decisions. E-extension services, delivered directly to farmers' phones, bridge the knowledge gap by making expert advice readily accessible. Platforms such as Hamwe East Africa and Axiom act as agri-aggregators, streamlining supply chains, reducing post-harvest losses and increasing profits for smallholder farmers.⁶⁹

Despite these advancements, Uganda still faces some key challenges in its digital agriculture journey. Limited access to quality input materials, markets and financial services continues to hinder progress across various levels of the agricultural value chain. Additionally, information remains a barrier, with many farmers lacking the digital literacy skills required to fully benefit from available solutions.

Compared with other low-developing countries, Uganda's digital agriculture infrastructure is relatively advanced. However, there is still a lot of room for improvement. For instance, in Tanzania, the government has implemented the e-Agriculture system, including the web-based platform "UshauriKilimo", which connects farmers to extension services, weather information and market prices. The platform also offers a mobile app and SMS service, making it accessible to farmers without Internet access.⁷⁰

Similarly, in Rwanda, the government has launched the e-Soko platform, which connects farmers to buyers, provides market information, and facilitates digital payments. The platform has been successful in increasing transparency and reducing post-harvest losses.⁷¹

In Nigeria, the government has implemented the Growth Enhancement Support Scheme (GESS), which uses mobile phone technology to deliver subsidized fertilizers and seeds to farmers. The scheme has been successful in increasing productivity and income for smallholder farmers. Similarly, in Kenya, the government has launched the e-Voucher system, which provides farmers with digital vouchers that they can redeem for inputs and services.⁷²

To fully unlock the transformative potential of digital agriculture, Uganda needs to address existing weaknesses and learn from successful programmes implemented in other countries. Here are some areas in summary where Uganda can improve:

- Improve access to quality input materials, markets and financial services to support smallholder farmers.

⁶⁸ Uganda Communications Commission (n.d.). "Digitalization of Agriculture: Experiences from Uganda". Available at www.itu.int/en/ITU-T/webinars/DT4CC/20220329/Documents/Drake%20Mirembe.pdf.

⁶⁹ Innovation Village (n.d.). "The Digital Revolution for the agricultural sector in Uganda". Available at <https://de.innovationvillage.africa/the-digital-revolution-for-the-agricultural-sector-in-uganda/>.

⁷⁰ Food and Agriculture Organization of the United Nations (2018). "e-Agriculture Promising Practice: UshauriKilimo information system Web and mobile phones for extension services in Tanzania". Available at www.fao.org/3/i9032en/I9032EN.pdf.

⁷¹ United Nations General Assembly (2024). "Laying foundation for digital revolution in Africa's food systems". 30 January. Available at www.un.org/africarenewal/magazine/january-2024/laying-foundation-digital-revolution-africa%E2%80%99s-food-systems#:~:text=Rwanda%20has%20begun%20digitalizing%20parts,fair%20prices%20for%20their%20produce.

⁷² AgEcon World's Largest Open Access Agricultural & Applied Economics Digital Library.

- Enhance digital literacy training programmes specifically designed for farmers to equip them with the necessary skills to navigate digital platforms, access information and confidently utilize technology to improve their agricultural practices.
- Expand access to affordable devices and Internet connectivity in rural areas to bridge the digital divide and empower farmers to fully utilize the available digital solutions.
- Promote the creation and sharing of agricultural knowledge and best practices through readily accessible digital platforms to foster collaboration, knowledge exchange and continuous learning within the agricultural community.
- Support the development of locally-relevant digital tools and platforms to foster innovation, leverage local expertise, and ensure solutions are tailored to address specific Ugandan challenges.

6.2.7 Satellite internet services

Satellite Internet presents a viable solution for connecting remote communities where terrestrial infrastructure is impractical or economically unfeasible. Investing in satellite broadband services and equipment can provide reliable Internet access to underserved regions, facilitating economic development and social inclusion.

Satellite Internet has been instrumental in bridging the digital divide in many parts of the world, particularly in remote or underserved regions. In Uganda, there are some satellite projects that have provided reliable Internet connectivity to businesses and individuals. One of them is the Spacecom AMOS satellite fleet, which offers a range of telecommunication services to Uganda, including broadband Internet connectivity, cellular backhauling, distance learning and private satellite networks for corporations.⁷³ There are other satellite projects such as BusinessCom Networks, which provides VSAT solutions for cellular backhaul via satellite, offering a cost-effective and flexible platform for mobile network operators (MNOs) in Uganda to extend their reach without compromising service quality. By utilizing VSAT technology, MNOs can offer IP services on top of cellular voice services, ensuring reliable connectivity in rural areas.⁷⁴

Several satellite projects have been implemented across the globe, providing high-speed Internet connectivity to areas that were previously unconnected and where Uganda can also learn from and see the potential of this in the development of ICT sector. Some of these projects are mentioned below.

OneWeb is a satellite Internet company that aims to provide global Internet access using a constellation of low-Earth orbit (LEO) satellites. The company has launched 74 satellites to date and plans to launch a total of 648 satellites to provide high-speed Internet access to remote and underserved areas. OneWeb has partnered with several governments and organizations to provide Internet connectivity to schools, hospitals and other community centres.⁷⁵ There is currently a popular one called Starlink, a satellite Internet service provider launched by SpaceX, the company owned by Elon Musk. The company aims to provide global Internet access using a constellation of thousands of LEO satellites. Starlink has already launched more than 1 000

⁷³ Spacecom (n.d.). "Uganda Broadband Satellite Operator". Available at <https://amos-spacecom.com/uganda-broadband-satellites/>.

⁷⁴ BusinessCom Networks. (n.d.). "Satellite Internet in Uganda". Available at www.bcsatellite.net/satellite-internet-in-uganda/.

⁷⁵ Eutelsat OneWeb (n.d.). Available at <https://oneweb.net/>.

satellites and has begun offering Internet services in some parts of the world. The company plans to expand its coverage to more regions in the coming months.⁷⁶

There may be certain aspects of the policy on satellite Internet services from the Uganda Communications Commission (UCC) that can be improved or addressed. For instance, the licensing process for satellite service providers is too cumbersome, or the tariffs set by UCC are too high, making the services unaffordable for some investors. UCC also needs to do more to ensure that there is sufficient competition among service providers, which can help to drive down prices and improve the quality of services. If necessary steps are taken, the impact could be significant.

Satellite Internet services could provide a viable solution for connecting remote communities where terrestrial infrastructure is impractical or economically unfeasible. Investors will be tapping into an underserved market and provide a much-needed service with the big potential to provide high returns on investment, especially if they are well managed and implemented.

Investing in satellite broadband services and equipment could provide reliable Internet access to underserved regions, facilitating economic development and social inclusion. This could help businesses in remote areas to connect with customers and suppliers in other parts of the world, improving their competitiveness and enabling them to grow. Satellite Internet services could also help government organizations provide better services to citizens in remote areas, improving their quality of life and promoting social inclusion. They could also help government organizations provide better services to citizens in remote areas, improving their quality of life and promoting social inclusion.

6.2.8 Fibre-optic extension

Extending fibre-optic networks to rural areas can provide high-speed and reliable Internet connectivity, enabling transformative applications such as telemedicine, e-learning and e-commerce. Public-private partnerships and government subsidies can incentivize investment in fibre-optic infrastructure in underserved regions.

Fibre-optic technology offers faster Internet speeds, greater reliability and improved bandwidth capacity compared with traditional copper cables. This technology can enable faster downloads and uploads, smoother video streaming, and better access to cloud-based services and applications. The deployment of fibre-optic networks in underserved areas can also boost economic growth, attract new businesses and create job opportunities. On the other hand, satellite Internet services can provide Internet access to remote and rural areas where fibre-optic networks may not be feasible. It is essential to conduct a deeper analysis to determine whether one of these solutions is indeed viable and practical in a particular area. When it comes to improving Internet access and connectivity, some of these key areas require careful consideration.

Firstly, cost-benefit analysis is very important to establish the overall feasibility of implementing satellite Internet services or fibre-optic extension. This analysis should take into account both the short-term and long-term costs and benefits of these solutions. It is crucial to also consider the cost of launching and maintaining satellites and laying fibre-optic cables, as well as the potential benefits of providing Internet access to remote or underserved areas.

⁷⁶ Starlink (n.d.) Available at www.starlink.com/.

Secondly, identifying potential partners to work with when it comes to these services is very important, since these services are capital-intensive and security concerns. Governments can partner with private sector companies to finance and implement satellite Internet services and fibre-optic extension. Such partnerships can bring together the expertise and resources of both parties to implement these solutions quickly and effectively. Moreover, partnerships can provide opportunities for governments to leverage private sector expertise and resources to achieve their goals.

Lastly, technical considerations play a crucial role in the successful implementation of satellite Internet services or fibre-optic extension. For instance, satellite Internet services require the launch and maintenance of satellites, as well as the development of ground stations and other infrastructure. Similarly, fibre-optic extension requires laying cables, installing equipment and connecting to existing networks. These technical considerations must be carefully planned and executed to ensure that the solutions are effective and reliable. Technical considerations also include satellite orbit choices, bandwidth limitations and cable types. These factors must be taken into account when implementing satellite Internet services and fibre-optic extension. For instance, the choice of satellite orbit can significantly impact latency and coverage, while fibre-optic cable distance can affect signal quality. Cable types also have their own advantages and disadvantages, which must be considered when selecting the appropriate type.

6.2.9 National roaming

Roaming refers to the ability of customers to automatically make and receive voice calls, send and receive data, or access other services, even when travelling outside the geographical coverage area of their service provider, by means of using the service of the other service provider network. The National Broadband Policy aims to enable customers to have seamless access and coverage for customers, irrespective of their network.⁷⁷ National roaming could be a pivotal strategy for extending last-mile connectivity in Uganda.

In Uganda, where the pursuit of ubiquitous connectivity remains a pressing concern, the concept of national roaming emerges as a beacon of hope. This strategic approach holds promise in extending last-mile connectivity to even the most remote corners of the country. As we navigate the landscape of telecommunication infrastructure, it becomes evident that national roaming stands as a crucial pillar in the edifice of digital inclusion, offering both opportunities and challenges that warrant thorough examination.

At its core, national roaming represents a paradigm shift in the traditional approach to network expansion for MNOs. By leveraging existing infrastructure in underserved areas, MNOs can circumvent the immediate need for extensive capital investment.⁷⁸ This reduction in financial burden is particularly pertinent when venturing into remote regions where the prospect of immediate returns on investment may seem bleak. Through national roaming, MNOs can tap into new customer bases, thereby bolstering their market presence and competitiveness in Uganda's dynamic telecommunication landscape.

However, the journey towards realizing the full potential of national roaming is not devoid of hurdles. Commercial negotiations between MNOs entail a complex web of considerations, including roaming fees, quality of service assurances and equitable revenue-sharing

⁷⁷ The National Broadband Policy 2018.

⁷⁸ GSMA Intelligence. "The State of Mobile Network Sharing in Africa 2022".

agreements.⁷⁹ Moreover, ensuring consistent quality of service for roaming subscribers poses a formidable challenge, necessitating substantial investments in infrastructure and interconnection agreements.

In navigating these challenges, a supportive regulatory framework emerges as a cornerstone of success. The UCC plays a pivotal role in establishing transparent guidelines that foster fair competition and mitigate the risk of anti-competitive practices. Clear regulations on roaming tariffs, traffic management and dispute resolution mechanisms are imperative in cultivating an environment conducive to collaboration and innovation within the telecommunication sector.

Yet amid these challenges lies a transformative opportunity to bridge the gap between policy aspirations and tangible outcomes. National roaming, when integrated with complementary initiatives such as network as a service (NaaS) and Tower Companies (TowerCos), becomes a catalyst for extending connectivity to the last mile. It offers temporary coverage solutions in areas where infrastructure development is logistically or economically unfeasible, ensuring that no corner of Uganda is left in the digital dark.

Moreover, national roaming serves as a testament to the power of collaboration in achieving shared goals. By fostering partnerships between MNOs and facilitating revenue-sharing agreements, national roaming embodies the spirit of collective progress. It transcends the boundaries of competition, prioritizing the greater good of extending connectivity to all citizens, regardless of geographic location or economic status.

