UAT-R RECOMMENDATION

relating to

Promotion of Rural ICT connectivity In Africa

numbered

ATU-R Recommendation 007-0

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Acronyms

3GPP – 3rd Generation Partnership Project

AMN – African Mobile Networks

ATU - African Telecommunications Union

ATU-R: ATU Radiocommunications sector

ESIM –Earth Stations in Motion

FSS – Fixed Satellite Service

FWA – Fixed Wireless Access

GSM – Global System for Mobile Communications

GSMA – Global System for Mobile Communications Association

GEO – Geostationary Earth Orbit

GSO – Geostationary Satellite Orbit

HAPS – High Altitude Platform Stations

HTS – High Throughput Satellite

IMT – International Mobile Telecommunication

ISP – Internet Service Provider

ITU – International Telecommunications Union

LDC – Least Developed Country

LEO – Low Earth Orbit

LTE – Long Term Evolution

MIMO – Multiple Input Multiple Output

MISTT – Mobile Internet Skills Training Toolkit

MNO – Mobile Network Operator

MSS – Mobile Satellite Service

NLOS – Non-Line-of-Sight

OFCOM – Office of Communications, United Kingdom

PtMP - Point to Multipoint

P2P – Point to Point

QOS – Quality of Service

QOE – Quality of Experience

RASCOM- Regional African Satellite Communication Organisation

SMP – Significant Market power

SSA – Sub Saharan Africa

UHF – Ultra High Frequency

UMTS – Universal Mobile Telecommunication System

USF – Universal Service Funds

USO – Universal Service Obligation

VHF – Very High Frequency

VSAT - Very Small Aperture Terminal

WOAN – Wireless Open Access Network

Executive Summary

Access to affordable and reliable ICT/telecommunications is essential for economic development and social inclusion. However, many rural areas in Africa still lack adequate affordable connectivity, which will limit access to essential services and effective participation in a digital economy. This document provides recommendations and case studies on how to overcome the rural connectivity challenge and improve access to communication in underserved communities.

One of the key strategies for promoting rural ICT connectivity is through spectrum management innovations, as described in **Section 2**. These strategies include specific spectrum assignments for rural areas; outsourcing of rural IMT spectrum to specialist rural operators by incumbent network operators; establishing wholesale wireless open access networks; and various spectrum-sharing mechanisms. Spectrum sharing can unlock access to unused spectrum in rural areas and potentially reduce the cost of deploying network infrastructure. Assigning specific spectrum for rural areas may lead to operators gaining affordable access to the frequencies required for sustainable rural operations. Lastly, **Section 2** discusses ways of sharing the same frequency band among multiple users and the characteristics of Wi-Fi and other license-exempt spectrum technologies.

Section 3 discusses the role of satellite networks in improving rural connectivity. The section provides an overview of different real use cases for satellite deployment in rural areas, including the Regional African Organization for Satellite Communications (RASCOM) and other regional use cases. It also discusses the concept of satellite backhaul, which involves using satellites to connect base stations in remote areas to core networks. The section concludes by discussing the innovation and trends in the satellite sector to provide rural connectivity, focusing on the latest GSO generation of satellites such as, High Throughput Satellites (HTS) as well as the NGSO constellations.

Governments play a key role in promoting rural ICT connectivity by creating supportive policy and regulatory frameworks. **Section 4** highlights the importance of policy and regulatory frameworks in promoting ICT connectivity in rural areas. This includes measures such as universal service obligations (USOs), which require operators to provide services in underserved areas, and tax incentives or subsidies for operators that invest in rural infrastructure. Such incentives should be available for all operators independent of their technology.

It is critical to ensure that initiatives aimed at improving rural ICT connectivity are sustainable over the long term. This requires careful planning and investment in infrastructure, as well as ongoing monitoring and evaluation of outcomes. **Section 5** provides recommendations on how to achieve sustainability through effective planning, investment, and monitoring.

Firstly, effective planning is essential for ensuring rural ICT initiatives are sustainable. This includes conducting an assessment to identify the specific requirements and challenges of the target community and developing a strategy that considers factors such

as infrastructure requirements, funding sources, and stakeholder engagement. Secondly, investment in infrastructure is a key component of sustainable rural ICT initiatives. Funding for these investments can come from a variety of sources, including government grants or loans, private sector investment, or public-private partnerships. It is important to carefully consider the costs and benefits of different funding models and to ensure that any investments are aligned with the overall strategy for the initiative. Lastly, regular monitoring and evaluation are essential for ensuring that rural ICT initiatives remain sustainable over time.

Section 6 provides recommendations on how to secure funding from a variety of sources to promote universal access to telecommunications in rural areas. Governments can play an important role in funding rural ICT initiatives through grants, loans, or tax incentives. Universal service funds (USFs) are important for financing rural ICT initiatives. USFs are typically financed through levies on operator revenues and are used to fund infrastructure investments in underserved areas. USFs must be well managed and transparent, with clear guidelines for how funds will be allocated and monitored. Policies should be put in place to ensure that all connectivity solutions are eligible for USF funding and that all players in the ICT ecosystem contribute their fair share towards promoting universal access.

The private sector can further play a role in funding rural ICT initiatives through direct investment or public-private partnerships. This includes investing in infrastructure, as well as providing financing for equipment and other capital expenditures. International development organizations such as the World Bank, African Development Bank, and other donor agencies can also provide funding for rural ICT initiatives.

Lastly, the **Annex** provides specific examples of use cases and company-specific innovations that promote rural connectivity.

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Section 1
Introduction

1.1 Preamble

The African Telecommunications Union (ATU or Union) is a specialised institution of the African Union (AU) in the field of telecommunications and ICTs.

It is the Union's objective, according to Article 3(d) of the Constitution and Convention of the ATU, to prepare special programmes for Africa's Least Developed Countries (LDCs) and rural telecommunications development.

In ATU's 2015-2018 Strategic Plan, the Union aimed to develop suitable infrastructure to achieve rural connectivity and universal access. The attainment of this strategic objective was hampered by constraints on the Union's finances and institutional capacity. The 2019-2022 Strategic Plan therefore sought to pursue appropriate strategies to promote "*Bridging the Digital Divide in Africa".*

According to the aforementioned statutory and strategic objectives, the ATU established a task group to develop recommendations relating to Spectrum Policies for ICT Connectivity in Rural Areas. However, the team recognized the limitations of only addressing spectrum-related issues, which affect ICT connectivity in rural areas, thus the scope was amended to address other relevant issues that promote ICT connectivity in rural areas.

1.2 Purpose and Scope

This Recommendation guides policies and best practices relating to rural connectivity including the management of the radio frequency spectrum to facilitate access to ICT services in rural areas, which includes, among others, access to information and education, access to internet telephony, broadband connectivity in general, and broadcasting services to enable people living in rural and remote areas to take part in the digital economy and improve the quality of their lives.

The Recommendation was developed from the perspective of promoting policies for ICT services and spectrum, which will enable the rapid and widespread deployment of affordable, sustainable and reliable communication services.

This Recommendation is complemented by other ATU Recommendations as well as ITU-R Recommendations and Reports relevant to the issues considered herein.

1.3 Definitions

These terms shall have the following meaning in this document:

a. *Affordability:* According to the African Union for the period 2020-2030, *broadband* service is affordable when the price of 6 Mbps is not more than 1 cent USD per MB through a smart device at the price of no more than 100 USD[1] [2].

b. *Cost-Effective*: Where technology can offer sustainable and affordable broadband services in rural settings, then it may be said to be a cost-effective technology.

c. *Broadcasting Service:* A radiocommunication service in which the transmissions are intended for direct reception by the general public. This service may include sound transmissions, television transmissions or other types of transmission.[3]

d. *Broadband Services:* According to the African Union and for the period up to 2030, a broadband service is a connection with a downlink throughput (speed) of at least 6.0 Mbps.

e. *Community Network:* A non-profit small-scale network service that is about, for, by and of a specific underserved/unserved/rural community (usually leverages new low-cost electronic networking equipment), whose ownership and management is representative of that community and provides connectivity to the community.

f. *Information and Communication Technology (ICT):* Technologies and equipment that handle (e.g. Access, create, collect, store, transmit, receive, disseminate) information and communication.[4]

g. *Rural areas:* Sparsely populated areas, characterized by problems of geographical access, inadequate enabling infrastructure such as regular electricity, absence of adequate telecommunication infrastructure, prohibitive access and equipment costs, and low geographic density of the target population.

   In some countries, such areas are defined as areas with a population of less than 2500[5]inhabitants.

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[1] Adapted from the Digital Transformation Strategy for Africa (2020-2030)", by the African Union. https://au.int/en/documents/20200518/digital-transformation-strategy-africa-2020-2030

[2] In the region, there other definition for the term affordability. For example, in South Africa, affordable internet is define d as 1 GB of data costing 2% or less than the average monthly income. (South African Institute of International Affairs (2020) "Africa's ICT infrastructure: Its present and prospects." https://saiia.org.za/research/africas-ict-infrastructure-its-present-and-prospects/)

[3] No. 1.38 of Article of 1 of the Radio Regulations of the International Telecommunication Union (ITU).