In the context of Uganda's broadband policy, national roaming emerges as a linchpin in realizing the vision of a digitally inclusive society. By mitigating connectivity disparities and promoting wider access to mobile broadband services, national roaming aligns seamlessly with the overarching objectives outlined in the National Broadband Strategy. It represents a tangible step towards harnessing the transformative potential of digital technologies to drive socio-economic development and empower communities across Uganda.

6.2.10 Unlocking last-mile connectivity: The case for government investment in open infrastructure

In Uganda, where the quest for universal connectivity is a paramount concern, the concept of government investment in open infrastructure for last-mile connectivity emerges as a transformative proposition. This strategic approach entails the construction of towers, fibre-optic cables, and other essential network components accessible to any MNO or ISP through leasing arrangements. As Uganda navigates its digital future, exploring the potential benefits, confronting challenges and crafting a strategic implementation plan for this innovative concept becomes imperative.

⁷⁹ Fjällström, P., and Aronsson, T. (2014). "Mobile roaming and network competition". *Telecommunications Policy*, 38(4), 302-313.

Potential benefits

One of the primary benefits of open infrastructure lies in its capacity to reduce the investment barrier for MNOs and ISPs, particularly in remote and underserved rural areas. By providing access to pre-built infrastructure, open networks mitigate the substantial upfront costs associated with network expansion, enabling providers to extend their services to previously unconnected regions. This reduction in financial burden not only facilitates market entry, but also promotes competition and innovation, ultimately driving down costs and improving service quality for consumers.

Moreover, open infrastructure facilitates a faster roll-out of network services. With pre established towers and fibre-optic cables readily available, MNOs and ISPs can expedite the deployment of broadband services, accelerating progress towards bridging the digital divide and ensuring equitable access to connectivity across the nation.

Additionally, open infrastructure fosters increased competition within the telecommunication sector. By allowing multiple providers to utilize the same infrastructure, open networks create a level playing field, encouraging innovation and driving efficiency. This competition not only benefits consumers through lower prices and improved service offerings, but also spurs investment in network quality and coverage expansion.

Challenges and considerations

Despite its potential benefits, government investment in open infrastructure is not without its challenges. Chief among these is the high initial investment required for infrastructure development. Constructing towers, laying fibre-optic cables, and establishing other network elements entail significant upfront costs, posing a financial burden for governments, especially in resource-constrained environments.

Furthermore, ensuring the sustainability of open infrastructure poses a formidable challenge. Identifying sustainable funding sources for infrastructure construction and maintenance is essential to ensure the long-term viability of open networks. PPPs present a potential solution, leveraging private sector expertise and investment to supplement government funding and promote infrastructure sustainability.

Moreover, maintaining neutrality and fairness in the management of open infrastructure is crucial to prevent any single operator from gaining undue advantage. Establishing transparent regulatory frameworks and independent oversight mechanisms is imperative to ensure equitable access to infrastructure and foster healthy competition within the telecommunication market.

Implementation plan (if viable)

A strategic and phased implementation plan is essential to realize the potential of government investment in open infrastructure. This plan should include the following key components:

- **Feasibility study:** A comprehensive feasibility study should be conducted to assess the economic viability, potential risks and benefits of investing in open infrastructure. Stakeholder consultations and input from industry experts are integral to this process.
- **Phased roll-out:** Adopting a phased roll-out strategy, commencing with a pilot project in a limited geographic area, allows for testing, evaluation and refinement of the model before broader implementation.
- **Regulatory framework:** Developing a clear regulatory framework governing access charge, service level agreements and dispute resolution mechanisms ensures transparency, accountability and fair competition in the utilization of open infrastructure.
- **PPPs:** Exploring partnerships with the private sector can leverage expertise and resources for building and managing open infrastructure, thereby mitigating financial risks and enhancing efficiency.

Insights

In contemplating the feasibility of government investment in open infrastructure, several additional considerations merit attention:

- **Alternative approaches:** Assessing the effectiveness of existing models such as NaaS and TowerCos is prudent before committing to a large-scale initiative.
- **Enabling environment:** Government intervention may be more effective in creating an enabling environment for private sector investment, such as streamlining regulatory processes and fostering a conducive business climate.
- **Long-term sustainability:** Sustained government commitment is indispensable to ensure the ongoing maintenance, upgrades and viability of open infrastructure in the long run.

6.3 Proposed sources of funds for bridging the digital divide in Uganda

In an era when the Internet acts as the cornerstone of economic growth and social progress, bridging the digital divide has become imperative. Uganda, like many other developing nations, grapples with the challenge of extending Internet access to its entire population, especially those residing in remote areas. Table 6 shows potential funding sources that the Ugandan public and private sectors can explore to accelerate the expansion of last-mile connectivity and bridge the digital gap.

Table 6: Investment opportunities and funding mechanisms

No.	Opportunity	Funding mechanism
1	Network-as-a-service (NaaS) models	NaaS models offer a practical solution by allowing third-party providers to build, own and operate network infrastructure, thereby reducing upfront investment burdens for MNOs and ISPs. Private equity firms and debt financing from commercial banks can serve as funding sources, along with revenue-sharing agreements with partnering MNOs/ISPs.
2	Cross-sectoral infrastructure sharing	Collaboration between sectors such as utilities and transportation can leverage existing infrastructure for deploying fibre-optic cables or mounting towers. PPPs and private sector investments can fund upgrades and modifications to existing infrastructure.
3	Submarine cable to connect islands	Building submarine cable connections to geographically isolated islands can provide them with high-speed and reliable Internet access. Government funding, international development loans and a consortium of telecommunication operators can serve as funding sources for such initiatives.
4	Community networks	Establishing community-owned and operated networks in rural areas can be facilitated through grant funding, microloans and crowd-funding initiatives for initial deployment. Long-term sustainability can be achieved through user subscriptions and partnerships with local businesses.
5	Digital inclusion programmes	Programmes addressing infrastructure gaps, affordability and user skills through subsidized Internet access, digital literacy training and local language content creation can be funded through PPPs, international development agencies and corporate social responsibility initiatives.

Table 6: Investment opportunities and funding mechanisms (continued)

No.	Opportunity	Funding mechanism
6	Digital infrastructure for agriculture	Investing in digital infrastructure for agriculture, such as sensor networks and mobile applications, can be supported by government initiatives, PPPs and donor funding focused on agricultural development.
7	Satellite Internet services	Advancements in satellite technology offer affordable and reliable connectivity in remote areas. Private sector investment in satellite constellations and partnerships with local ISPs can fund such initiatives.
8	Fibre-optic extension	Extending existing fibre-optic networks into underserved areas is crucial and can be funded through PPPs, government budgetary allocations and potential subsidies from universal service funds.
9	National roaming	National roaming agreements between MNOs can improve connectivity in remote areas. Commercial agreements and government policies may incentivize participation and ensure fair competition.
10	Open infrastructure	Government investment in open infrastructure, such as shared telecommunication towers and fibre-optic cables, can be funded through budgetary allocations, PPPs and concessional loans from international development agencies.

6.4 The role UCUSAF could play

Expanding the role of the Uganda Communications Universal Service and Access Fund (UCUSAF) alongside other funding mechanisms is crucial for effectively bridging the digital divide in Uganda. UCUSAF can be utilized in conjunction with other funding sources:

- **Complementary funding support:** UCUSAF can serve as a foundational funding source, providing subsidies and financial assistance for projects aimed at extending connectivity to underserved and remote areas. It can complement other funding mechanisms by providing the initial capital needed to kickstart projects and attract further investment from private sector entities and international development agencies.
- **Leveraging private sector investment:** UCUSAF can incentivize private sector participation by offering matching grants or subsidies for infrastructure projects in areas where commercial viability is low. This can encourage telecommunication operators and ISPs to invest in last-mile connectivity initiatives, knowing that their financial risks are mitigated through support from UCUSAF.
- **PPP initiatives:** PPPs can be enhanced by integrating UCUSAF funding into partnership agreements. UCUSAF can provide financial support for the public sector share of investment in infrastructure projects, leveraging private sector expertise and resources. This collaboration can result in more efficient project delivery and better utilization of available funds.
- **Infrastructure development:** UCUSAF can focus on funding infrastructure development projects, such as laying fibre-optic cables, installing telecommunication towers, and deploying broadband networks in rural and underserved areas. These infrastructure investments are critical for improving Internet access and connectivity across the country.
- **Innovative initiatives:** UCUSAF can support innovative initiatives that address specific challenges in extending Internet access, such as community networks, digital literacy programmes and content development in local languages. By investing in these initiatives,

UCUSAF can ensure that Internet connectivity is not only accessible, but also meaningful and impactful for all segments of the population.

- **Regulatory support:** UCUSAF can work closely with regulatory bodies to streamline approval processes and facilitate the implementation of projects funded through various mechanisms. Clear and supportive regulations can encourage private sector investment and ensure that funding is utilized effectively to achieve the goals of bridging the digital divide.
- **Monitoring and evaluation:** UCUSAF can play a vital role in monitoring and evaluating the impact of funded projects to ensure accountability and transparency. By tracking key performance indicators and assessing the socio-economic benefits of improved connectivity, UCUSAF can optimize its funding allocations and inform future investment decisions.
- **Capacity building:** UCUSAF can invest in capacity-building initiatives to strengthen local institutions and empower communities to take ownership of Internet infrastructure projects. This can include training programmes for local technicians, awareness campaigns on the benefits of Internet access, and support for community-led initiatives to sustain connectivity solutions in the long term.

6.5 Considerations

Investing in last-mile connectivity in rural and remote areas of Uganda presents significant opportunities for investors to contribute to socio-economic development while realizing profitable returns. By leveraging a combination of technologies, partnerships and innovative business models, investors can help bridge the digital divide and unlock the full potential of Uganda's rural communities. However, careful consideration of challenges such as infrastructure costs, regulatory hurdles and digital literacy is essential for successful investment outcomes.

Cross-sectoral infrastructure sharing between the power and telecommunication industries presents a compelling opportunity to accelerate last-mile connectivity efforts in rural and remote areas of Uganda. By leveraging existing power transmission towers for mounting communication base stations, the government can facilitate cost-effective expansion of telecommunication networks while optimizing resource utilization. Emulating successful case studies from other countries and implementing supportive policies and regulatory frameworks are essential steps towards realizing the benefits of cross-sectoral infrastructure sharing in Uganda's journey towards digital inclusion and socio-economic development.

Investing in a submarine fibre-optic cable to connect the islands of Lake Victoria and other lakes in Uganda represents a strategic opportunity to enhance last-mile connectivity, drive economic growth and promote social inclusion. By leveraging PPPs, regulatory support and stakeholder engagement, the government can realize the transformative potential of improved island connectivity, unlocking new opportunities for development and prosperity in these remote communities.

Investing in community networks for last-mile connectivity presents a strategic opportunity to empower rural communities, promote economic development and bridge the digital divide in Uganda. By supporting capacity building, technical training and equipment provision, investors can enable communities to deploy and manage their Internet infrastructure sustainably. Collaborating with established community networks such as RCBN, RENU and BOSCO leverages existing expertise and resources to amplify the impact of investment initiatives. Through partnerships, policy advocacy, and monitoring and evaluation, investors can foster a

thriving ecosystem of community-led Internet networks, driving social inclusion, empowerment and sustainable development in rural Uganda.

National roaming holds the key to unlocking the full potential of Uganda's telecommunication landscape. It embodies the spirit of innovation, collaboration and inclusivity, offering a pathway towards bridging the digital divide and ushering in a new era of connectivity for all. As we embark on this journey, let us seize the opportunities that national roaming presents and chart a course towards a brighter, more connected future for Uganda and its people.

While government investment in open infrastructure for last-mile connectivity holds immense promise, a cautious and well-considered approach is indispensable. Thorough feasibility studies, strategic planning and collaboration with stakeholders are imperative to navigate challenges and maximize benefits. By embracing open infrastructure alongside private sector-led initiatives, Uganda can realize its vision of universal connectivity and unlock the transformative potential of digital technologies for all its citizens.