[4] Plenipotentiary Conference (PP-14): Report on The Work Carried Out by the Correspondence Group on the Elaboration of a Working Definition of the Term "ICT". https://www.itu.int/md/dologin_md.asp?lang=en&id=S14-PP-C-0048!R2!MSW-E

[5] ITU-D Study Group 2 Final Report on Question 10-3/2, Telecommunications / ICTs for Rural and Remote Areas, 2014; https://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG02.10.3-2014-PDF-E.pdf, Page 3

h. *Rural Connectivity:* An ICT service that is affordable, reliable, secure, relevant, sustainable and accessible to the people living in rural and /or remote areas.

i. *Satellite service:* A form of communications/ICTs to and/or from space to the earth providing fixed, mobile, data and/or broadcasting services[6].

j. *Telephony:* A form of telecommunication primarily intended for the exchange of information in the form of speech.[7]

k. *Two-way Radio:* A wireless communication service in which transmission is possible simultaneously in both directions of a telecommunication channel.[8]

1.4 The Rural Connectivity Challenge

The connectivity challenge in brief

There are two main categories of the connectivity challenge, coverage gap and usage gap:

- The coverage gap refers to people who live in areas without network coverage. The coverage gap is about 17% on average in SSA.
- The usage gap refers to people who live within areas with network coverage, yet do not use the internet for various reasons. The usage gap is about 61% in SSA. The main factors contributing to the high usage gap include:
    - High illiteracy and low digital skills
    - Affordability of devices and the services
    - Lack of relevant content
    - Cyber security concerns

[6] See Article 1 of ITU-R RR. Where different sub-categories of satellite services are presented

[7] No. 1.123 of Article 1 of the Radio Regulations of the International Telecommunication Union (ITU)

[8] No. 1.126 of Article 1 of the Radio Regulations of the International Telecommunication Union (ITU)

The International Telecommunication Union (ITU) recognises that the urban-rural gap remains a major challenge for digital connectivity in developing countries. Globally, people in urban areas are twice as likely to use the Internet than those in rural areas (76 % urban compared to 39 % rural), whereas in Least Developed Countries (LDCs), urban dwellers are almost four times as likely to use the Internet as people living in rural areas (47 % urban compared to 13 % rural).[9]

The World Bank reports that, as of the year 2020, approximately 60% of people living in Sub-Saharan Africa (SSA) live in rural areas[10]. These areas are characterised by low population densities and dispersed settlements, which render them geographically challenging to access.

For example, the Broadband Commission report indicated that as of 2020, in Cote D'Ivoire, 28% of the population lived in areas without mobile broadband coverage, representing a digital divide of over 7 million people. In Ethiopia, roughly 15% of the population lives in areas without minimum 3G coverage, representing nearly 17 million people without access to mobile broadband[11]. Furthermore, the ITU Global Connectivity Report 2022 indicated that almost 30% of the rural population in Africa could not access the Internet. Further, 18% of the rural population has no mobile-network coverage, and another 11% has only access to a 2G network".[12] This is also supported by the 2022 report from the Broadband Commission, which claims that less than a quarter of households have access to the internet in Sub-Saharan Africa.[13]

Rural areas tend to have geographic access challenges due to distance, terrain, poor quality of road/transport network and lack of or inadequate basic enabling infrastructure such as regular electricity supply[14]. The demography of rural areas makes them commercially unattractive for private communication service providers who derive most of their revenue from urban centres. This phenomenon has produced a coverage gap between the urban and rural areas. As of the end of 2021, SSA had the widest coverage gap in the world, with a coverage gap of 17% and a usage gap of 61%[15]. ITU indicators show that in 2022, the proportion of individuals using the Internet in Africa is 40% while this figure is 66% globally[16]. Accordingly, by 2022, 64% of urban dwellers were using the internet as compared to 23% of people in rural areas. In 2019, the ratio of rural-urban connectivity was four (04) but this improved to 2.8 in 2022[17]. Even with the trends of urbanisation in most countries and the increasing use of mobile internet services, a significant rural-urban gap persists in most SSA countries.

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[9] PP-22 Res.71 is suggested. ITU Plenipotentiary Conference Resolution 71 (Rev. Bucharest, 2022), Annex 2 https://www.itu.int/dms_ties/itu-s/md/22/pp/c/S22-PP-C-0202!!PDF-E.pdf

[10] World Bank Data, https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=ZG

[11] Broadband Commission (2020) "The role of geostationary satellite networks in meeting the rural connectivity challenge." https://broadbandcommission.org/insight/the-role-of-geostationary-satellite-networks-in-meeting-the-rural-connectivity-challenge/

[12] Global Connectivity Report 2022 - ITU Publication, p.33

[13] The_State_of_Broadband_2022.pdf

[14] ITU-D Study Group 2 Final Report on Question 10-3/2, Telecommunications / ICTs for Rural and Remote Areas, 2014; https://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG02.10.3-2014-PDF-E.pdf, Page 3

[15] https://www.gsma.com/r/wp-content/uploads/2022/10/The-State-of-Mobile-Internet-Connectivity-Report-2022.pdf

[16] https://www.itu.int/en/mediacentre/Pages/PR-2022-11-30-Facts-Figures-2022.aspx

[17] https://www.itu.int/itu-d/reports/statistics/2022/11/24/ff22-internet-use-in-urban-and-rural-areas/

The African continent has a large land mass of 30.37 million square kilometres characterised by topography, which makes deployment of terrestrial networks in the different countries a challenge, particularly in the rural and remote areas. Because of this, other services need to be considered to complement the terrestrial networks in the different countries.

A report issued by the Broadband Commission in October 2019 estimated that around $ 100 billion would be needed to achieve universal access to broadband connectivity in Africa by 2030[18]. A proportion of the required investment is needed to roll out an estimated 250, 000 new 4G base stations and at least 250, 000 kilometres of new fibre across the region to achieve the goal. Additionally, satellite services using both GSO and/or NGSO systems have the capability of providing connectivity to any location in the world including rural, remote hard-to-reach areas.

The digitization of the global economy has dire implications for rural communities without coverage because citizens may be deprived of critical services including banking, education and health. Television and sound broadcasting systems are more pervasive than broadband network connectivity and can provide vital information and education services. However, broadcasting systems do not provide a direct return path for engagement, interactivity and commercial transactions. The lack, or inadequacy of connectivity, poses high risks for many in rural settlements. Therefore, governments across the world, particularly in developing countries with significant rural populations, are actively exploring technology and policy options that can speedily, and affordably, provide rural network connectivity. These governmental efforts are in pursuit of **Target 9c** of the Sustainable Development Goals (SDG), which aims to significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least-developed countries by 2020[19].

Governments are looking at the growth of national ICT penetration, and the private sector is also looking at areas where they will be able to have their return on investment and has inevitably prioritised urban and semi-urban areas where there are guaranteed returns, to the detriment of rural, more sparsely populated areas. The GSMA has summed up the issue succinctly in their policy paper on Enabling Rural Access[20]:

> *"The lack of coverage in rural areas is the consequence of a basic economic challenge: deploying infrastructure in remote areas can be twice as expensive, while revenue opportunities are as much as ten times lower, a combination that deeply affects the business case for MNOs to deploy infrastructure."*

While the application of Universal Service Funds in some countries has been able to mitigate this problem by subsidising the capital costs of rural deployments by MNOs, the operational

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[18] https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.20-2019-PDF-E.pdf

[19] United Nations Department of Economic and Social Affairs, Sustainable Development, Goal 9, https://sdgs.un.org/goals/goal9

[20] Enabling Rural Coverage: Regulatory and policy recommendations to foster mobile broadband coverage in developing countries. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/02/Enabling_Rural_Coverage_English_February_2018.pdf GSMA 2018

costs in many cases still do not match the income levels in rural areas. Thus, even when coverage obligations are imposed on operators, it may still not result in active service.

The COVID-19 pandemic has highlighted the extent of the digital gap in our society, underscoring the importance of connecting everybody and ensuring that no individuals or communities are left behind[21]. Many lessons have been learned during the pandemic on the importance of digital inclusion, especially with most social activities, teaching and learning, and business activities moving online. Considering the importance of ICT connectivity in life, there is an urgent need to introduce alternative business models and regulatory approaches to existing methodologies as well as support a mix of technologies to ensure affordable service delivery in rural and remote areas. For example, economic growth and prosperity have already been advanced by increased connectivity[22].

The pressure to expand broadband infrastructure affects the entire value chain from local access to international connectivity. The benefits of consistent synergistic development can be viewed within the context of the markets of a single region or nation, as well as within the context of uniting fragmented markets across disparate national or regional chains. Each link in the infrastructure chain, shown in Figure 1 below, poses its challenges in the process of installation, expansion, and upgrade. To meet these challenges, service providers, investors, and governments must use a variety of technical, commercial, and business solutions.

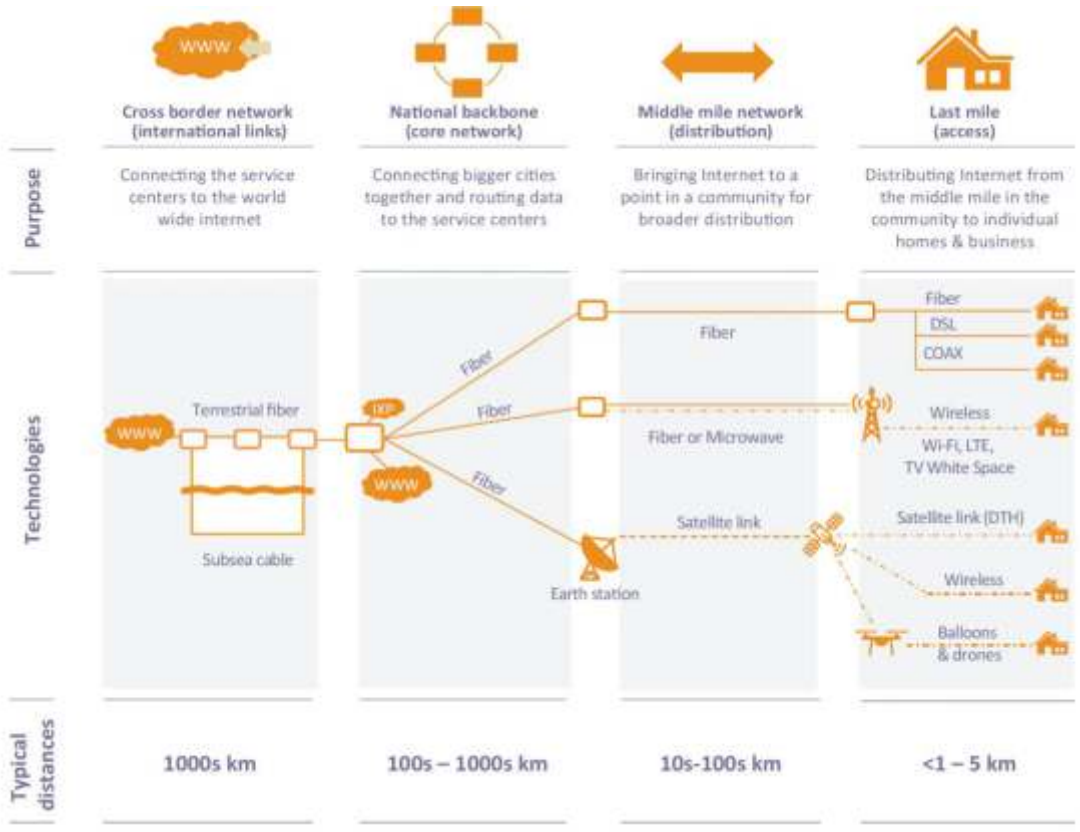

Figure 1 World Bank, 2019, innovative business models for expanding fibre-optic networks and closing the access gaps[23]

[21] ATU-R Recommendation 006-0 (see www.atuuat.africa)

[22] ITWeb (2020) "ITU study lifts the lid on ICT adoption in Africa." https://www.itweb.co.za/content/xnklOqzLDZO74Ymz

[23] https://documents1.worldbank.org/curated/en/674601544534500678/pdf/Main-Report.pdf

Over the last two decades, wireless communication technologies have proven to be the means to rapidly extend communication services to rural settlements. These technologies depend primarily on the Radio Frequency (RF) spectrum. Therefore, the technical, economic, regulatory and policy approaches to the management of the RF spectrum have implications for providing connectivity to rural areas.

This recommendation aims to compile a set of good practices and innovative approaches in the management of the RF spectrum and other relevant regulatory measures. The primary goal is to accelerate the extension of coverage to rural and remote areas by enabling the deployment and operation of innovative technologies through a conducive regulatory environment.

1.5 Structure of the Recommendation

The Recommendation is presented as follows:

Section 1: Introduction
Section 2: Spectrum Management Innovations that Promote Rural ICT Connectivity.
Section 3: Satellite Networks and Rural Connectivity.
Section 4: Policy, Strategy, Legal/Regulatory Framework for ICT Connectivity Initiatives in Rural Areas.
Section 5: Sustainability of Rural Telecommunication/ICT Initiatives.
Section 6: Funding Approaches for Rural Connectivity.
Annex.

Section 2
Spectrum Management Innovations that Promote Rural ICT Connectivity

Approaches to spectrum licensing aimed at enhancing connectivity in rural areas:

1. Spectrum licensing models for rural connectivity
    a. Assignment of dedicated spectrum for rural network deployment. With this approach, spectrum licenses are granted to operators in areas designated as rural, unserved or underserved.
    b. Outsourcing to specialized rural operators. A new class of rural service provider has emerged in recent years, which focuses on affordable rural infrastructure. They partner with incumbent operators to deploy networks in rural areas using the incumbent's frequency with revenue sharing business model.
    c. Wholesale wireless Open Network Access (WOAN) refers to a shared national IMT network offering service to existing licensed operators, built with the aim of increasing network coverage. Licensed operators access the network on a lease term.
    d. Incentivized spectrum licensing. Some administrations have adopted low-priced spectrum licensing model with coverage obligations, especially the lower frequency bands to enhance rural coverage.
2. Spectrum sharing. In recent years, shared spectrum access has gained significant attention because of the benefits of reduced initial capital requirement, especially for rural network deployment. The various spectrum sharing approaches include:
    a. Non-competitive Local Licensing, which involves setting aside IMT spectrum to be assigned in, limited geographic areas on a demand basis.
    b. Dynamic spectrum sharing which is another form of local licensing that relies on automated assignment of local spectrum licenses through a geo-location database.
    c. Shared access to IMT spectrum, which involves the introduction of use-it-or-share-it principles to spectrum licenses enabling access to licensed but unused spectrum in underserved regions.
3. License Exempt Spectrum
   Wi-Fi has proven to be a successfully technology for both access networks and for fixed wireless access for large and small operators alike. Low equipment cost and absence of license fees have made it a popular access technology.

2.1 Introduction

The radio frequency (RF) spectrum is a finite natural resource. It is a heterogeneous resource with segments of frequencies exhibiting similar characteristics called bands. Due to their unique technical features, spectrum bands are allocated to different services.

In today's ICT connectivity, spectrum is crucial because much of it depends on the resource to enable wireless connections between ICT delivery systems (network infrastructure) and the users (user access terminals). Whereas spectrum is a crucial enabler of ICT connectivity everywhere, its vital role is more pronounced in rural and remote areas where other forms of connectivity, such as fibre, are much more challenging to implement than in urban areas.

Recognising the pivotal role that spectrum can play in rural and remote areas, this section presents various spectrum management innovations (case studies) in Africa and around the world, which are seen to promote rural ICT connectivity.

2.2 Case Studies on spectrum management innovations in Africa and around the world that promote rural ICT connectivity

2.2.1 Licensed Spectrum Innovations for Rural Connectivity

In the absence of spectrum-sharing regulations, there have been limited options available to regulators or operators to ensure access to spectrum in rural areas. In some cases, regulators have deliberately set aside spectrum for rural operators. In other cases, operators have outsourced rural connectivity allowing access to their spectrum in rural areas by companies that have developed technologies and business models uniquely suited to rural markets.

2.2.1.1 Specific Spectrum Assignments for Rural Areas

In Sub-Saharan Africa, there have been at least two instances where regulators have set aside spectrum for rural use.

In Senegal, ARTP granted a spectrum license in 2009 to Consortium du Service Universel (CSU), trading commercially as Hayotel[24], to cover the northeast part of the country, in the Matam region. The company had a frequency license in the 2.3GHz band to provide WiMAX services. The frequency license had a coverage obligation to cover 156 villages in the Matam region. CSU started operating in 2013, however, the network faced several challenges at the beginning in providing sustainable rural services, ranging from the availability of power and network backhaul for base stations to the challenge of

[24] Hayotel home page http://www.hayotel.com/

affordable handsets for WiMAX. They have since addressed many of these issues. In 2018, CSU was granted a spectrum license in the 1800MHz band for GSM services in the same region. The switch to GSM brought significant cost savings to consumers in the form of affordable handsets and to CSU in the form of affordable IP-backhauled GSM network infrastructure. They have also been able to take advantage of the growth of national fibre optic backbone infrastructure to switch from satellite to fibre backhaul. According to ARTP Senegal, as of 2022, CSU has a 0.002% market share of the national mobile subscribers[25].

In Tanzania, Rural NetCo was launched in 2010[26] to provide affordable broadband service in rural regions. Rural NetCo was granted 2x5MHz of 900MHz spectrum for the provision of UMTS 3G services. Rural NetCo was set up as a wholesale operator from which operators buy capacity to provide services to their customers. Rural NetCo subsequently became Shared Network Tanzania Ltd (SNT), which was acquired by Vodacom Tanzania

Elsewhere in the world, Mexico has assigned spectrum for rural, underserved areas and indigenous peoples. After a successful pilot by a non-profit organisation[27] in the state of Oaxaca, the Mexican communication regulator (IFETEL) determined that a modest amount of spectrum, 2x5MHz in the 850MHz band, was unassigned and could be made available permanently. This amount of spectrum was of little value to commercial operators. As a result, in IFETEL's Annual Program for the Use and Exploitation of Frequency Bands 2015[28], it was assigned for "social use". Thus, 2x5 MHz of 850 MHz spectrum in 7 regions (excluding the urban areas occupied by Guadalajara and Monterrey) and 2 x 2.54 MHz of spectrum in one other region, was made available for use by non-profit, social benefit organisations with the provision that:

- deployments must be in rural settlements with a population of less than 2,500 people; and,
- the regulator reserves the right to assign the spectrum for commercial use in the future.

Tecnologías Indígenas Comunitarias (TIC), a non-profit organisation based in Oaxaca, Mexico, holds a concession as a social telecommunications operator and currently serves 3,350 active daily users spread across 63 villages and communities in the state of Oaxaca

[25] ARTP - Tableau de bord marché du mobile au 31 Décembre 2022 https://artp.sn/votre-documentation/tableau-de-bord-marche-du-mobile-au-31-decembre-2022

[26] Yonah, Z.O. et al. Overview of Broadband Connectivity for Rural Areas-Tanzania as a Case Study. April 2017. International Journal of Computer Science and Information Security, 15(4):312-320 https://www.researchgate.net/publication/317281075_Overview_of_Broadband_Connectivity_for_Rural_Areas-Tanzania_as_a_Case_Study

[27] Rhizomatica website https://rhizomatica.org

[28] Agreement by which the Plenary of the Federal Telecommunications Institute modifies the Annual Programme for the Use and Exploitation of Frequency Bands 2015. https://www.dof.gob.mx/nota_detalle.php?codigo=5387867&fecha=06/04/2015

with 2G voice and data services. These users are served by 14 community-owned and operated-cellular sites[29].

In Canada, communities are also providing mobile network services in rural areas. This has been achieved through an agreement with one of the incumbent telecommunications operators holding a long-term, nationwide, exclusive-use spectrum license. The Indigenous-people-owned and controlled KMobile service began in 2008 in the Sioux Lookout region of north-western Ontario, in partnership with Keewaytinook Okimakanak, an organisation that supports infrastructure development in its member communities. KMobile successfully obtained the right to use 2x5 MHz in the 850 MHz frequency band from the national provider who had no plans to use it in this region because the Indigenous communities did not meet their population requirements[30]. Legally, KMobile is registered as a non-dominant carrier operating on a Subordinate license (800 to 900 MHz) assigned to that operator. Currently, 26 communities have 3G services, covering an estimated population of 22,000 across the indigenous region.

2.2.1.2 Operator Outsourcing for Rural IMT Spectrum (Network-As-A-Service (NAAS))

Thanks to advances in wireless manufacturing technology, some new manufacturers and service providers have entered the market producing IMT wireless infrastructure that is tailored to rural service provision in terms of coverage, power consumption, ruggedness and above all affordability. Manufacturers such as Vanu[31] and NuRAN Wireless[32] have been producing low-cost GSM equipment for the last decade, initially 2G but now 3G/4G and even 5G equipment.