Bridging the digital divide in Uganda necessitates a comprehensive approach involving both the public and private sectors. By exploring diverse investment opportunities and leveraging various funding mechanisms, Uganda can expedite the expansion of last-mile connectivity, thereby fostering economic development and social inclusion across the nation.

UCUSAF can serve as a catalyst for bridging the digital divide in Uganda by providing financial support, fostering private sector engagement and promoting innovative approaches to expanding Internet access. By collaborating with other funding mechanisms and stakeholders, UCUSAF can maximize the impact of its investments and contribute to the socio-economic development of the country.

Successful investment in last-mile connectivity requires careful planning, strategic partnerships, and a deep understanding of local needs and market dynamics.

7 Framework for non-State actor collaboration in last-mile connectivity for rural and remote areas in Uganda

This framework is designed to facilitate and enhance effective collaboration and partnership between non-State actors (NSAs) and stakeholders in order to improve the implementation of last-mile connectivity interventions in the rural and remote areas of Uganda. The framework seeks to leverage the collective expertise, resources and networks of these actors to address the connectivity challenges faced by communities in these areas. Through this collaborative effort, the framework aims to improve the accessibility and affordability of reliable communication services, which is critical for promoting economic growth, social development and access to basic services such as health care and education.

7.1 Documenting and updating the landscape

In recent years, there has been a growing effort to improve last-mile connectivity, particularly in rural and remote areas, where access to digital services is often limited or non-existent. To conduct a comprehensive analysis of the current infrastructure for last-mile connectivity, it is important to consider the technologies that are currently being used and their coverage. Some of the technologies that are commonly used for last-mile connectivity include satellite, wireless and fibre-optic networks. Each technology has its own strengths and weaknesses, and the choice of technology will depend on factors such as cost, availability and the geographic terrain.

In rural and remote areas, last-mile connectivity is often limited by challenges such as terrain, lack of infrastructure and low population density. These challenges can make it difficult and expensive to deploy traditional telecommunication infrastructure. However, there are several innovative solutions that are being developed to address these challenges. For example, some companies are using drones to deliver Internet access to remote areas, while others are deploying low-cost, low-power wireless networks that can be easily set up and maintained by local communities.

7.2 Stakeholder mapping and engagement

Identifying key stakeholders involved in last-mile connectivity efforts is important. Government agencies, telecommunication companies, NGOs, CBOs, international organizations, and local communities all have roles to play in improving last-mile connectivity. For example, governments can provide funding and regulatory support for last-mile connectivity projects, while telecommunication companies can deploy infrastructure and provide services. NGOs and CBOs can work with local communities to identify their needs and develop solutions that are tailored to their specific circumstances, while international organizations can provide technical expertise and financial support.

Developing a stakeholder map is an essential step in any project or initiative. A stakeholder map illustrates the roles, interests and influence of each stakeholder group. A stakeholder map is a visual representation of the stakeholders and their relationships with the project. It is a crucial tool that allows the project team to understand the stakeholder landscape and develop strategies to engage and collaborate with them effectively. The stakeholder map typically includes different groups such as customers, suppliers, employees, shareholders, regulators and the wider community. The map should outline stakeholder interests, needs and

expectations, as well as their level of influence on the project. This information can be gathered through surveys, focus groups or interviews with the stakeholders.

Workshops and meetings should be facilitated to foster dialogue, collaboration and alignment of objectives. Once the stakeholder map is developed, the next step is to facilitate stakeholder workshops and meetings. These provide an opportunity for the project team to engage with the stakeholders, understand their perspectives and develop strategies to address their concerns. They also help to build trust and credibility with the stakeholders, which is crucial for the success of the project. During the workshops and meetings, it is essential to ensure that all stakeholders are given an equal opportunity to participate and share their views. The project team should be open and transparent about the project objectives, progress and challenges, and be willing to listen to feedback and suggestions from the stakeholders. This approach will help to build a collaborative and inclusive culture, which is critical for the success of the project.

Establishing communication channels and platforms for ongoing engagement and information sharing is also crucial to maintaining an open and transparent relationship with the stakeholders. This can include regular updates through newsletters, social media or webinars, as well as one-on-one meetings or focus groups. The project team should also be responsive to stakeholder queries and concerns and provide timely feedback and updates on the project progress.

7.3 Partnership framework

The roles and responsibilities of each stakeholder group should be defined within the partnership framework. Partnerships are an essential aspect of the development process, and they play a crucial role in achieving national ICT development goals and strategies. These partnerships bring together people, institutions and organizations from different walks of life to work together towards a common objective. To achieve the desired outcomes, the roles and responsibilities of all stakeholders must be clearly defined. The stakeholder groups comprise government institutions, private sector players, civil society organizations and development partners. Each group has a unique responsibility and a significant role to play in the partnership.

The government institutions are responsible for creating the necessary policy and regulatory frameworks that will enable the private sector to invest in ICT development. They also provide the necessary resources and infrastructure to support the partnership objectives. The private sector players, on the other hand, are responsible for investing in the development of ICT infrastructure, products and services that are necessary for the partnership success. Civil society organizations bring the perspective of the citizens, and they advocate for the inclusion of marginalized groups in the development process. They also work towards ensuring that the partnership outcomes are aligned with the needs of the community. Development partners provide the necessary financial and technical expertise to support the partnership objectives.

To ensure the success of the partnership, clear objectives, targets and timelines for collaboration must be established, ensuring alignment with national ICT development goals and strategies. The objectives should be specific, measurable, achievable, relevant and time-bound (SMART). This will enable the stakeholders to track progress and make necessary adjustments to ensure that the partnership objectives are met.

Mechanisms should be developed for resource mobilization, including funding, technical expertise and infrastructure sharing. Another critical aspect of the partnership is resource mobilization. Funding is critical to support the development of ICT infrastructure and products,

while technical expertise is necessary to ensure that the infrastructure and products are of high quality. Infrastructure sharing is also essential as it enables the stakeholders to leverage existing infrastructure to develop new products and services.

7.4 Multi-stakeholder platform

A platform (physical or virtual) should be established for information sharing, collaboration and joint problem solving between NSAs (such as NGOs, the private sector and academia), government (Ministry of ICT and National Guidance, and local authorities), and communities.

The platform can host:

- Needs assessments: A platform like this can be beneficial in many ways. It can host needs assessments that help stakeholders identify connectivity gaps, user needs and existing infrastructure in rural areas. By conducting these assessments jointly, stakeholders can better understand the challenges of providing last-mile connectivity solutions and develop more effective strategies to address them.
- Resource mapping: This is another critical function the platform can provide. Mapping resources, expertise and ongoing initiatives of each stakeholder can help identify key strengths and weaknesses in the existing infrastructure. This way, stakeholders can better align their efforts and resources towards common goals, reducing duplication of efforts and increasing overall efficiency.
- Project development: The platform can also facilitate collaboration on developing and implementing sustainable last-mile connectivity solutions. For example, community Wi-Fi networks are a cost-effective way to provide Internet access to remote areas. These networks can be run by local entrepreneurs or community organizations, creating employment opportunities and supporting the local economy. Innovative financing models can also be developed and implemented to support these initiatives.
- To make the platform effective, it is essential to involve all stakeholders in the design and implementation process. This way, the platform can be tailored to meet the specific needs of each group, and everyone can feel ownership of the initiative. The platform should also be user-friendly, accessible and secure, to ensure that stakeholders can communicate and share information with confidence.

7.5 Capacity building

Providing capacity-building initiatives and training programmes to enhance the skills and knowledge of NSAs and local communities in last-mile connectivity technologies and practices is important in sustaining the collaboration. Capacity building enhances the expertise and knowledge of NSAs and local communities in the field of last-mile connectivity technologies and practices.

Through these initiatives, NSAs can gain valuable knowledge on technology alternatives for rural connectivity, such as fixed wireless access and satellite. They will also learn about project management and proposal writing skills, which are essential for the successful implementation of connectivity projects. Additionally, they will be equipped with community engagement and mobilization strategies to ensure that local communities are involved in the development process.

The training programmes will also provide government and local authorities with the necessary skills to facilitate the entry and operation of NSAs in rural areas. They will learn how to create regulatory frameworks for community networks and promote PPPs for last-mile connectivity.

These initiatives will help create an enabling environment for NSAs to operate and thrive, which is crucial for the development of rural connectivity.

The training programmes will emphasize the importance of community-based networks and how they can help bridge the digital divide. By promoting community networks, last-mile connectivity solutions can be developed and implemented in a sustainable and equitable manner. These initiatives will ensure that rural communities can access essential services, education and economic opportunities.

7.6 Funding and incentives

Developing a mechanism to attract funding for last-mile connectivity projects in rural areas could take the following forms:

- Establishing matching grants that combine public and private funds: This would encourage private investors to contribute to the development of rural connectivity infrastructure by offering them a financial incentive. Additionally, tax breaks or subsidies for NSAs investing in rural connectivity could provide further support to this cause. Crowdfunding platforms could also be utilized to raise capital from local communities and the diaspora. This would allow individuals who are passionate about improving rural connectivity to contribute to the cause, regardless of their location. Additionally, crowdfunding could help to raise awareness of the issue and increase community engagement.
- Exploring innovative financing models: Innovative financing models could also be explored to attract funding for rural connectivity. For example, digital service fees could be implemented, allowing communities to charge a small fee for Internet access to cover maintenance costs. This would ensure that rural connectivity projects remain sustainable in the long term. Another innovative financing model that could be explored is spectrum licensing. This would facilitate access to unused spectrum frequencies for NSAs to deploy low-cost connectivity solutions. By providing access to spectrum frequencies, NSAs could develop more cost-effective methods of providing Internet connectivity to rural areas.

7.7 Community engagement and empowerment

Mainstreaming community involvement and consultation in the design, implementation and monitoring of last-mile connectivity projects is important in promoting NSA collaboration and community ownership and sustainability through participatory decision-making processes.

7.8 Knowledge sharing and monitoring

Knowledge sharing and best practice exchange through workshops, seminars and online platforms assist in NSA collaboration. Knowledge sharing should be aimed at facilitating technology transfer and localization to empower local stakeholders in deploying and maintaining connectivity solutions. The following activities shall be performed:

- Establishing a knowledge-sharing platform for best practices, case studies and lessons learned from last-mile connectivity interventions.
- Establishing performance indicators and benchmarks to monitor the progress and impact of collaborative initiatives.
- Developing clear monitoring and evaluation indicators to track the progress and impact of collaborative projects. Factors such as the following should be considered:
 - Increase in Internet penetration rates in rural areas.

- Improved access to e-government services, education and health care.
- Socio-economic development indicators in target communities.
- Conducting regular evaluations to assess the effectiveness of interventions and identifying areas for improvement.
- Sharing lessons learned and success stories to inspire replication and scale-up of successful models.

7.9 Sustainability

One of the most critical challenges facing communities today is the lack of access to reliable and sustainable solutions to meet their basic needs. To address this issue, promoting the development of locally owned and operated solutions that can be maintained in the long term is crucial. This approach ensures a more sustainable model of development, empowering communities to take ownership of their own infrastructure and decision-making processes.

Encouraging skills development within communities is equally important. Communities must be equipped with the necessary skills to ensure local capacity for network maintenance and operation. This capacity building can take place through targeted training programmes, apprenticeships and mentorship initiatives. By investing in skills development, communities can not only maintain their own infrastructure, but also create employment opportunities and stimulate economic growth.

Fostering partnerships with private sector actors is another critical component of promoting sustainable solutions for underserved areas. The private sector can bring significant resources to the table, including technical expertise, funding and business acumen. By exploring commercially viable solutions for underserved areas, these partnerships can deliver sustainable solutions that meet the needs of both communities and private sector actors.

7.10 Policy advocacy and regulatory support

Advocating for supportive policies and regulatory frameworks that incentivize investment in last-mile connectivity infrastructure and promote competition can be achieved through partnerships between governments, private sector entities and community organizations. Such collaborations can help to identify the areas that lack infrastructure and need investment.

It is also important to engage with government agencies and policy-makers to address regulatory barriers and streamline approval processes for infrastructure deployment. This can be done by providing recommendations for policy reform based on emerging trends and challenges in last-mile connectivity. By working with policy-makers, we can help to create a conducive environment that encourages investment in last-mile infrastructure and promotes competition.