Accordingly, Vanu, Africa Mobile Networks (AMN)[33] [34] and others have pioneered a full-service business model in which they take full responsibility for the deployment and operation of their networks. Often referred to as Network as a Service (NaaS), it offers incumbent mobile network operators the opportunity to expand their coverage with no capital expenditure or operating equipment risk. In exchange, these rural service providers gain access to the IMT spectrum held by their MNO clients and enter into a revenue-sharing agreement for traffic over their network. To deploy their connectivity solutions, these companies use many solutions for backhaul including satellite services.

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[29] DIY Telecoms. The Economist. 7 March 2015. https://www.economist.com/technology-quarterly/2015/03/05/diy-telecoms

[30] Beaton, B. et al. Keewaytinook Mobile: An Indigenous Community-Owned Mobile Phone Service in Northern Canada In L. Dyson, S. Grant & M. Hendriks (eds.), Indigenous People and Mobile Technologies, Routledge. Sydney, Australia, 109-124. http://firstmile.ca/wp-content/uploads/2015-Beaton-Burnard-Linden-ODonnell-Keewaytinook-Mobile.pdf

[31] Vanu home page https://www.vanu.com

[32] NuRan Wireless home page https://nuranwireless.com/

[33] https://www.vanu.com/products/community_connect_village_bts/

[34] Metier-led consortium invests $36 mn in Africa Mobile Networks. The Capital Quest. July 20, 2021. https://thecapitalquest.com/2021/07/20/metier-led-consortium-invests-36-mn-in-africa-mobile-networks/

For instance, AMN has a partnership with Intelsat to cover backhauling for cellular deployment in remote areas[35] (see example in section 3.3)

Global manufacturers like Huawei have also entered the low-cost rural market. RuralStar and now RuralStarPro[36] also offer low-cost, rugged rural wireless IMT infrastructure but Huawei typically rely on more traditional supply-chain vendor relationships to sell equipment to existing operators as opposed to offering a service model. More details can be found in a GSMA case study[37].

2.2.1.3 Wholesale Wireless Open Access Networks (WOANs)

As an attempt to share the cost of spectrum access and rollout of infrastructure, some countries have implemented Wholesale Wireless Open Access Networks (WOANs). WOANs are typically implemented as a strategic decision by national governments to bring down the cost of access and to lower the cost of rural rollout. A WOAN is typically granted a national IMT spectrum license for a significant portion of the spectrum to be able to support multiple service providers on the network. It is not a characteristic of a WOAN but in some cases, profiled below, countries have implemented their WOANs as monopolies.

The GSMA has identified certain challenges with WOAN implementation, for example, the cost of the service. According to GSMA, other approaches such as *voluntary* network sharing among MNOs may be adopted in areas where building networks is not commercially viable[38]. The Shared Rural Network (SRN) in the UK by four MNOs – EE, O2, Three and Vodafone has adopted this approach. The SRN aims to deliver reliable mobile broadband to 95% of the UK, addressing the digital divide by improving 4G coverage in the not-spots. The programme could be a sustainable approach to the challenge of delivering rural mobile coverage that will not only transform 4G coverage without duplicating infrastructure but also reduce the impact on the countryside[39].

In 2014, the Rwandan Government and Korea Telecom signed a shareholder's agreement to establish a joint venture company (KTRN)[40] which would have exclusive rights for 25 years to build and operate a wholesale-only 4G LTE broadband network in the 800MHz band. Within four years, KTRN had provided coverage to 95% of the population[41]. In 2019, KTRN improved its network performance by upgrading 120 Sites whose resources were over utilized (110 in Kigali and 10 outside Kigali) and expanded coverage from 480

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[35] https://www.intelsat.com/newsroom/amn-and-intelsat-partner-to-connect-ultra-rural-sub-saharan-africa/

[36] https://www.huawei.com/en/tech4all/stories/ruralstar

[37] https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/01/Huawei_RuralStar_MTN_Ghana_Rural_Innovation_Connectivity_Case_Study_Nov.pdf

[38] https://www.gsma.com/spectrum/resources/woan-report/

[39] https://srn.org.uk/about/

[40] KT Rwanda https://www.ktrn.rw/

[41] Four years later, 95% of Rwanda covered with 4G Internet. https://www.newtimes.co.rw/news/four-years-later-95-rwanda-covered-4g-internet

to 600 sites[42]. In February of 2023, the Rwandan government announced[43] their decision to change the wholesale network policy because the exclusivity model on 4G was not sustainable. The model made the broadband market one-sided, despite the wide deployment of the 4G network; there was low uptake of the service because the Mobile Network Operators expressed concerns that the wholesale prices were not economically viable. Hence, operators focused on marketing their 3G services to their customers even though the quality of experience was inferior to that of 4G. Considering the challenges with the initial monopolised 4G network policy, the Government of Rwanda has liberalised technology deployments and wireless access spectrum assignments to ensure that all operators can deploy such advanced broadband services[44].

In 2020, the South African government announced[45] that it would implement a WOAN as part of its plans to auction a large amount of IMT spectrum. The WOAN was to comprise frequencies in the 700MHz, 2600MHz, and 3500MHz bands. However, the policy for the licencing of the high demand spectrum for WOAN was withdrawn after the Department of Communications and Digital Technologies established through a study that WOAN would not meet the viability threshold.

Elsewhere in the world, in 2018, Mexico introduced a WOAN using the entire 700MHz band, called the Red Compartida[46]. The network struggled with buy-in from incumbent operators and ultimately became insolvent in late 2021[47]. However, the Mexico government shortly thereafter bailed it out and the network continues to grow. As of March 2023, the network offers 4.5G coverage to more than 80 million people representing 70.73% of the population. In terms of subscription to the service, there are 111 MVNOs serving over 5 million subscribers[48]. Critics have suggested that Red Compartida's business model may continue to struggle due to its mandate to serve population areas not covered by existing operators[49].

In 2022, the Malaysian government announced plans to build a 5G WOAN. In January 2023, the Malaysian government announced that its 5G network had achieved 50%

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[42] RURA Annual Report 2019-2020. https://www.rura.rw/fileadmin/docs/report/RURA_ANNUAL_REPORT_2019-2020.pdf

[43] Korea Telecom Rwanda Networks loses 4G infrastructure monopoly https://www.connectingafrica.com/author.asp?section_id=816&doc_id=783093& Connecting Africa. 7 February 2023.

[44] Rwanda National Broadband Policy, 2022 https://www.minict.gov.rw/index.php?eID=dumpFile&t=f&f=55955&token=4f911fb560969db5f90a30e7247393d25ba8d6c9

[45] ICASA sets out the rules for the WOAN. TechCentral. 2 October 2020. https://techcentral.co.za/icasa-sets-out-the-rules-for-the-woan/177209/

[46] Red Compartida. http://www.sct.gob.mx/red-compartida/proyecto-eng.html

[47] Mexican government bails out bankrupt Altan Redes. Developing Telecoms. 13 June 2022. https://developingtelecoms.com/telecom-business/operator-news/13598-mexican-government-bails-out-bankrupt-altan-redes.html

[48] Altan Redes – Nuestra Cobertura - https://www.altanredes.com/soluciones-a-operadores/nuestra-cobertura/ Accessed on 15 May 2022.

[49] Mexico's shared network exits bankruptcy but faces a tricky future https://telecoms.com/518298/mexicos-shared-network-exits-bankruptcy-but-faces-a-tricky-future/ Telecoms.com 07 November 2022.

coverage of populated areas, exceeding its original target of 40% in 2022[50]. However, a new Government, which came into office in November 2022, reviewed the rationale behind the introduction of the monopoly WOAN, and decided against this approach. In May of 2023, the government confirmed that it would end exclusivity for its 5G wholesale network, a move that was welcomed by incumbent operators[51].As at the time of developing this report, the Government was in the process of abolishing the one 5G network policy.

2.2.1.4 Incentivised rural connectivity via currently licensed spectrum or new IMT spectrum bands

a. Spectrum Pricing as a tool to achieve rural coverage objectives

Raising revenue has, historically, been a by-product or, in some instances, the main objective, of awarding spectrum. Research has shown that there is strong evidence linking higher spectrum prices with a persistent negative impact on 4G coverage, as well as a negative impact on 3G coverage, in the short and medium term.[52] Indeed, countries in Africa with lower spectrum prices have achieved wider population coverage and faster speeds.[53] It is also a considered fact that spectrum licences have traditionally contained a range of non-price terms and conditions. However, pricing spectrum reasonably low whilst carefully considering the conditions imposed in licences can lead to practical solutions that will result in coverage obligations that are impactful, but also commercially and technically feasible. This is a useful approach to enhancing coverage of rural unserved and underserved areas.

Case Study: Tanzania

Having successfully completed the Digital Switchover in 2015, in 2018 the Tanzania Communications Regulatory Authority (TCRA) held a public auction for the 700 MHz band. The TCRA had highlighted its intention that the spectrum promotes mobile broadband capabilities, lower costs because of the fewer base stations needed and expand mobile services to rural areas[54]. The Government's approach was to place emphasis on long-term economic benefits from increased mobile broadband far outweighing the benefits of smaller, short-term auction proceeds. As such, a relatively low reserve price was set and the auction resulted in the entire spectrum assigned. Modest revenues were raised, but coverage obligations were imposed to promote rural broadband coverage. The coverage obligations were designed to promote the extension

[50] Malaysia delivers 5G to half of population https://developingtelecoms.com/telecom-business/operator-news/14374-malaysia-delivers-5g-to-half-of-population.html Developing Telecoms. 3 January 2023

[51] Malaysian operators open arms to second 5G network https://developingtelecoms.com/telecom-business/operator-news/14939-malaysian-operators-open-arms-to-second-5g-network.html Developing Telecoms. 4 May 2023

[52] The Impact of Spectrum Prices on Consumers - https://www.gsma.com/spectrum/wp-content/uploads/2019/09/Impact-of-spectrum-prices-on-consumers.pdf

[53] Effective Spectrum Pricing in Africa - https://www.gsma.com/spectrum/wp-content/uploads/2020/11/Effective-Spectrum-Pricing-Africa.pdf

[54] Tanzania – Results of the 700 MHz auction https://www.tcra.go.tz/uploads/documents/sw-1619106560-RESULTS%20OF%20THE%20700%20MHz%20SPECTRUM%20AUCTION.pdf

of broadband access without diminishing the value in the spectrum secured by successful bidders.[55] As at the end of 2021, mobile network population coverage was 95%.[56]

b. Exploiting the features of Low-bands for expanded mobile network coverage

Spectrum in the low 'Sub-1 GHz' bands offers significant cost advantages due to its propagation characteristics that allow for covering greater distances. These advantages, in turn, allow mobile operators to expand coverage for rural communities as well as to offer lower costs for consumers, facilitating greater mobile penetration. Therefore, where the aim is to extend mobile network coverage to more rural unserved and underserved areas, emphasis on making spectrum available in this spectrum range is crucial. Completing the Digital Switchover process and freeing-up the 700 MHz and 800 MHz bands, for example, will help network operators to extend coverage to rural areas.

Case Study: Australia

In Australia APT700 spectrum has been instrumental in extending 4G coverage to regional and remote areas of Australia that otherwise would not have been possible to cover economically, or at all. Prior to APT700 deployment, one mobile operator's networks covered approximately 85% of population and 100,000 sq. km. Deploying the APT700 with existing and new 4G sites helped increased their 4G coverage to over 99% of the population and more than 1.6m sq. km of Australia.[57]

c. Investment commitments in exchange for lower prices for spectrum

The process of awarding spectrum to mobile operators, whether via auctions or other methodologies, can be used to encourage rollout of infrastructure and services in rural unserved and underserved areas if the approach is set out to focus on striking a balance between government objectives, operators' requirements and consumer welfare. Spectrum policies and license award processes aimed to improve rural connectivity can adopt the following principles to ensure long-term network investment and greater rural connectivity:

- investment-friendly payment terms such as yearly instalments for the duration of the licence
- converting the premium achieved above the auction reserve price into investment obligations
- deducting coverage obligation costs from final prices, as seen in Brazil's 2021 multi-band auction.[58]

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[55] Tanzania 700 MHz Spectrum Auction - http://www.coleago.com/app/uploads/2020/06/Learning-from-Best-Practice-in-Tanzania-TCRA-Final.pdf

[56] TCRA 2021 COUNTRY DATA https://www.tcra.go.tz/uploads/text-editor/files/Country%20ICTs%20Indicators%202021_1645555763.pdf

[57] Telstra 4G coverage hits 99%, switches on LTE-M https://www.mobileworldlive.com/featured-content/top-three/telstra-4g-coverage-hits-99-switches-on-cat-m1/

[58] Brazil multi-band auction: one of the largest in mobile history https://www.gsma.com/spectrum/brazil-multi-band-auction-one-of-the-largest-in-mobile-history/

Case Study: Sweden

When the Swedish Post and Telecom Authority (PTS) has no explicit mandate to raise revenues in the awarding of spectrum, but is happy to do so as a by-product of securing an efficient outcome. It often prices spectrum at a low but non-trivial level. When it auctioned the 800 MHz, it took the decision that a coverage obligation was required to ensure service in selected rural areas. The Regulator attached specific coverage obligation to only one of 2x10 MHz licences on offer in the auction, to avoid unnecessary infrastructure duplication. It further adopted an innovative approach of allowing operators that bid for this licence to commit to spending between SEK150m-300m ($22m-44m) on specified rural coverage, and count this amount towards their bid. This created an implicit discount for taking the coverage obligation, which encouraged active competition between operators for the associated licence. Because of such approaches, as of 2020, all Swedish households had 4G coverage.[59]

2.3.1 Spectrum Sharing Mechanisms

Some regulators have begun to complement long-term, national, exclusive-use spectrum licences with mechanisms to allow for contextual, granular access to wireless spectrum. However, the urgency of establishing an effective spectrum-sharing regime has risen dramatically in recent years due to increasing market demand for spectrum and the increasing priority that access to communication represents in modern society.

2.3.1.1 Non-competitive Local Licensing of IMT Spectrum

Some regulators have also acknowledged the potential of local licensing to address rural connectivity. In this regard, they have begun to offer granular assignment of spectrum to offer flexible, local, spectrum access. This "local licensing" of spectrum has often been used to enable private LTE, and 5G networks for any interested parties, that may wish to deploy networks to address security and/or cost concerns.

United Kingdom: In the UK, the regulator introduced a Shared Access License[60] in 2019, which made localised licences available in a range of frequency bands, including:

- 1800 MHz band: 1781.7 to 1785 MHz paired with 1876.7 to 1880 MHz;
- 2300 MHz band: 2390 to 2400 MHz;
- 3800 to 4200 MHz band; and,
- 24.25-26.5 GHz: this band is only available for indoor low power licences.

The license allows for low power use in urban areas and medium power use in rural areas where interference is less likely. Licence fees are modest, in the range of hundreds of pounds, and are renewable annually. This license has distinct potential for rural LTE/5G

[59] Share of households with 4G coverage in Sweden from 2016 to 2019, based on DESI - https://www.statista.com/statistics/1068625/4g-coverage-among-households-in-sweden/

[60] OFCOM: Shared access licences. 09 December 2019 https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences/shared-access

deployments. As the license has only been in operation since 2019, there is not yet much public information on uptake.

UK regulator, Ofcom introduced a new licensing approach in the 3.8-4.2 GHz, through local licenses (called Shared Access Licenses). Potential users can apply to Ofcom for coordinated access to these bands in specific locations on a first-come-first-served basis. This licensing regime is associated with low and medium power limitations in combination with examination from the regulator for each license to protect existing services (5G services in the adjacent band, FSS, FS). As of 2023, more than 1600 licenses have been issued[61].

New Zealand: The New Zealand regulator has set aside spectrum as a managed park or pool of spectrum: setting aside 40MHz of spectrum (2580-2620MHz) in the 2.5 GHz band as a Managed Spectrum Park[62], which offers geographically limited spectrum licences. The Managed Spectrum Park was introduced in 2009. Eighty licences were granted initially and thereafter were made available on a first-come, first-served basis. License terms are six years. There are limits on geographic coverage of licences held by any single organisation. While not without its own challenges, this model has proven successful in enabling wireless ISPs to offer rural LTE services.

Canada: In August of 2022, the Canadian spectrum regulator (ISED) launched a consultation on a Non-Competitive Local Licensing Framework[63]. The proposed framework draws significantly on the UK's Shared Access License referenced above. However, ISED have selected the 3900-3980 MHz Band and portions of the 26, 28 and 38 GHz bands, all of which are 5G frequencies. Canada has now issued their framework on Non-Competitive Local Licensing (May 2023[64])

Germany: The regulator[65] opened 100 MHz in the 3.7-3.8 GHz band for 5G local spectrum licences. Applicants could apply for up to 100 MHz of spectrum, in 10 MHz blocks for use in a defined coverage area with licences duration of up to 10 years, with the possibility of renewal. Users must ensure interference-free use, including by coordinating with other geographically near local users and protecting existing users in the band (e.g., FSS earth stations). The spectrum must be used within one year of assignment and BNetzA must

[61] https://www.ofcom.org.uk/__data/assets/pdf_file/0032/255965/call-for-inputs-evolution-of-shared-access.pdf

[62] RSM: Managed Spectrum Park https://www.rsm.govt.nz/projects-and-auctions/expressions-of-interest/managed-spectrum-park/

[63] Consultation on a Non-Competitive Local Licensing Framework, Including Spectrum in the 3900-3980 MHz Band and Portions of the 26, 28 and 38 GHz Bands https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11793.html

[64] https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/spectrum-allocation/decision-non-competitive-local-licensing-framework-including-spectrum-3900-3980-mhz-band-and

[65] https://digitalregulation.org/spectrum-licensing-local-and-private-networks-in-germany/

approve any transfers. Several companies from various technology related industries applied for private 5G licenses.

2.3.1.2 Automated Dynamic Spectrum Sharing

Dynamic Spectrum Sharing, referred to here as Automated Dynamic Spectrum Sharing in order to distinguish it from more manual approaches in the preceding section, refers to the dynamic assignment of spectrum via an authorisation database that assigns spectrum based on calculated availability.

Television White Space (TVWS)

Advocacy for secondary access to licensed spectrum in the VHF/UHF frequencies for terrestrial television broadcasting began in the United States in the early 2000s culminating in regulation for TV White Space (TVWS) technology being implemented in 2011. Kenya and South Africa were the first African countries to pilot the use of TVWS technology in 2013. While the technology trials proved successful, enabling regulation took much longer due to the novelty of the regulatory framework and the need to provide guarantees of non-interference to the primary spectrum holders. In the African region, the Digital Switchover from analogue to terrestrial broadcasting in the same UHF frequencies has further complicated this. Some regulators have insisted that the transition from analogue to digital terrestrial broadcasting be completed before TVWS can be considered.

Overall adoption of TVWS regulation in Sub-Saharan Africa has been slower than might be expected given that successful trials were carried out in 2013. As at 2023, South Africa[66], Kenya[67], Mozambique[68], Ghana[69] and Zambia[70] have TVWS regulations in place. Other countries such as, Nigeria in the region have initiated consultations on TVWS. And whilst TVWS may not yet have proven to be as feasible in bridging connectivity gaps as theoretically promised, the increasing normalisation of TVWS regulation should send positive signals to manufacturers resulting in lower prices and a more diverse ecosystem of devices.