Monitoring policy developments is critical to providing timely recommendations for policy reform. By keeping abreast of policy trends and challenges, we can better understand the needs of communities that lack last-mile infrastructure and provide recommendations to address these challenges. In conclusion, promoting last-mile connectivity is essential for achieving universal connectivity, and it requires a concerted effort from stakeholders across the public and private sectors.

7.11 Adaptive management and continuous improvement

Embracing a culture of adaptive management is crucial for success in any field, especially in the ever-changing landscape of last-mile connectivity. It involves continuously refining strategies and interventions based on feedback and lessons learned. This approach helps organizations to stay nimble and responsive to emerging trends and challenges.

In order to foster a supportive learning environment, it is essential to encourage innovation, experimentation and risk-taking. This involves providing staff with the tools and resources they need to think creatively and explore new ideas. Leaders should also create a culture that values learning from failure and encourages staff to take calculated risks in pursuit of innovation.

Regularly reviewing and updating the collaboration framework is also critical in the last-mile connectivity landscape. This framework should reflect evolving needs and priorities and be flexible enough to accommodate changes in the landscape. This involves engaging stakeholders in ongoing dialogue and incorporating feedback into the framework.

7.12 Additional considerations

a. Addressing the gender gap

One of the fundamental steps towards achieving gender equality is ensuring women's participation in decision-making processes. Women have been underrepresented in decision-making positions in many fields, including technology. To address this, it is essential to encourage women's active participation in designing connectivity solutions. It is also important to consider their specific needs and challenges, such as access to education, training and financial resources. Failing to address the gender gap in technology could result in a significant loss of potential talent and innovation in the field.

b. Cyber safety and security for new users

The number of cybersecurity incidents will continue to increase as more people become connected and conduct more of their daily activities online. Since 2010, the top 10 data breaches have resulted in over 20 billion records being breached. Many users in low-middle-income countries connect to the Internet through their phones; however, GSMA Intelligence has found that safety and security concerns are among the key barriers to mobile Internet adoption in low-middle-income countries. According to the Nokia Threat Intelligence Report, the average monthly infection rate in mobile networks was 0.31 per cent in 2019 (one out of every 300 mobile devices had a high threat-level malware infection). In 2019, cybersecurity incidents were rated a higher risk to global businesses than supply chain disruption, political upheaval or natural catastrophes.

Connectivity brings opportunities, but also risks. Cybersecurity needs to be considered at a strategic level to ensure a coherent approach to threats that could outweigh the socio-economic gains of improved connectivity. A range of measures can be taken to reduce cybersecurity risks; all require continuous, active engagement on the part of governments, the private sector, civil society and individuals – and resources.

ISPs play a particularly crucial role in ensuring that their networks are sufficiently cybersecure. In January 2020, the World Economic Forum and its partners released high-level principles

for ISPs to bear in mind when deploying network services, and these may also be relevant for last-mile connectivity deployments. The four principles are:

- Protect consumers by default from widespread cyberattacks and act collectively with peers to identify and respond to known threats.
- Take action to raise awareness and understanding of threats, and support consumers in protecting themselves and their networks.
- Work more closely with manufacturers and vendors of hardware, software and infrastructure to increase minimum levels of security.
- Take action to shore up the security of routing and signalling to reinforce effective defence against attacks.

7.13 Conclusion

The framework presented here provides a valuable guide for NSAs to work collaboratively with relevant stakeholders, with the ultimate goal of facilitating last-mile connectivity in the remote and rural parts of Uganda. By implementing this framework, underserved communities can benefit from improved digital inclusion and socio-economic growth, leading to a more equitable and prosperous society.

8 Framework for collaboration between non-State actors and government for last-mile connectivity in rural and remote Uganda

The framework aims to provide a comprehensive plan for NSAs and the government to work together to find solutions to address last-mile connectivity challenges. This includes identifying the most effective and efficient technologies and infrastructure to connect these areas to the Internet, as well as developing strategies to overcome challenges such as funding, regulatory barriers, and social and cultural factors. By working collaboratively, the government and NSAs can leverage each other's strengths and resources to achieve their shared goal of providing Internet connectivity to remote and rural areas.

8.1 Joint planning and strategy development

A formal joint task force can be formed for planning and strategy development. The task force would, among others, develop a National Connectivity Masterplan. This plan should:

- Identify underserved areas and prioritize based on need and potential impact;
- Consider diverse connectivity solutions such as fixed wireless and wired access, TV white spaces and satellite technologies;
- Define roles and responsibilities for NSAs and government in project implementation.

The task force can also be used as a platform for input towards a transparent and inclusive spectrum allocation process that allows NSAs access to underutilized frequencies and spectrum resources for deploying low-cost connectivity solutions.

8.2 Stakeholder mapping and resource mapping

To effectively implement any ICT and connectivity initiative, it is essential to identify and map all relevant stakeholders involved in the process. This includes government agencies, NGOs, community-based organizations, private sector entities and international organizations. Each of these stakeholders plays a crucial role in ensuring that the initiative is successful and sustainable in the long run. For instance, government agencies are responsible for creating policies and regulations that enable the deployment of ICT infrastructure, while NGOs and community-based organizations often work to ensure that marginalized communities benefit from these initiatives.

Identifying and leveraging existing resources is equally critical. This includes infrastructure, expertise, funding and technology. NSAs, such as private sector entities and international organizations, can provide funding, expertise and technology that can support the implementation of these initiatives. In the same vein, government agencies can provide the necessary infrastructure to enable connectivity in remote areas.

8.3 Needs assessment and objectives alignment

In order to effectively address the connectivity challenges and infrastructure gaps that exist in rural and remote areas, it is essential to conduct a comprehensive needs assessment. This assessment should take into account the specific socio-economic conditions that are present in the country, as well as the unique challenges that they face when it comes to accessing reliable and affordable Internet connectivity.

By conducting a comprehensive needs assessment, stakeholders can gain a deeper understanding of the root causes of connectivity challenges in rural and remote areas. This can help to inform the development of effective strategies for addressing these challenges, including investments in infrastructure, policy changes and PPPs.

In addition to conducting a needs assessment, it is also important to ensure alignment of objectives among stakeholders. This can be achieved by facilitating discussions between different stakeholders to define common goals, expectations and outcomes of the collaboration. By bringing stakeholders together and encouraging open dialogue, it is possible to build consensus around the most important priorities and strategies for improving connectivity in rural and remote areas.

8.4 Regulatory environment

It is important to review and develop a clear regulatory framework that defines the roles, responsibilities and legal obligations of NSAs, government agencies and other stakeholders involved in last-mile connectivity initiatives. Two areas should be particularly reviewed:

- Streamlining licensing process: There is a need to develop a streamlined licensing framework for NSAs involved in last-mile connectivity projects. This could include:
 - Simplified application processes with reduced fees for non-profit NSAs;
 - Expedited licensing timelines, especially for community network projects.
- Light-touch regulation: There is also a need to develop a light-touch regulatory approach that balances promoting innovation with ensuring consumer protection and cybersecurity. This could involve:
 - Focusing on broad principles rather than micromanaging technical specifications;
 - Encouraging self-regulation within the NSA community through industry codes of conduct.

8.5 Public-private partnerships

Collaboration between government and NSAs can be enhanced by developing clear and transparent guidelines for establishing effective PPPs between NSAs, private communication service providers, and the government for last-mile connectivity projects. The guidelines could consider:

- Government providing infrastructure subsidies or tax breaks to incentivize private sector investment in rural areas;
- NSAs acting as last-mile service providers or community outreach partners for private operators;
- Innovative financing models and service packages for underserved communities.

8.6 Capacity building and knowledge sharing

Collaboration can be promoted by providing capacity-building initiatives to enhance the technical skills and knowledge of local communities, government officials and NSAs involved in last-mile connectivity projects. Knowledge sharing and exchange of best practices among

stakeholders through workshops, conferences and online platforms shall be promoted to foster learning and innovation, through the following forms:

- Joint training programmes: Organizing joint training programmes for NSAs, government officials and local communities on:
 - Technical aspects of last-mile technologies;
 - Project management and financial sustainability;
 - Community engagement and mobilization.
- Knowledge repository: Establishing a central repository for best practices, case studies and lessons learned from NSA-government collaborations on last-mile connectivity.

8.7 Risk management

One of the primary risks associated with last-mile connectivity projects is the lack of infrastructure in remote areas. Building the necessary infrastructure can be expensive, time-consuming and challenging, especially in areas with difficult terrain or limited access to resources. Additionally, the lack of trained personnel in remote areas can make it difficult to maintain and repair the infrastructure once it is in place. Another significant challenge is the lack of awareness and understanding of the benefits of Internet access in underserved communities. Addressing this challenge requires awareness campaigns to educate people about the benefits of Internet access, particularly in improving education, health care and economic opportunities. Lastly, political instability, social unrest and security concerns can also impact last-mile connectivity projects. These factors can lead to delays in project implementation or pose risks to the safety of personnel involved in the project.

To mitigate these risks and challenges, several strategies can be adopted, including PPPs, to share the costs of infrastructure development, training and capacity-building programmes for local personnel, and community engagement and awareness campaigns. Additionally, contingency plans should be developed to address potential security risks and ensure the safety of personnel involved in the project.

8.8 Sustainability strategies

Incorporating sustainability strategies into collaboration frameworks is critical for ensuring the long-term viability of connectivity initiatives. These strategies should address key factors such as community ownership, revenue generation models and long-term maintenance plans:

- Community ownership: By providing communities with ownership and control over connectivity infrastructure, they are more likely to take ownership of the project and ensure its continued success. This can be achieved through community-led initiatives, such as cooperatives, which allow communities to pool resources and share the responsibility of maintaining the infrastructure.
- Revenue generation models: Connectivity initiatives must be financially sustainable, which means they must generate enough revenue to cover their operating costs. Revenue can be generated through a variety of means, including subscription fees, advertising and partnerships with local businesses.
- Long-term maintenance plans: These are essential for ensuring that connectivity initiatives remain operational and effective over the long term. Maintenance plans should take into account factors such as regular equipment upgrades, repairs and replacement, and should be implemented with the support of local communities to ensure their success.

8.9 Monitoring and evaluation

Effective collaboration requires robust monitoring and evaluation mechanisms to track the progress, impact and effectiveness of collaborative efforts, and to ensure accountability and transparency. A collaborative monitoring and evaluation framework should be developed to track the progress and impact of last-mile connectivity projects implemented through NSA-government partnerships. It could include:

- Indicators for Internet penetration rates, access to e-government services, and socio-economic development in target communities;
- Regular stakeholder meetings to review progress, identify challenges and adjust strategies.

8.10 Considerations

To bridge the digital divide and ensure that everyone has access to the Internet, Uganda can accelerate the roll-out of last-mile connectivity initiatives in remote and rural areas by implementing a collaborative framework, and by following the recommendations proposed in this report, Uganda can leverage the expertise and resources of NSAs alongside government efforts. This will help in bringing the Internet to those who currently lack access, thereby facilitating the growth of digital infrastructure and providing opportunities for increased economic and social development in the region.

9 Recommendations

This section summarizes recommendations to enhance last-mile connectivity in Uganda. Engaging various entities – including private companies, government agencies, development partners and community networks – has yielded invaluable insights into the challenges and opportunities within the sector. To overcome these challenges, the study proposes several key recommendations:

1. **Policy and regulatory frameworks:** There is an urgent need to establish clear policies and regulations that encourage private sector investment and innovation in last-mile connectivity, particularly in economically unviable regions. The creation of incentives, such as tax breaks or subsidies, for telecommunication companies investing in rural connectivity projects can stimulate private sector involvement and accelerate the expansion of Internet services to marginalized communities.
2. **Promoting alternative technologies:** To ensure the sustainability of connectivity projects, especially in remote and underserved regions, it is essential to promote the use of alternative technologies and innovative business models. Satellite Internet, TVWS and other non-traditional methods can provide viable solutions where traditional infrastructure is not feasible.
3. **Promoting cross-sectoral infrastructure sharing between Uganda's telecommunication and electricity sectors:** This requires a strategic approach, beginning with a comprehensive review of current policies and regulations. This review should identify existing barriers to collaboration and ensure that the regulatory environment is conducive to joint efforts. Once these obstacles are addressed, the next step is to create an enabling regulatory framework that streamlines approval processes, establishes clear technical guidelines for infrastructure co-location, and offers incentives to encourage cooperation between sectors.
4. **Capacity building:** Strengthening the capacity of local communities and stakeholders is vital for the long-term success of connectivity projects. By empowering these groups to manage and sustain projects independently, communities can become active participants in their digital development, ensuring that connectivity solutions are both relevant and sustainable.
5. **Strategic partnerships:** Collaboration between NSAs, telecommunication companies, government agencies and community organizations is key to deploying sustainable connectivity solutions. Strategic partnerships can pool resources and expertise, enabling the deployment of cost-effective and scalable solutions. For example, partnerships between mobile network operators and local NGOs could facilitate the deployment of mobile broadband services in rural areas, improving access to information and services for remote populations.
6. **Investment in economically unviable regions:** A focused effort to attract investment in economically unviable regions is essential. By conducting cost-benefit analyses and exploring alternative technologies, stakeholders can identify the most effective interventions for expanding connectivity in these challenging areas.
7. **Comprehensive policy framework:** The development of a comprehensive policy framework to guide collaborative efforts and regulatory support is critical for sustainable connectivity solutions. This framework should include specific targets and timelines, ensuring that all stakeholders work towards universal access to high-speed Internet services across Uganda.

These recommendations serve as a road map for strategic interventions aimed at bridging connectivity gaps, fostering innovation and empowering communities across the nation.

Table 7: Recommendations

#	Area	Recommendations
1	Investment reforms	<ul style="list-style-type: none"> • Invest in fibre-optic infrastructure, last-mile towers, or common ducts alongside road construction and energy transmission projects in rural areas. This can significantly reduce deployment costs and encourage private sector participation in underserved and unserved areas. • Conduct a cost-benefit analysis comparing different infrastructure deployment methods (fibre vs wireless) in rural Ugandan contexts to inform efficient and effective policy direction. • Analyse the effectiveness of existing community network models and explore possibilities for scaling them up with government support. • Expanding the reach of the National Backbone Infrastructure (NBI) through strategic partnerships and innovative financing mechanisms is a crucial step toward connecting underserved regions in the country. • Promote the establishment of PPPs between NSAs and government agencies to leverage resources, expertise, and funding for last-mile connectivity projects.
2	Policy, regulation and licensing reforms	<ul style="list-style-type: none"> • Collaborate with stakeholders like the UCC and ISPs to review licensing structures and explore utilizing free spectrum bands like the 5.8 GHz ISM band and TVWS. This can promote wider access and encourage investment. • Address device affordability and data costs by reviewing taxation policies to make devices and data more affordable for underserved communities. • Review the potential licensing of the 6GHz band, ensuring it does not create unnecessary barriers for ISPs. • Implement tax breaks, subsidies, or grants specifically targeted at projects focused on expanding connectivity in underserved regions. This can make investments in these areas more financially attractive. • Consider opening platforms such as Facebook for business use can stimulate economic growth by enabling entrepreneurs, particularly those in underserved areas, to connect with new markets and customers, participate in e-commerce, and access a wider range of business tools and services. • Review regulations for issuing SIM cards to potentially involve age verification or parental controls to limit access to inappropriate content, promoting a safe online environment for children and vulnerable populations. • Adopt inclusive policies that prioritize the needs of marginalized communities, women, and other vulnerable groups in the design and implementation of last-mile connectivity projects.

Table 7: Recommendations (continued)

#	Area	Recommendations
3	Financing reforms	<ul style="list-style-type: none"> • Restructure UCUSAF to prioritize projects that target underserved areas and ensure fairer distribution of benefits across all stakeholders, including fibre infrastructure providers and other stakeholders. • Adopt the innovative UNCDF model to encourage private sector participation in last-mile projects through the provision of grants, guarantees, and risk-sharing mechanisms. • Develop and promote commercially viable business models and clear pathways to profitability that can ensure the financial sustainability of last mile connectivity projects over the long term, making them a sound investment opportunity for all involved. • Allocate seed funding and innovation grants to support pilot projects of promising NSA-led last-mile connectivity initiatives.
4	Technology reforms	<ul style="list-style-type: none"> • Provide research funding and encourage pilot projects focused on implementing sustainable technologies like dual-beam antennas and fixed wireless solutions. This can pave the way for cost-effective and efficient connectivity solutions. • Investigate the specific challenges faced by different underserved communities (e.g., mountainous regions, refugee settlements) to tailor interventions. • Provide incentives and promote TVWS technology to encourage wider adoption and ensure its long-term viability in bridging the digital divide, especially in remote areas where traditional fibre-optic infrastructure might be challenging or cost prohibitive.
5	NSAs collaboration	<ul style="list-style-type: none"> • Promoting collaboration: • Encourage collaboration between MNOs, ISPs, and community networks through workshops, funding opportunities, and streamlined regulatory processes. This can leverage resources and expertise for more efficient infrastructure development. • Encourage collaboration between MNOs, ISPs, and community networks through workshops
6	Advocacy and Capacity Building	<ul style="list-style-type: none"> • Implement national digital literacy programmes to equip people in underserved/unserved areas with the skills necessary to utilize technology effectively. • Build the capacity of local communities through training programmes on network maintenance, troubleshooting, for the long-term sustainability and effective utilization of connectivity solutions. • Support capacity building initiatives for government officials to enhance their understanding of ICT technologies, project management, and regulatory frameworks.
7	NSAs-Government Collaboration	<ul style="list-style-type: none"> • Establish a dedicated unit within the Ministry of ICT and National Guidance: This unit would serve as a single point of contact for NSAs, facilitating information sharing, collaboration, and problem-solving. • Recognise NSAs associations and mainstream in government decision making organs • Establish data-sharing frameworks between NSAs and government to improve targeting of underserved areas and optimize resource allocation.

Table 7: Recommendations (continued)

#	Area	Recommendations
8	Community Engagement	<ul style="list-style-type: none"> • Mainstream community participation and engagement in the design, implementation, and monitoring of last-mile connectivity projects to ensure their relevance, acceptance, ownership and sustainability. • Create and develop localized content and applications that are relevant to local community needs, a model piloted by RCBN. This approach can incentivize the adoption of technology and promote its wider usage, thereby contributing to the overall growth and development of the community.

The potential of ICT infrastructure to unlock economic opportunities and empower citizens is vast. Uganda can take significant steps to enhance the investment environment for Internet infrastructure development, mainly in areas with limited access. By adopting a comprehensive approach combining a range of strategies, underpinned by these recommendations, Uganda can create a more inclusive and sustainable digital future for all its citizens. Such an approach will foster an environment that encourages private sector investment and innovation, ensuring that even underserved areas have access to quality and reliable Internet services.

Reliable Internet access can open doors to e-commerce, online education, telemedicine and other digital services that fuel economic growth and promote social inclusion. By implementing the strategies recommended in this study, Uganda can close the digital gap, fast-track its path to widespread digital access, and fully realize the benefits of socio-economic development in the digital era.

Annex 1. Key informants

Access Plus
Airtel Uganda
American Tower Corporation
Bandwidth and Cloud Services
Blue Crane Communications
BOSCO
Canalbox
CSquared
Echotel Uganda
Gilat Telecom
Hamilton Telecom
Liquid
Lycamobile
MTN Uganda
NITA-U
Raxio
RENU
Roke Telkom
Seacom
Smile
Sprint Uganda
TOA (Ubuntu)
UCC
Uganda Electricity Transmission Company Limited
Office of the United Nations High Commissioner for Refugees
United Wireless
UTCL
Wanainchi Group (Zuku)

Annex 2. Stakeholder feedback

Mobile network operator feedback

Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
Infra-structure deployment	What percentage of your licensed areas currently has access to mobile broadband coverage (e.g. 2G 3G, 4G)?	Currently have a coverage of 25 per cent, primarily in major towns, and are focusing on urban areas initially to establish a revenue base. However, it's worth noting that only rural areas located along highways are included in this coverage.	The Airtel Uganda network is 100 per cent 4G since 2019. Our continuous network expansion, particularly in rural and semi-rural areas, is giving millions of people access to reliable and high-quality digital and financial services, often for the first time. This is critical for addressing the inequalities that have troubled Africa for far too long. Without differentiation, this network allows us to distribute affordable data, voice and financial solutions across the country. The aggregate coverage of the population exceeds 90 per cent for the entire national populace. Verification for rural areas will be conducted to ensure this coverage.	While their standalone coverage stands at 30 per cent, partnerships have extended it to over 80 per cent. They boast coverage across every part of Uganda, although service quality may vary. Leveraging NBI/NITA-U/ MTN infrastructure or infrastructure sharing has been instrumental in expanding their footprint, with a presence in most major towns.
	Can you provide details on the coverage and capacity of your network in these areas?	Not provided. However, emphasized that regulator is updated on a quarterly basis on progressive network expansion and coverage footprint.	Approximately 30 per cent of the total geographical area is considered economically unviable, with inhabitants living below the per capita gross domestic product. These populations are predominantly located in the highlands of eastern Uganda, adjacent to game parks and fishing villages.	Their targets encompass all major towns in Uganda. They receive approximately 1 Gbps from NBI/NITA-U for backhaul, while their main points of presence (PoPs) have about 20 Mbps. Moreover, they reciprocate by sharing their microwave infrastructure with others, offering a capacity of 10 Mbps.

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Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
Challenges and barriers	What are the main challenges faced by MNOs in extending connectivity to the last mile?	<ol style="list-style-type: none"> 1. The lack of infrastructure presents challenges in extending services, prompting efforts towards outsourcing and infrastructure sharing to reduce costs and manage resource replication. In rural areas, fibre infrastructure is often absent, or if available, limited to highways or major towns. The cost of renting or leasing NITA-U fibre for three years is almost equivalent to building new infrastructure, hence duplication of fibre infrastructure. 2. The cost of deployment in areas without existing fibre infrastructure is high compared to the low revenue/returns from these areas. 	<ol style="list-style-type: none"> 1. Areas lacking economic viability - These regions generate minimal revenue; therefore, government intervention with subsidies or similar support is necessary. 2. Inadequate infrastructure - The country faces challenges with: (a) electrical power supply; (b) road networks; and (c) terrain obstacles, such as highlands and geographical barriers, which hinder accessibility. 3. Regulatory approvals - Obtaining permits presents difficulties; infrastructure development in game parks is often obstructed due to outright rejections or excessively drawn-out procedures. 4. Community opposition - There are prevalent myths, such as the belief that infrastructure causes cancer or affects animal reproduction, leading to resistance. 5. Security concerns - Border areas, in particular, face security issues. 	<ol style="list-style-type: none"> 1. The high cost of extending last-mile connectivity to rural and remote areas contrasts with the low revenue generated from these regions. 2. Challenges arise due to the geographical locations, making it difficult to construct fibre infrastructure. 3. Unreliable power supply in remote areas poses a significant obstacle to maintaining connectivity. 4. Interference in the unlicensed ISM band from neighbouring service providers complicates operations.

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Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
	How do these challenges differ from those faced in urban areas?	<p>1. Commercial viability is favourable in urban areas, where infrastructure is often replicated or shared, reducing the costs of renting or leasing.</p> <p>2. However, challenges arise in getting landlords to accept the deployment of infrastructure such as towers, and some may not allow fibre to cross their land. Additionally, the presence of roads complicates deployment efforts, especially when digging under roads to lay fibre.</p>	<p>In urban areas, there is often a blend of issues. Obtaining permits is a common and significant challenge. Community resistance tends to be stronger in urban settings. Urban development, such as construction, can result in the loss of line of sight, necessitating the relocation of sites. Moreover, finding a location for erecting a tower is not only difficult but also involves substantial rental costs.</p>	<p>A single site in urban areas generates substantial revenue, allowing for the development of multiple products with the same operational costs.</p>
	Are there regulatory or licensing barriers that hinder infrastructure deployment?	<p>High cost of licenses but they believe that regulators have put a lot of effort to develop this sector.</p>	<p>Obtaining permits from the National Environment Management Authority is a lengthy process, as is the case with the Civil Aviation Authority. Local authorities also pose challenges when acquiring building permits/plans. Licensing itself isn't problematic for them. The geographical licensing regime, which 90 per cent adhere to, was based on a misunderstanding; it's believed that it should be assessed based on population size rather than area. The resources allocated to certain areas could have been better utilized to enhance services in more densely populated regions – services that will take at least 10 years for the populace to start using. The roll-out of new towers has been halted in favour of using existing tower companies – a decision that the government did not adequately consider.</p>	<ol style="list-style-type: none"> 1. The lack of infrastructure-sharing implementation results in unnecessary replication of resources. 2. There is no available common duct for laying fibre in all major cities, which poses a challenge to infrastructure development.