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[66] (South Africa)

[67] Dynamic Spectrum Access Framework for Authorization of the use of TV White Spaces. Communications Authority of Kenya. May 2021. https://www.ca.go.ke/industry/frequency-spectrum/spectrum-sharing-strategies

[68] Technical standard TV-White Space (TVWS) for telecommunications services in the frequency bands 470-694 MHz INCM. 24 June 2019. https://www.arecom.gov.mz/index.php/mercado/documentos-telecomunicacoes/190-resolucao-que-aprova-a-norma-tecnica-tv-white-space-tvws

[69] Television White Space (TVWS) Guidelines, NCA 2019. https://nca.org.gh/wp-content/uploads/2021/11/Guidelines-for-TVWS-Data-Services.pdf

[70] Television White Space (TVWS) Guidelines. ZICTA. 2021. https://www.zicta.zm/storage/posts/attachments/KoqgmWNLeNuxc592HcO83tMqHJHzz82ub0nOM5Do.pdf

An issue that has proven challenging with the implementation of TVWS regulation has been the establishment of a geo-location database service to authenticate frequency use for each TVWS device. Because automated geo-location spectrum authorisation databases are a relatively new approach to spectrum regulation, it has not always been obvious who should operate the database, who should pay for it, how it should be overseen, and how it should be regularly validated for accuracy.

While geo-location databases have proven to be a successful mechanism for the control of access to TVWS frequencies in the United States and the United Kingdom, it has not always been as clear-cut in African countries.

Citizens Broadband Radio Service (CBRS)

The United States Federal Communications Commission (FCC) has been a pioneer in implementing opportunistic spectrum sharing. Building on the approach of TVWS, using a geo-location database to dynamically assign spectrum, the FCC introduced a similar concept in 3.5 GHz spectrum with Citizen Broadcast Radio Services (CBRS).[71] CBRS is a three-tier dynamic sharing framework that contains a three-tier access-licensing framework from license-exempt to exclusive use.

Tiered-based spectrum sharing refers to a regulatory framework whereby users are categorised according to their priority to access spectrum in a determined location. Beyond the incumbent license holders who maintain their rights to spectrum access in 3.5GHz, there are two other types of spectrum assignment: priority assignments and opportunistic assignments. Both are managed by a geo-location spectrum authorisation database, the Automatic Frequency Coordination (AFC). Any given area may have a mix of priority and opportunistic assignments.

In the CBRS band, a Spectrum Access System (SAS) that ensures coexistence between new systems and incumbent military radar systems governs new commercial operations. The CBRS framework could be streamlined to something much simpler, especially if the incumbent stations are fixed stations (e.g. Fixed Satellite Service earth stations) and not radars on board ships in USA. The CBRS specifications developed by the Wireless Innovation Forum (WInnForum) for the interactions of the SAS with the new commercial users can be adapted.

The other example is the use of an Automated Frequency Coordination (AFC) [72]system in USA to allow standard power indoor and outdoor operations that would prevent interference to incumbent fixed systems in the unlicensed 6 GHz band. Federal Communications Commission (FCC)[73] in the US has embraced this solution for the lower

[71] https://www.fcc.gov/wireless/bureau-divisions/mobility-division/35-ghz-band/35-ghz-band-overview

[72] https://docs.fcc.gov/public/attachments/FCC-21-100A1.pdf

[73] https://www.fcc.gov/wireless/bureau-divisions/mobility-division/35-ghz-band/35-ghz-band-overview

portion of the C-band (3550 to 3700MHz), where satellites are one of the incumbents. Under the FCC's Citizens Broadband Radio Service (CBRS) rules, the US Government's Navy radar services, along with the limited satellite service deployments in the lower portion of the C-band (3550 to 3700MHz), are protected from interference from terrestrial broadband.

The CBRS band enables the deployment of broadband services, including densification opportunities for wireless operators and opportunities for companies, campuses, and organisations to improve their connectivity solutions with their cap-ex investment or neutral-host opportunities for both wireless operators and third parties. CBRS is referred to, by many, as the 'Innovation Band' because it uses a three-tier approach to spectrum access between the incumbent, a Priority Access Licensee (PAL), and a General Authorized Access (GAA) user. The US Government and satellite services are fully protected all the time. PAL tier users will receive rights through an auction process and will be protected against GAA use, all while protecting incumbents. GAA users have the benefit of not having to participate in the auction but can use the spectrum subject to protecting the other two tiers. The CBRS approach could be applied to other bands (e.g., C-band uplink and downlink bands) to give satellite services incumbent rights and protections.

The Dynamic Spectrum Alliance have promoted a more generalised version of CBRS called Tiered Spectrum Sharing Model (TSSM)[74], which might be applied to any frequency band. In TSSM, there are three tiers of usage in a shared IMT bands:

- Existing licensees, who have previously been granted exclusive licences and protection from other users:
    - Incumbent users with conventional (not TSSM) licences.
- Priority grants:
    - Users holding authorisations issued as TSSM priority grants.
    - Priority grants may be issued for periods as long as years, providing investment certainty.
    - Holders of priority grants are assured access to the spectrum granted, subject to it not being used by the incumbent licensees.
    - Incumbent licensees may start using their spectrum in a previously unused area following a specified notice period.
    - Devices using priority grants must regularly indicate usage to the AFC.
- Opportunistic grants:
    - Users holding authorisations issued as TSSM opportunistic grants.

[74] Spectrum Sharing: Past, Present, and Future. Dynamic Spectrum Alliance presentation at the Wireless Innovation Forum. https://www.wirelessinnovation.org/assets/Webinar_Slides/Spectrum_Sharing_Deep_Dive/Suarez%20Keynote%20-%20WInnforum%20Spectrum%20Sharing%20Workshop.pdf

- Provide scope for rapid access to spectrum.
- Grants may be revoked when a holder of an overlapping priority grant gives notice of intended use.

2.3.1.3 Shared Access to Assigned IMT Spectrum

Recognizing that large amounts of nationally licensed spectrum often remains unused, especially in rural areas; regulators around the world have begun to implement shared spectrum strategies. This entails the creation of spectrum management regimes that continue to empower existing and new national spectrum license holders while at the same time unlocking access to spectrum in areas where licensees have no strategic interest.

European Union: Licensed Shared Access (LSA) is a spectrum sharing approach developed in Europe designed to allow an existing license holder to authorise other operators to use their licensed spectrum in accordance with a set of sharing rules. This approach has been initially targeted at the 2.3GHz band. To date the implementation and operationalisation of LSA appears to be limited although that may change with the growth of private networks for 5G[75]. Uptake of LSA is dependent on the incumbent license holder being willing to share spectrum.

United Kingdom: In the United Kingdom, the regulator (OFCOM) introduced a "Local Access License"[76] in 2019, which offers access to spectrum that has already been licensed to existing mobile network operators in locations where they are not using their spectrum.

Canada: In 2021, the Canadian agency responsible for spectrum management (Innovation, Science and Economic Development Canada) issued a public consultation[77] to formulate a shared spectrum strategy that supports rural and remote deployments. Drawing on OFCOM's shared spectrum approach, the consultation proposed the introduction of a new supplementary licensing process (Access Licensing framework) for licensed but unused spectrum. As of October 2022, the consultation has been completed but no regulations have yet been announced.

South Africa: The Independent Communications Authority of South Africa (ICASA) has recognized the need to act on underutilised spectrum. Quoting from second Information

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[75] Medeisis, A., Fomin, V., & Webb, W. Untangling the paradox of Licensed Shared Access: Need for regulatory refocus. Telecommunications Policy, Volume 46, Issue 8. 2022. https://www.sciencedirect.com/science/article/abs/pii/S0308596122000829

[76] OFCOM: Local Access Licence - Guidance document (2019) https://www.ofcom.org.uk/data/assets/pdf_file/0037/157888/local-access-licence-guidance.pdf

[77] Consultation on New Access Licensing Framework, Changes to Subordinate Licensing and White Space to Support Rural and Remote Deployment. August 2021 https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11717.html

Memorandum on South Africa's recent spectrum auction, the memorandum states that spectrum is:

> *"to be shared with ECNS licensees in areas that spectrum is not utilised to stimulate competition, promote SMMEs and cooperatives, and ensure that the radio frequency spectrum is used efficiently in accordance with section 2 (f), (p) and (e) of the ECA, respectively."*

The memorandum also provides for the sharing of spectrum licensed to primary spectrum holders in cases where the licensed spectrum is not fully utilised.

> *"11.6.2 In cases where the spectrum is not fully utilised by the licensee within 5 years of issuance of the Radio Frequency Spectrum Licences, the Authority will initiate the process for the Licensee:*
>
> *11.6.2.1 to share unused spectrum in all areas to ECNS licensees who may, inter alia, combine licensed spectrum in any innovative combinations in order to address local and rural connectivity in some municipalities including by entrepreneurial SMMEs;*
>
> *11.6.2.2 to surrender the radio frequency spectrum licence or portion of the unused assigned spectrum in accordance with Radio Frequency Spectrum Regulations, 2015"*

2.3.1.4 Implications for Exclusive-Use Spectrum Licences

The Shared Access to IMT Spectrum model described in the section above represents an opportunity to bridge the significant gap that exists between increasingly expensive exclusive-use spectrum licences and the zero-cost license-exempt ecosystem. Recognising that large amounts of licensed spectrum remain unused, especially in rural areas, regulators around the world have begun to implement shared access spectrum regulation that continues to empower spectrum license holders while at the same time unlocking access to spectrum in areas where operators have no strategic interest.