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Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
Community engagement	How do you engage with local communities to understand their connectivity needs?	They do not have a direct connection with them due to their nature of outsourcing.	Airtel Uganda consistently engages in outreach programmes to gather feedback on the quality of service. They receive correspondence from the community and utilize social media platforms for communication. Additionally, they respond to requests from the UCC regarding service delivery. In partnership with the UCC and Tower Companies, they conduct general awareness campaigns. Market activation initiatives are also undertaken, which provide an opportunity to receive feedback on their services.	N/A because of the nature of services they are offering and also internal challenges.
	Have there been successful community-led initiatives in collaboration with MNOs?	N/A. Could use corporate social responsibility to win the hearts of people	Several key stakeholders, for instance, have made contributions such as providing land at no cost, particularly in areas where sugar cane is cultivated. Infrastructure has been established within refugee camps, and there are provisions for indoor solutions where individuals may contribute space, electricity or both. Through collaboration with UCUSAF, efforts are made to construct sites across various communities. In 2023, we participated in a mentorship programme with Women In Technology Uganda (witu.org) to provide leadership insights to young and ambitious girls in technology. Through our landmark partnership with UNICEF, we are developing a plan that will allow us to provide educational resources, free of charge, to more than 1 million children.	N/A

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Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
			<p>We firmly believe that access to education is the key to addressing inequality in life opportunities for children - it is a basic human right and drives economic development. The transformative power of the Internet will assist in reforming the way teachers illustrate science and other concepts.</p> <p>Airtel Uganda, in partnership with UNICEF, started with 10 schools in 2023, and will scale up to 300 schools over the next few years.</p> <p>Under this transformative partnership, Airtel Uganda is providing up to 300 GB of data per month, connecting up to 7 986 students. In celebration of Uganda's 60th anniversary of independence, in October 2022 we asked the public to nominate 60 schools that we could connect to the opportunities of the Internet. The schools had to be outside the cities of Uganda and with an existing Internet connection. In this 2023 project, worth UGX 36 million, we connected schools nominated by members of the public. In 2023, through 14 public libraries powered by Airtel Internet, 184 764 people (students, pupils and adults) were reached across Uganda. Through this UGX 222.2 million project, both in-school and out-of-school learners can use basic to advanced Internet skills to improve their learning and skills.</p> <p>Additionally, in 2023, a total of 334 young people were trained in basic ICT skills at the Mbale, Lira, Kabale, Pallisa and Kawempe public libraries. Under the partnership of the Absa Ready-to-Work Program, Airtel Uganda provides discounted Internet access to educational resources to prepare young people.</p>	

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Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
			<p>As young people set out to find employment or create self-employment, they need skills that will help them transition from the world of education into the world of work. Absa Ready-to-Work is an education and skills development initiative designed to help young people go from learning to earning.</p> <p>Young people can register on the Absa Ready-to-Work app to access free online training courses. In 2023, 294 000 students accessed the resources. Our short-term partnership with EzyAgric ensured digital access to verified, quality agricultural information that farmers use through dialling a USSD code to request information, understand weather patterns, receive videos, SMS and audio of how to plant and take care of their animals, and ultimately speak to or meet an Agricultural Extension Worker, who advises them on how to manage their farms.</p> <p>Over 8 000 farmers have accessed agricultural information using the Airtel Internet, and an additional 75 995 people have accessed farming tips through the USSD code *163#.</p> <p>In 2023, 294 000 students accessed the resources. Through our partnership with the Buganda Kingdom, we have supported this annual event for over five years to raise money to support the reduction of the disease burden in Uganda. The treatment of fistula, HIV/AIDS, cancer and maternal health are some of the causes we have supported under this partnership.</p> <p>In 2023, the Airtel Kabaka Birthday Run was the biggest in Africa, having attracted over 100 000 people to run for the cause of fighting HIV/AIDS in Uganda.</p>	

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Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
Financial and business models	What financial models have been successful in making last-mile connectivity economically viable?	<ol style="list-style-type: none"> Utilizing the IRU (indefeasible right of use) model can help spread the cost of operation by allowing upfront payments. Infrastructure sharing is being implemented to a lesser extent but holds potential for further cost reduction and efficiency improvement. 	<p>Airtel Uganda doesn't have a specific model, but due to customer demand and support from UCUSAF, they have engaged in partnerships to bolster these initiatives. They have developed various products and arranged for financial institutions to offer devices on credit. Airtel Uganda, without differentiation, provides access to affordable data, voice and value-added services to grow the stock of the country's ICT asset base.</p> <p>In 2023, we enlisted six smartphone partnerships that delivered 65.5 per cent incremental growth of smartphones in the country, pushing the smartphone penetration from 31.9 per cent to 35.9 per cent. We remain committed to growing this agenda.</p> <p>We increased our sites-on-fibre by 5 per cent to 40 per cent and deployed 217 new sites as part of our network optimization for national development.</p>	<p>No modelling so far. They are rolling out FTTH within the towns where they initially had the infrastructure.</p>
	What is the average cost per user of providing mobile broadband in rural areas compared with urban areas?	No exact figures, but higher in rural areas compared with urban areas.	See above.	N/A but obviously/ maybe/will be higher in rural areas.
	Are there specific business models tailored for rural and underserved areas?	No. It is treated globally. But it is food for thought for them.	See above.	No.

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Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
	Are there any government subsidies or other financial mechanisms supporting rural connectivity projects?	It's recognized that the RCDF/UCUSAF requires restructuring to ensure fair benefits for all MNOs, rather than favouring only the big players or well-established MNOs. This restructuring aims to address issues where lower bid percentages suggested by these players often result in their selection, potentially disadvantaging smaller or newer operators.	See above.	The RCDF/UCUSAF and UTCL have benefited from connecting schools, having implemented a project to connect schools across Uganda a decade ago. However, it was noted that many schools did not benefit as they were not adequately sensitized about the project, rendering the service unsustainable.
Technology adoption	What technologies are being employed to enhance last-mile connectivity?	Using microwave technology in unlicensed bands or deploying traditional towers can help reduce licensing spectrum costs, as these methods often require less regulatory oversight and licensing fees compared with other spectrum bands.	2G, 3G and 4G technologies, along with microwave and fibre connections, are being deployed to cater to targeted consumers, including offices, NGOs and other entities.	Fibre and wireless in ISM band.
	Are there plans for adopting emerging technologies for improved coverage?	Deploying dual-beam antennas with high power gain can significantly improve coverage, extending up to 21 km compared to the 11 km range of normal antennas. This enhanced coverage can be beneficial for providing connectivity over larger geographic areas with fewer infrastructure installations.	At present, there are no fresh initiatives, but there's a possibility of revitalizing certain older technologies in the future. Additionally, there may be investments in satellite projects in collaboration with various companies.	Fixed wireless over 4G and 5G.

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Category	Questions	Responses from MNOs		
		Lycamobile	Airtel	UTCL
	What are the potential challenges and opportunities associated with adopting these technologies?	<ol style="list-style-type: none"> 1. Limited availability of this technology poses a challenge. 2. However, opportunities exist to improve coverage efficiency and reduce deployment or operational costs. 	<p>Accessing remote locations remains difficult, but satellite deployment could simplify this. However, these technologies are not without expense. The adoption rate is influenced by public perception. Additionally, there's often regulatory pushback; new technologies can catch regulators off guard, leading to delays. Supporting these technologies demands more resources, such as spectrum allocation. Device compatibility is crucial, and there's the issue of counterfeit devices misleading consumers into believing they are supported.</p>	<ol style="list-style-type: none"> 1. Addressing regulatory challenges is important. 2. There is a need for a significant number of sites to support 5G deployment.

Community networks' feedback

Category	Questions	Responses from community networks		
		RENU	BOSCO Uganda	RCBN
Community involvement	How are local communities involved in the planning and implementation of last-mile connectivity projects?	<p>RENU operates as a research and educational network and is a component of the Global Institution Research Network. Its primary objective is to ensure that institutions have reliable access to the Internet and high-quality network services. RENU boasts eight points of presence and has successfully connected 600 campuses. Although RENU holds a national operator licence from UCC as a private network, it also operates as a community network. To address the issue of extending connectivity, RENU offers financial contributions alongside technical assistance and equipment provision, as well as assistance with planning and implementation. It adheres to guidelines established by local authorities and collaborates with other service providers in delivering connectivity services. RENU also engages subcontractors, particularly suppliers, to provide equipment.</p>	<p>Battery-operated systems for communities began in 2007 during the peak of the conflict between the Lord's Resistance Army (LRA) and the Ugandan Government. The initiative aimed to provide Voice over Internet Protocol (VoIP) and Internet services to connect affected individuals. With assistance from Catechists and Uganda One, the project sought ways to submit reports safely, as delivering reports put them at risk of being targeted by the LRA. This led to the adoption of wireless technology, including point-to-point, 2.5G and 5G technologies, which were granted by the Uganda Communications Commission (UCC). These systems are operational across eight districts of Acholi, two districts of Lango (Oyam and Lira), and three districts of West Nile.</p> <p>When identifying a community, a community needs assessment is conducted. This involves seeking recommendations from community leaders, especially religious leaders, to identify groups and encourage participation. There are currently 54 computer centres distributed among different denominations, schools and hospitals. This approach has evolved from crisis response to developmental response over time.</p>	<p>Rural Communications Broadband Network (RCBN) is a non-profit community network operating under an unlicensed framework. It was established with support from the Government of Uganda through the Makerere University Research Innovation Fund, Ministry of Gender.</p> <p>Currently operational in Apac, RCBN targets areas with high population density such as schools, cafes, radios, markets, training centres and farms.</p> <p>RCBN utilizes the Radio Apac tower and TVWS technology, supported by a single backhaul link, to distribute signals. The network also features multiple repeaters to enhance coverage. Initially focused on supporting online learning, RCBN is now expanding its services to include various online applications. Moving forward, the network aims to empower local communities to leverage connectivity for community development. In terms of sustainability, RCBN is actively seeking continued support from funders, and is exploring grant opportunities to ensure the project's longevity. Additionally, it has obtained a temporary licence from the Uganda Communications Commission (UCC) to utilize TVWS technology, extending its reach across frequencies including 2.4 GHz and 5.8 GHz.</p>