Implementation of such regulation has implications for existing license holders. The key to opening up access opportunities lies in the framing of IMT spectrum licenses. Nation-wide spectrum licenses have historically provided a guarantee of exclusivity of spectrum access across an entire country. As such, any decision to share spectrum is then vested in the license holder, who may not have a significant incentive to share the spectrum. Things began to change, however, in 2012 with the publication in the United States of a presidential report on Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth[78], which proposed that the right to exclusivity in spectrum licensing be transformed into a right to protection from interference. This subtle but profound change

[78] Report to the President on Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth. Executive Office of the President. President's Council of Advisors on Science and Technology. July 2012 https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf

enables the regulator to implement spectrum sharing in a manner that preserves all the rights of the primary licensee but unlocks the potential of unused spectrum. An example of this kind of clause can be found in Section 4.2 of the OFCOM 800MHz and 2600MHz license[79] which states:

> *"4.2 For the avoidance of doubt the Licences will not guarantee exclusive use of the spectrum awarded. In the future, we may grant additional authorisations to allow the use of all, or part, of the spectrum, including the spectrum that is the subject of this Award Process. We would develop and consult on the conditions of use under any such additional authorisations in order to manage the risk of harmful interference."*

It can also be found in the renewal of the PCS license[80] in Mexico:

> *"8.6. Services for secondary use: The Institute reserves the right to grant other authorisations for the use, development and exploitation of the frequency bands that are the subject of this Radio Spectrum concession, or portions thereof, for secondary use. In such case, the use of the bands subject to this Radio Spectrum concession shall be protected against harmful interference. "*

Clauses such as this extend spectrum sharing beyond generic sharing frameworks, as they have in the UK with the Local License framework and in Mexico where the regulator has set aside spectrum for underserved regions. The "use-it-or-share-it" approach to spectrum licensing contrasts with "use-it-or-lose-it" policies which have proven challenging to implement given the significant sunk costs of the licensees[81].

2.3.2 License-Exempt Spectrum

License-exempt spectrum technologies, in particular Wi-Fi, have undergone profound changes in the last 15 years. Not only have Wi-Fi technologies become ubiquitous in both public and commercial venues but Wi-Fi has also evolved dramatically as a broadband Point-to-Point (P2P) and Point to Multipoint (PtMP) technology. Fixed wireless technologies using license-exempt spectrum have gone from a few tens of megabits per second when first launched in 2008-2009 to now offering more than a gigabit per second[82] thanks to improvements in radio and antenna design and new technologies such

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[79] OFCOM: The award of 800 MHz and 2.6 GHz spectrum Information Memorandum. July 2012 https://www.ofcom.org.uk/__data/assets/pdf_file/0022/32872/im.pdf

[80] https://rpc.ift.org.mx/vrpc//pdfs/68531_190715125729_364.pdf Original text in Spanish. "8.6. Servicios para uso secundarlo. El Instituto se reserva el derecho de otorgar otras autorizaciones para el uso, aprovechamiento y explotación de las bandas de frecuencias objeto de la presente concesión de Espectro Radioeléctrico, o porciones de las mismas, para uso secundarlo. En tal caso, el uso de las bandas materia de esta concesión de Espectro Radioeléctrico contarán con protección contra Interferencias perjudiciales."

[81] Taylor, Gregory, Use It or What? (August 1, 2022). Available at SSRN: https://ssrn.com/abstract=4178641 or https://dx.doi.org/10.2139/ssrn.4178641

[82] Ubiquiti: airFiber P2P Wireless Bridging https://www.ui.com/uisp/ptp-bridging Accessed on 17 Mar 2022

as MIMO[83]. Not only has Wi-Fi radio equipment become more efficient in its use of spectrum for P2P and PtMP use but it has also become more effective at managing interference.

As such, Wi-Fi has proven itself as an ideal complementary technology to the spread of terrestrial fibre optic networks. Wi-Fi can extend access from a fibre network Point of Presence at very low cost. This can have particular impact in rural areas where cost of infrastructure is a significant factor in sustainability.

Wi-Fi has also been a significant catalyst for a growing number of small Internet Service Providers (ISPs), both commercial and non-commercial, which have been able to take advantage of license-exempt technologies to grow wireless access services without having to surmount the now significant financial barrier that access to IMT spectrum represents.

Indeed, license-exempt radio equipment has become so effective and affordable for P2P links that even mobile network operators are choosing to replace some licensed microwave links with license-exempt technologies.

Because license-exempt spectrum does not generate direct revenues for the government in the manner that licensed spectrum auctions do, its economic value is often underrated. A recent study[84] published by the Wi-Fi Alliance estimates that the global economic value of Wi-Fi is greater than $3.3 trillion and that by 2025 that value is expected to grow to nearly $5 trillion. However, that prediction is predicated on the assumption that countries will introduce regulations that permit operators to extract maximum value from the license-exempt spectrum.

License-exempt spectrum currently is the one avenue that small operators have to enter the wireless broadband market. In countries where the use of Wi-Fi for broadband is encouraged, small operators have leapt to take advantage of improvements in Wi-Fi technologies as both an access and a backhaul technology.

For Wi-Fi to operate in more sparsely populated areas, it requires the most viable backhaul network connectivity to work similarly to other wireless access networks. The restricted power output of Wi-Fi, which enables its license-exempt status, requires deploying many access points to cover a given region.

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[83] Understanding the Basics of MIMO Communication Technology, 2016 Southwest Antennas, Inc. https://www.rfmw.com/data/swa-mimo-basics.pdf

[84] Economic value of Wi-Fi® forecast in Africa, Middle East, and India. 14 Sept 2021 Wi-Fi Alliance https://www.wi-fi.org/discover-wi-fi/value-of-wi-fi

Section 3
Satellite Networks and Rural Connectivity

Satellite networks play a significant role in complementing the terrestrial system to connect remote and rural areas.

Summary of innovative satellite solutions for rural connectivity

- In 1992, the African Union Member states established the Regional African Satellite Communication Organisation (RASCOM) to spearhead the development of satellite communication infrastructure aimed at addressing the connectivity challenges in the region. RASCOM has launched its satellite at 2.9°E through RascomStar, its operational entity with footprint over Africa and parts of the Middle East. The network has since provided connectivity to hard to reach areas in many countries across Africa.
- In some rural/remote areas, satellite networks are the only practical means of providing backhaul for the cell sites. There are several examples in Benin, Nigeria, Uganda, Kenya and many African countries.
- There is a progressive growth in the space industry in Africa. Many African countries have increased their budgetary allocation to the sector. In the Africa Space Industry report, 2021, six (6) countries have launched satellites and 15 other countries plan to establish their national space programs. The development would make satellite services more accessible and affordable for rural users.
- The satellite industry has experienced significant development. New design and manufacturing technologies have reduced the cost and time of satellite launch. The emergence of mega constellations, the MEO and LEO satellites would increase the satellite broadband speed, accessibility and affordability.

3.1 Introduction

Satellite networks in different orbital altitudes can bridge the digital divide and provide rural connectivity. With the technological advances in the field, satellites will undoubtedly continue to play a significant role in providing affordable access to broadband across Africa and the globe.

Satellite technology can complement terrestrial technologies and solutions connecting remote and hard-to-reach areas. In some rural areas, satellite networks provide backhaul connectivity for cellular networks. Administrations can adopt multiple approaches combining terrestrial and satellite technologies to augment the existing network in expanding coverage to rural areas. Moreover, to maximize the benefits of satellite-based services, spectrum in the L, S, C, X, Ku, Ka, Q and V bands should be available for use by satellite operators on an interference-free basis under the ITU Radio Regulations.

The need for satellite connectivity was recognised in the launch of GIGA[85] by UNICEF and ITU, which sets out the need to connect the education sector to the internet. This initiative aims at bringing together a multi-stakeholder coalition to help map, finance and connect every school in the world.

Since satellite networks have a large footprint covering many countries, adopting a harmonised regional regulatory framework for satellite systems in Africa could facilitate the development of satellite services in the region. Member States are invited to adopt the Toolkit for Licensing of Satellite Systems, Services, and Applications of the ATU-R Framework 001-0, Harmonized (Model) Framework for Licensing of Satellite Services in Africa[86]. The framework seeks to promote satellite services in Africa including rural connectivity.

Member States are also encouraged to adopt the provisions in Section 3 of ATU-R Recommendation 005-0 relating to the Implementation of Emerging Radiocommunication Technologies including FSS ESIM; MSS Applications; FSS VSAT and other Applications to facilitate rural connectivity.

The rural connectivity challenge is complex and requires collaboration among stakeholders. Administrations should develop a regulatory framework that will promote partnerships between satellite network operators, mobile network operators, and in some cases, the government to create sustainable business models and solutions that suit the conditions of a targeted location. Recently, some satellite operators and their partners have adopted several models in providing connectivity solutions. One such solution is Satellite as a service, which offers a choice for network operators globally, allowing them to focus on service delivery through their IP management and value-added

[85] https://giga.global/

[86] ATU Task Group on Satellite Resources. http0s://atuuat.africa/atu-r-reports//

services while supporting their customers via their existing Network Operation Centres (NOC). Satellite Wi-Fi services enable the use of satellite networks connected to Wi-Fi networks to provide services to a rural location. Such networks can be installed at stores, schools, community centres and the like and are used by members of the community who may not have access to broadband at their homes, businesses, etc. These are cost-effective networks with users being able to purchase the amount of capacity they require.

Advances in satellite technology now make satellite connectivity directly to end-user devices a realistic option. 3GPP adopted the 5G-Non-Terrestrial Networks (5G-NTN) standard Release 17[87], several satellite systems are being developed that will be able to provide 5G direct-to-device connectivity for voice and narrowband services. This is critical to ensure continuity of terrestrial wireless coverage wherever the user may be.

3.2 Use Cases of Satellite Deployment for Rural Connectivity

Many satellite solutions have been implemented around the world to address the rural connectivity problem. This sub-section highlights some of the use cases in Africa and around the globe.

3.2.1 African Regional Group Satellite network

African leaders having recognised the importance of telecommunications/ICT services on economic development and quality of life of the people, decided, after several consultations, to combine their efforts to provide the African continent with a telecommunications infrastructure capable of supporting the sustainable development of telecommunications on the continent and in each African country, with particular emphasis on serving rural areas.

To address this concern, they decided to undertake a feasibility study. This study, conducted from 1987 to 1990, involved 50 African countries and used 600 African experts in addition to international organizations such as the International Telecommunications Union, the United Nations Development Program and the African Development Bank[88]. African States adopted the conclusions of this study in February 1991 in Abuja, Nigeria. The main results of this study are as follows:

- A telecommunications satellite meeting well-defined specifications is the best technological choice to satisfy globally and optimally the telecommunications needs in Africa.
- This system is only economically and financially viable if it is designed on a continental scale.