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Category	Questions	Responses from community networks		
		RENU	BOSCO Uganda	RCBN
		<p>Additionally, it co-owns the infrastructure, with the cost of laying infrastructure being shared among participating institutions. In RENU's sense, there are two categories of local communities: the RENU member institutions and the service providers. RENU members are involved in key decision making at the annual general meeting and board of directors level. They are also key financial contributors when it comes to financing the deployment of last miles. RENU on the other hand works with different service providers: the last-mile deployment team, equipment vendors and infrastructure providers. These also contribute in the quality of the design and installations of the RENU last miles.</p>	<p>After identifying a community, a memorandum of understanding is drafted, clearly outlining the expectations and roles of both parties. Once signed, representatives undergo capacity building in leadership and management skills. They are also trained as trainers on digital literacy, enabling them to train other community members. Additionally, the community is tasked with providing space for an ICT centre, or building one if necessary. They are also responsible for providing security.</p> <p>During technical support, community members volunteer to provide assistance, as many of them have received training in basic maintenance.</p>	<p>To the question: The community has been actively engaged in the project from its inception, with involvement from district leaders, local authorities and stakeholders prior to approaching funders. Workshops were conducted to provide an overview of the project and gather input from community members. District technicians, local residents, NGOs like WUGNET, and youth leaders are also involved in the day-to-day operations of the network. To raise awareness about the project, the team organized talk shows on Radio Apac to educate the community about the opportunities it offers and how to access and utilize the network effectively. This inclusive approach ensures that the project meets the needs and priorities of the local community while fostering ownership and sustainability.</p>
	Can you share examples of successful community-driven initiatives?	<p>RENU as a whole is the biggest community-driven initiative I can point out first. With the growth of RENU, members are leveraging the different projects coming out of RENU. Among these: The Metro-Edu roam Wi-Fi hotspots providing a secure resilient, trusted and free wireless connection on the move. RENU Identity Federation service is offering members access to worldwide federated research content at no cost and last but not least the RENU cloud services. Cloud services are giving members the opportunity to locally back up their sensitive data and ability to buy VMs, which is saving them on hardware purchase and maintenance costs.</p>	<p>They contribute on a monthly basis, providing a small portion of funds to support the operational costs. Communities actively manage the computer centre, including conducting training sessions independently.</p>	<p>Maruzi Seed Secondary School, previously without Internet access, was able to participate in the National Conference for Communications organized by UCC for the first time, thanks to the network infrastructure. Remarkably, the school emerged as the top-performing institution in Northern Uganda. Furthermore, it participated in online workshops facilitated by the Ministry of ICT and National Guidance, demonstrating the network's role in facilitating digital engagement and educational opportunities.</p> <p>Additionally, a farmer group that benefitted from our service, with the mobile phones provided by Makerere University several years ago, enabled them to access the Internet and mobile applications. This highlights the broader impact of connectivity initiatives in empowering communities and facilitating access to information and resources.</p>

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Category	Questions	Responses from community networks		
		RENU	BOSCO Uganda	RCBN
	Do you offer training or resources to empower community members to participate actively?	RENU has a robust capacity-building programme that has been running since 2014 with the aim of equipping the member institution techies with relevant skills to run a resilient network. Three different tracks are run each year: Scalable Network Design, Campus Wireless, Campus Network Security, Federated Identity, System administration/Linux operations and NOC operations. Training costs are always covered by RENU.	See above.	They maintain a close collaboration with the organization that provided assistance during their initial installation or inception phase. With a recent grant from APC, they plan to expand their initiatives by organizing training sessions, establishing a blog platform and developing various content resources. Additionally, they have offered basic troubleshooting techniques to their partners during the installation process, ensuring smooth operations and effective utilization of the network infrastructure. This ongoing support and capacity-building efforts reflect their commitment to enhancing connectivity and empowering communities.

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Category	Questions	Responses from community networks		
		RENU	BOSCO Uganda	RCBN
Challenges and solutions	What challenges do community networks face in providing last-mile connectivity?	<p>The cost of a quality fibre last mile in Uganda is still high. The penetration of the fibre footprint is also too low, which means many of the RENU members are located more than 5 km from the nearest NBI. This only suggests using the limited microwave and LTE last-mile solutions, which limit bandwidth growth.</p>	<p>The cost of Internet in Uganda is notably high compared with other countries, posing a significant challenge for companies operating there. Despite Internet access being considered a human right, its affordability remains a concern due to the steep prices.</p> <ol style="list-style-type: none"> 1. For communities affected by prolonged conflicts lasting over two decades, prioritizing basic needs over investing in connectivity becomes essential. 2. Limited availability of equipment and supply chain challenges further compounds the issue in Uganda. Certain equipment may not be readily accessible, and delays in procurement are common, exacerbating the difficulties in establishing reliable connectivity infrastructure. 	<ol style="list-style-type: none"> 1. Technical challenges: Overcoming the cost associated with acquiring last-mile connectivity equipment and infrastructure has been a significant hurdle. 2. Adoption or community perception: Encouraging community members to embrace and utilize the connectivity has been a gradual process, requiring time to build awareness and acceptance. 3. Lack of devices: A persistent challenge is the limited availability of devices for connecting to the services. Many individuals in the local community do not possess the necessary devices, primarily due to the associated expense. 4. Electricity requirements: The need for a stable electricity supply to support these devices poses an additional obstacle, as access to reliable power sources may be limited in certain areas.

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Category	Questions	Responses from community networks		
		RENU	BOSCO Uganda	RCBN
	Have there been innovative solutions or partnerships to overcome these challenges?	Government through NITA-U is working on extending the NBI to other areas to help in reducing the last-mile cost. RENU also runs a private APN solution, which has seen members in very remote hard-to-reach areas getting connected to the high-speed network.	1. Collaborating with other service providers, they have initiated a pilot project involving the bamboo tower, which could potentially be the first of its kind in Uganda and Africa. Currently, one tower is already operational, marking a significant step forward in addressing connectivity challenges.	<ol style="list-style-type: none"> 1. Power challenge addressed: To tackle the power challenge, they implemented solar systems to provide power for both the equipment and personal phones, ensuring a reliable energy source even in areas with limited electricity access. 2. Capacity building: Training sessions were conducted to enhance local capacities for troubleshooting, empowering community members to address technical issues independently and ensuring the smooth operation of the connectivity infrastructure. 3. Application platform development: They are in the process of building an application platform tailored to the needs of the community, aiming to enhance sustainability by providing valuable services and functionalities to users.

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Category	Questions	Responses from community networks		
		RENU	BOSCO Uganda	RCBN
Collaborations	What is your network's vision for future expansion and potential collaboration opportunities?	Our vision is to have a high-speed OFC connection from Kalangala Islands to the mainland. This will revolutionize quality of connection on the very remote and underserved islands of Kalangala.	They have been receiving overwhelming requests from various community members, and recently, the Uganda Communications Commission (UCC) visited them, urging them to expand to different regions. The primary challenge lies not in resources but rather in the inability to reach everyone, even with their current footprint, which covers only the subcounty areas. The optimal solution lies in forming partnerships or alliances to extend these services further. By establishing community networks, they can not only enhance connectivity but also collaborate on various other initiatives, maximizing their impact beyond just providing Internet access.	They have established partnerships to broaden their connectivity reach, including collaborations with entities such as Radio Apac, which provides access to their towers. Additionally, in Oyam, they have partnered with a local radio station, and a similar arrangement exists in Moroto. Collaborations with institutions like the College of Gender ensure gender inclusivity, while partnerships with organizations such as the University of Thailand, WUGNET, NITA-U and UCC strengthen their network. In their upcoming project, they are collaborating with WUGNET to extend their impact further, with a commitment to continued partnership with various stakeholders in the future. They are also looking to engage regional universities like Lira University to expand research opportunities and enhance their initiatives.

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Category	Questions	Responses from community networks		
		RENU	BOSCO Uganda	RCBN
	How does your network ensure affordability, and long-term financial and operational sustainability?	We try to seek grants to aid in the key infrastructure expansions, and collaborate with local agencies and international players interested in transforming the education sector in Uganda.	In addition to the monthly subscription, they offer various installation packages. They provide 3-in-1 printers at subsidized costs to promote sustainability. Communities utilize these centres for phone charging, with charges set at subsidized rates to assist in covering subscription fees. Moreover, they have a "trainer of trainers" programme where community members are trained to impart knowledge independently. Local governments extend support through equipment provision or covering monthly subscriptions. Furthermore, these centres have Village Savings and Loan Associations to ensure sustainability, providing support to the centres at the end of each year. Local governments also conduct awareness campaigns and monitor these centres to ensure their effective operation.	Ensuring access at a lower cost makes it more affordable for a wider range of individuals. By facilitating access, those without personal devices can still benefit from the connectivity shared by others. Although users are currently not paying for the service, sustainability remains a concern. This is why they are exploring the development of local applications to generate native content, enhancing sustainability by fostering community engagement and ownership of the network.

Development partners' feedback

Category	Questions	Responses from development partner
		UNCDF
Support and funding	How do development partners and NGOs contribute to last-mile connectivity projects?	Since 2016, there have been projects with MNOs like MTN and Airtel on how to digitalize agriculture. In the Kapchorwa region, they used MTN towers and after six months, they had broken. They give incentives to MNOs through either guarantee (on use cases promising that it will break even) or grants to digitalize the agricultural sector. Also, in refugee camps, they work with these partners to teach farmers to use this in their different activities in agricultural activities, and also in refugee areas or northern Uganda.
	Can you provide details on funding mechanisms and support provided?	<ol style="list-style-type: none"> 1. Guarantees. 2. Innovation grant for people to come up with solutions to be consumed by the last mile. How do you sustain that they work together to improve on the usage to then can make money and break even then for the innovation grant? They give it to business.
Capacity building	Are there capacity-building programmes for local communities and stakeholders involved in last-mile connectivity?	This is one of the biggest concerns - affordability vs capability. UNCDF does biggest investment on capacity building. So they also advise the fin-techs, etc., to invest in user-friendly innovations.
	How do you ensure sustainable and community-led interventions?	<p>Most of the projects are taking private sector models:</p> <ol style="list-style-type: none"> 1. Use of rural value chain/anchor partners in the value chain. 2. Human-centred design; building with the rural people (test, iterate, etc.) to adapt the solution to the reality of the last mile.
Success stories	Can you share success stories or case studies from other regions that might offer insights into successful interventions?	<ol style="list-style-type: none"> 1. Device financing by Copia in Kenya for last mile and UCUSAF. 2. Infrastructure sharing in Uganda. 3. In Rwanda, there is a drive for access to device. 4. Digital literacy programme by digital ambassador in Rwanda.
	How do you measure the impact of your interventions?	<ol style="list-style-type: none"> 1. Usage: How many people are using the given solution, what service are they consuming through digital means? 2. Then they look at the impact of the rural communities. 3. Also, how do they see this transforming their lives?
	Recommendations	<ol style="list-style-type: none"> 1. Affordability of device and data by improving the taxation policy. 2. Digital literacy across the country - let them have this. 3. Investment in infrastructure like chicken-and-egg relation; they should have reasons for buying data -there should be reason to connect to communicate or talk or bet.

Internet service providers' feedback

Category	Questions	Responses from ISPs	
		Seacom	Sombha Solutions
Service provision	What percentage of the rural population in your target areas do you currently serve with fibre-optic Internet?	They do not deal directly with rural population but only through partnership with other service providers. They offer wholesale carrier services to other service providers and business-to-business retail Internet capacity.	They have significantly expanded Internet access in most parts of Uganda through partnerships with mobile network operators (MNOs), and are also exploring satellite services to further extend connectivity. Their commitment to connectivity leaves no room for excuses. Recently, they've ventured into technological collaborations, such as with the Swedish company Omge, to implement Open Access Wi-Fi Technology utilizing Terana Technology, operating within the 6 GHz band. They are conducting testing and pilot projects in densely populated areas like downtown Kampala in Somali communities like Kisenyi.
	Can you provide details on the bandwidth and service quality in these regions?	It is all standardized. Almost the same. Response times for up-country tend to be longer. But in most cases, the bandwidth and service quality in urban areas are higher than those in villages.	Dependent on the number of population but ensures best practices.
Collaboration with MNOs	Are there any ongoing or planned collaborations with MNOs to extend last-mile connectivity in underserved areas?	Yes, with Airtel and MTN and other ISPs.	Working with MTN on bundled packages, but there is always an issue with cost or affordability. They are looking into alternative approaches and technologies like satellite.
	What challenges or successes have you experienced in such collaborations?	<ol style="list-style-type: none"> 1. Price limitations persist, exemplified by MTN's consistent high rates despite insufficient coverage. 2. Technological disparities, such as differences in connection protocols like QnQ, routing protocols, and IPv6 usage, pose compatibility challenges among various mobile network operators (MNOs). 	MNOs are too commercial, which makes the cost of running the infrastructure high. They have success in the remote areas.
Community networks	Have there been instances where community networks have played a significant role in connectivity provision?	They actively support incubation hubs like Outbox by providing them with connectivity, enabling their operations. Additionally, they extend support to RENU on the back end, further strengthening the infrastructure for educational and research institutions.	RENU, but the challenge is they don't have infrastructure, which becomes a challenge.

Assessment of last-mile connectivity interventions in Uganda

		Liquid Intelligent Technologies	Roke Telkom
Service provision	What percentage of the rural population in your target areas do you currently serve with fibre-optic Internet?	Reducing costs for end users is a key benefit of fixed wireless access over 4G and 5G networks, making high-speed Internet services more affordable and accessible to a wider range of people.	Their target is town areas only. Roke has received funding from the United States Agency for International Development to extend its services to rural and remote locations.
	Can you provide details on the bandwidth and service quality in these regions?	Utilizing outsourcing and monitoring techniques, they implement a monitoring system to verify information sourced from outsourcing partners. This system enables them to ensure the accuracy and reliability of the outsourced data or services.	No.
Collaboration with MNOs	Are there any ongoing or planned collaborations with MNOs to extend last-mile connectivity in underserved areas?	Collaborating with other mobile network operators (MNOs), they aim to develop solutions for wide network access, thereby extending their footprint and improving coverage in various areas.	Yes, with Hello World. Built up to 70 points of presence to offer free Internet, and this necessitates collaborations with MNOs. They typically use microwave using an unlicensed ISM band. There is also a Roke spot in different public places like markets, schools, etc. People are doing the same -replicating and reselling Internet.
	What challenges or successes have you experienced in such collaborations?	Pricing concerns, such as reluctance to offer MNOs wholesale pricing, pose challenges. However, they have still managed to extend their services.	Cost of subsidizing connecting to underserved communities.
Community networks	Have there been instances where community networks have played a significant role in connectivity provision?	Working with RENU is valuable, but challenges extend beyond just cost or infrastructure.	Yes, Hello World is a typical example.
	How do you offer support and technical assistance to community-driven connectivity initiatives?	Yes	We offer free Internet to Hello World sites.
	Are you open to partnering with community networks to expand your reach and services?	Indeed, the viability of collaboration depends on various factors. One challenge is dependency on Internet service providers (ISPs) for infrastructure.	Yes

(continued)

		Liquid Intelligent Technologies	Roke Telkom
Regulatory landscape	How does the regulatory environment impact your ability to provide Internet services in underserved areas?	The mandate includes reaching certain areas that may not be economically viable on their own.	Licensing the unlicensed band will reduce providing the kind of service they are doing with Hello World. High license fees will reduce the service delivery.
	Are there regulatory bottlenecks that need to be addressed?	Advocating for government-owned towers through ISPUA (Infrastructure Sharing Platform Uganda Association) complements the national backbone infrastructure, ensuring broader coverage and connectivity.	In general, we feel UCC doesn't pay attention to the concerns of small players/ISPs. Most regulation is geared towards the MNOs.
	Can you identify specific regulations or policies that may impact your efforts to deliver last-mile connectivity to underserved and unserved areas?	The government should promote a practical free market economy, fostering competition and innovation in the telecommunications sector. Additionally, avoiding exclusive procurement from government-owned entities like UTCL can encourage diversity and efficiency in infrastructure development.	Licensing part of 5 GHz, delayed decision on 6 GHz and 60 GHz licensing framework.
	What regulatory and policy recommendations do you propose would be most beneficial to support last-mile connectivity to underserved and unserved areas?	<ol style="list-style-type: none"> 1. Government investment in additional infrastructure such as last-mile towers or fibre can help reduce costs and improve connectivity. 2. Coordination is key; laying fibre during road construction is more cost-effective than afterward. The government could lay a common fibre or duct alongside road construction projects. 3. Leveraging existing infrastructure like electric poles to carry telecommunication lines can further streamline deployment and reduce costs. 	Open up 6 GHz and 60 GHz as unlicensed or design licensing to benefit ISP market. Policy to subsidize connectivity to underserved areas, the government and support organizations should come in to support ISPs to connect underserved areas.

Fibre infrastructure providers' feedback

Category	Questions	Responses from fibre infrastructure providers		
		Bandwidth and cloud services	NITA-U	CSquared
Service provision	What percentage of the rural population in your target areas do you currently serve with fibre-optic Internet?	Since 2014, significant progress has been made in establishing a backbone network across most parts of Uganda. In 2018, in collaboration with Airtel Uganda and with support from Facebook, approximately 770 km of shared fibre backhaul was constructed in northwest Uganda. The primary objective was to connect around 3 million people in underserved communities and facilitate cross-border connectivity to neighbouring countries. While the coverage extends to around 80 per cent, there's limited presence in the north-east due to financial constraints. Additionally, independently, they've installed 500 km of fibre backhaul.	Currently, the National Backbone Infrastructure (NBI) is primarily concentrated along highways and not extended to rural areas. However, there are plans to increase coverage to 80 per cent in the next phase, aiming to accomplish this within the next five years.	Its coverage is primarily on the Jinja, Mukono and Kampala areas, serving residential, business and other service providers. Their business model predominantly caters to business-to-business transactions, indicating a 0 per cent focus on direct consumer engagement.
	Can you provide details on the bandwidth and service quality in these regions?	N/A	N/A	Their approach includes both proactive measures, such as monitoring systems, and reactive responses to faults. This combination ensures a comprehensive strategy for maintaining network integrity and addressing issues promptly when they arise.

(continued)

Category	Questions	Responses from fibre infrastructure providers		
		Bandwidth and cloud services	NITA-U	CSquared
Collaboration with MNOs	Are there any ongoing or planned collaborations with MNOs to extend last-mile connectivity in underserved areas?	Collaboration with Airtel. Co-built shared backhaul fibre.	There were no tangible outcomes from the project. Initially, the plan involved leveraging the infrastructures of mobile network operators (MNOs) with government investment to establish infrastructure, but it proved to be unviable. Additionally, attempts at co-building infrastructure did not succeed as intended.	While their current focus remains on urban areas, they are open to collaborations that extend services to underserved areas, provided such partnerships align with their business objectives.
	What challenges or successes have you experienced in such collaborations?	No challenge.	N/A	The high cost of deployment, coupled with concerns about business viability, is a significant challenge. Additionally, Wi-Fi's limited range and the common perception that it should be nearly free pose difficulties in generating revenue. To offset costs, they may charge higher fees, especially when dealing with larger entities they consider as major players in the market.

(continued)

Category	Questions	Responses from fibre infrastructure providers		
		Bandwidth and cloud services	NITA-U	CSquared
Community networks	Have there been instances where community networks have played a significant role in connectivity provision?	They carry RENU to the north-east to connect universities and also with MTN.	Yes, collaboration with RENU aims to support educational institutions, with a target of reaching up to 80 per cent coverage either directly or through the National Backbone Infrastructure (NBI). Additionally, initiatives with BOSCO involve providing backhaul and offering last-mile connectivity. NBI, which relies on fibre technology, was primarily motivated by cost-efficiency but encountered challenges such as fibre cuts. Currently, 18 out of 25 Internet service providers (ISPs) have been supported with ISP services.	They supported MyUG, which offers free bandwidth to the public during after-hours, a service provided in collaboration with the government. Secondly, in partnership with RENU, students can access connectivity anywhere through Eduroam, facilitating their access to educational resources.
	How do you offer support and technical assistance to community-driven connectivity initiatives?	N/A	N/A	Before-sale service, they provided support in areas like design and suggesting the best solutions, as well as encouraging ISPs to prioritize certain locations. After-sale service, their support extends to functions like Network Operations Centre (NOC) management, fault handling and monitoring services.
	Are you open to partnering with community networks to expand your reach and services?		N/A	Yes.

(continued)

Category	Questions	Responses from fibre infrastructure providers		
		Bandwidth and cloud services	NITA-U	CSquared
Regulatory landscape	How does the regulatory environment impact your ability to provide Internet services in underserved areas?	On UCUSAF-Uganda Communications Universal Service Access Fund. Why RENU being given? It would be great to given to Fiber also not only MNOs. They need to benefits.	The primary limiting factor remains funding. However, it's also beneficial for them to support other players to ensure sustainability. Their mandate includes extending services closer to end users, which can help bridge gaps and enhance accessibility.	Indeed, funding is crucial to support everyone involved in such initiatives. Additionally, tax waivers and subsidies could be instrumental in making these services more accessible and sustainable for both providers and users.
	Are there regulatory bottlenecks that need to be addressed?		N/A	Addressing the duplication of infrastructures is crucial and warrants careful consideration to optimize resources and avoid unnecessary redundancies.
	Can you identify specific regulations or policies that may impact your efforts to deliver last-mile connectivity to underserved and unserved areas?	N/A	N/A	<ol style="list-style-type: none"> 1. Exploring infrastructure-sharing opportunities can help minimize duplication and maximize resource efficiency. 2. Reviewing licensing regimes, such as the utilization of the 5.8 GHz ISM band (C band), can promote more efficient spectrum allocation. 3. Considering alternatives like TVWS for utilizing free spectrum bands can further enhance connectivity and expand access to underserved areas.

(continued)

Category	Questions	Responses from fibre infrastructure providers		
		Bandwidth and cloud services	NITA-U	CSquared
	What regulatory and policy recommendations do you propose would be most beneficial to support last-mile connectivity to underserved and unserved areas?	The Uganda Communications Universal Service Access Fund (UCUSAF) should be revitalized to extend benefits to fibre infrastructure providers, not just mobile network operators (MNOs). This broader approach ensures that all stakeholders, including various players in the industry, can benefit from the fund's initiatives.	N/A	Incentivizing the adoption of sustainable technologies like TVWS can be instrumental in promoting their widespread use and ensuring their long-term viability.

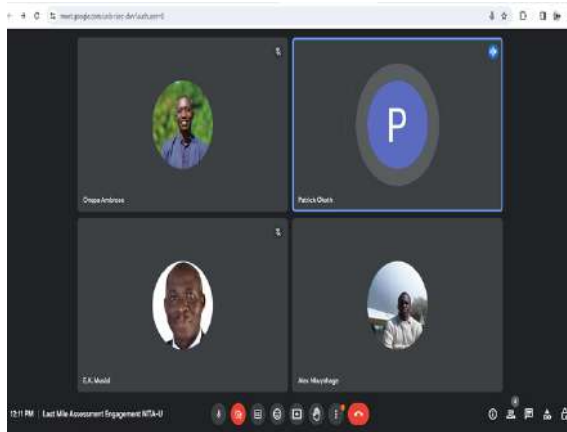
Annex 3. Images of interviews with stakeholders



**Liquid Intelligent Technologies,
12 February 2024.**



**Uganda Telecommunication Corporation
Limited, 14 February 2024.**

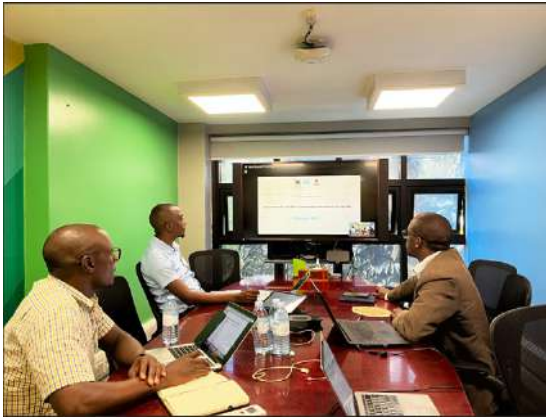


**National Information Technology Authority
Uganda (NITA-U), 19 February 2024.**



**Roke Telkom,
22 February 2024.**

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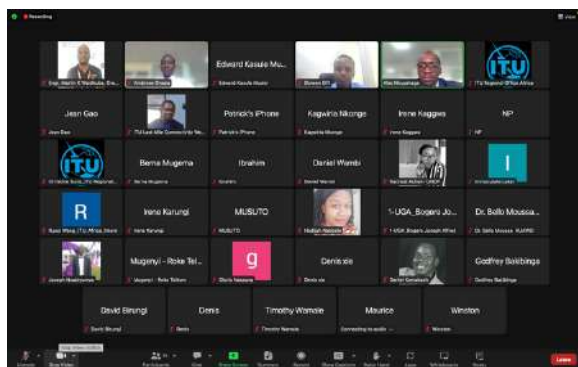
**CSquared Uganda,
22 February 2024.**



**Uganda Communications Commission,
23 February 2024.**



**Group Vivendi Uganda (Canalbox), 23
February 2024.**



**Webinar: Stakeholder validation workshop
on the assessment of last-mile connectivity
projects in Uganda, 8 April 2024.**

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