[87] https://www.3gpp.org/news-events/partner-news/ntn-rel17
[88] http://www.rascom.org/info_detail.php?langue_id=1&id_r=5&id_sr=0&id_gr=2

To implement the conclusions of this study, the African States meeting in Abidjan in May 1992, created the Regional African Organization for Satellite Communications (RASCOM).

RASCOM is an intergovernmental organization with the following objectives:

- Provide large-scale telecommunications infrastructure at low cost to rural areas of the continent using appropriate technology;
- Improve and/or develop long distance communications in each country;
- Establish direct lines between all African countries without exception;
- Provide facilities for radio and television broadcasts in each country and enable exchanges of radio and television programs between African countries;
- Supporting international connectivity: continuing to connect where others cannot go;
- Provide a range of services, voice, data, multimedia, tele-education, tele-medicine, video conferencing, etc.

In attaining the said objectives, RASCOM in 1998 entered into a concession agreement with RasCom-QAF, referred to as the Execution Agreement. Under this Execution Agreement, RASCOM assigned the frequency rights and other orbital rights obtained for the project to RasCom-QAF for the duration of the concession and established terms and conditions for the construction, deployment and operation of the space segment and ground segment of a Pan-African satellite telecommunications system.

Rascom and Rascomstar are still very active in Africa in 45 countries and on top of supplying capacity in C and Ku band. Rascomstar, whose mandate is to connect the unconnected, has developed a series of end-to-end managed services to serve the rural communities such as Internet VSAT, combined with Wi-Fi, national VSAT networks as well as GSM backhaul for Mobile operators.

3.2.2 Other regional use cases

In 2021, Eutelsat launched Konnect, its satellite broadband initiative in Africa. Konnect delivers easy, affordable, and fast internet, supporting social and economic development by creating new digital highways that terrestrial networks cannot reach. In Tanzania, Eutelsat Konnect collaborated with Vodacom to extend internet access to businesses operating in rural areas. This partnership will enable Vodacom to provide 100% coverage throughout Tanzania, connecting previously unconnected areas in regions, districts, and villages within the country[89]. In Nigeria, Eutelsat undertook a similar partnership with

[89] BusinessWire (2021)" Eutelsat's Konnect Africa and Vodacom Partner to Bring High-Speed Broadband to Unserved Regions of Tanzania."

Globacom (Glo), enabling Glo to provide connectivity in underserved areas throughout Nigeria[90].

Intelsat has 20-years of partnership with Mindset Network (an organization that develops and delivers educational resources to students, teachers, health care professionals, and patients across Africa). Intelsat 17 enables Mindset to broadcast its health and education channels to clinics and schools across the African continent. This has enabled Mindset to deliver educational materials to 1,607 schools, 1,025 health care facilities and 6 million homes[91].

SES is using its combined GSO and NGSO assets to provide connectivity to rural areas, through its partnership with telecoms players. Intelsat is delivering broadcast and streaming services to provide access to high-quality content for reliable and accurate news, sports and intelligence; smart agriculture solutions to farmers with Lentera Africa; or Internet connectivity services that enable E4Impact to connect schools, libraries, institutions and businesses[92]. In the Democratic Republic of Congo (DRC), Gilat Telecom has collaborated with SES to ensure connectivity by using multiple Gbps of bandwidth on the O3b MEO system in Ka-band and added services via SES's GEO satellites in Ku-band since 2017. Gilat Telecom expanded its partnership with SES in 2020 to provide more bandwidth to rural areas and extend services beyond Kinshasa and Lubumbashi, reaching unserved or underserved areas.

In the same vein, MNO Tigo Tchad is relying on SES solutions in C, Ku and Ka-band to deploy 3G and 4G services all over the country[93].

Avanti Communications Group Satellite through the Project iMlango connected 205 primary schools and 40 secondary schools across four regions in Kenya, which has doubled the numeracy learning rates of its 180,000 marginalized students. Key to the project is the satellite connectivity and individualized tutoring its online platform provides. The content enables machine learning and artificial intelligence to tailor each session per child. This means that no two children have the same profile or session, enabling each child to learn based on their own needs and learning levels. In these schools, satellite is the only option for internet connectivity due to their remote locations.

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https://www.businesswire.com/news/home/20211202005455/en/Eutelsat%E2%80%99s-Konnect-Africa-and-Vodacom-Partner-to-Bring-High-Speed-Broadband-to-Unserved-Regions-of-Tanzania

[90] Africa.com (2021)"Eutelsat's Konnect Africa Selected by Globacom to bring satellite broadband to underserved regions of Nigeria." https://www.africa.com/eutelsats-konnect-africa-selected-by-globacom-to-bring-satellite-broadband-to-underserved-regions-of-nigeria/

[91] Intelsat (2020) "Intelsat and Mindset Networks 18-year partnership expands access to high impact social economic education resources across Africa during COVID-19." https://www.intelsat.com/newsroom/intelsat-and-mindset-networks-18-year-partnership-expands-access-to-high-impact-social-economic-education-resources-across-africa-during-covid-19/

[92] InterSAT and SES Renew Partnership to Accelerate Digital Inclusion Across Africa | SES

[93] Tigo Tchad | SES

Telesat [94]has collaborated with GlobalTT/ IPSEOS to establish satellite internet connectivity for NGOs, Embassies and other projects in Yana, Nigeria, through its GEO satellite Telstar-11N.

Lastly, OneWeb and Airtel Africa signed a cooperation agreement to collaborate to provide enhanced connectivity services in Africa.[95] AirTel Africa is a leading provider of telecommunications and mobile money services, serving as the second largest telecoms operator in Africa with a presence in 14 countries, primarily in East Africa and Central and West Africa. Airtel Africa offers an integrated suite of telecommunications solutions to over 128.4 million customers, including mobile voice and data services as well as mobile money services both nationally and internationally. At the time of this report, OneWeb had licenses to operate its earth stations across the African continent including Mauritius and Ghana.

Starlink is a Low Earth Orbit constellation of satellites providing high-speed, low-latency broadband services aimed at retail customers. Launched in 2021, Starlink offers services in 53 countries as of Q2 2023. In the African region, Starlink has been licensed to provide services in Nigeria, Mozambique, and Rwanda, at the time of this report.

3.3 Satellite backhaul

Satellite backhaul enables cellular services to be provided in areas where traditional terrestrial connectivity such as fibre, cable, or microwave are too expensive or impossible to install. Satellite backhaul facilitates data distribution over cellular networks allowing Mobile Network Operators to carry 2G, 3G, and 4G/LTE traffic in rural and remote areas.

An ATU-R Report 002-0 "Survey on Spectrum Policies for Rural Connectivity in Africa" showed that 77% of the respondents confirmed they are using satellites for backhaul to provide services in rural areas.

Satellite backhaul is used where geographic challenges such as mountains and heavily forested areas make terrestrial backhaul (such as fibre optic cable or microwave links often referred to as last-mile connectivity) prohibitively expensive. In addition, given the lower population densities found in most rural areas, terrestrial backhaul becomes financially unsustainable.[96]

Distance and topography are not constraints when providing backhaul connectivity to hard-to-reach areas through satellite. In addition, because satellite coverage is

[94] https://www.telesat.com/
[95] https://www.globaltt.com/en/internet-connection/Nigeria/Yana.html
[95] Press release November 2022 "https://oneweb.net/resources/oneweb-and-airtel-africa-collaborate-provide-enhanced-connectivity-services-africa"
[96] Intelsat (2020) Cell backhaul MNO Product Sheet https://www.intelsat.com/wp-content/uploads/2020/08/intelsat-cellbackhaul-MNOs-product-sheet.pdf

everywhere, service providers can connect to any number of rural and remote wireless sites in far less time than using fibre or microwave.[97]

Gilat Satellite Networks, working with African Mobile Networks (AMN), has established Africa's largest satellite cellular backhaul network, extending coverage to several African countries. AMN works with telcos and builds mobile network base stations that serve rural communities in sub-Saharan Africa with no existing service[98]. Satellite Company, Intelsat is a shareholder of AMN, and both corporations are committed to creating Africa's largest cellular backhaul network.

In Benin, AMN installed a base station that utilizes a solar-based electrical power system and a satellite-based backhaul communication link to make the base station completely autonomous with no reliance on any local infrastructure. The base station can deliver service to a range of up to 7 km and covers approximately 150 sq. km[99].

In Uganda, MTN made use of Intelsat's satellite backhaul connectivity to provide mobile connectivity services to Ugandans in rural areas. In addition, in Nigeria, Avanti's EXTEND ultra-rural solution provided backhaul for MNOs to connect 500 sites and planned to connect additional 10, 000 sites within the next five years in extreme remote villages across parts of the country.

Kenyan mobile operator, Safaricom has signed a multi-year contract with Intelsat to modernise its network and expand LTE coverage across the country. Intelsat will provide Safaricom with both cellular backhaul over satellite and enterprise connectivity services for the approximately 70% of Kenya's population which lives in rural areas. This will enhance the connectivity of LTE service in hard-to-reach areas. Intelsat satellite network can reach across Africa, offering Safaricom growth opportunities as it expands into other jurisdictions.

In the United Kingdom BT and OneWeb signed a Memorandum of Understanding (MoU) to explore LEO satellite communication service for rural customers. The partnership focuses on improving capacity, mobile resilience, backhaul, and on building out coverage in challenging locations. Although not much information has been made public about this partnership, it shows that satellite can be used as a network backhaul, especially for rural areas

[97] Broadband Commission (2020) "The role of geostationary satellite networks in meeting the rural connectivity challenge." https://broadbandcommission.org/insight/the-role-of-geostationary-satellite-networks-in-meeting-the-rural-connectivity-challenge/

[98] ViaSatellite(2021) "African satellite cellular backhaul network expands coverage with Gilat Hubs." https://www.satellitetoday.com/telecom/2021/11/15/african -satellite-cellular-backhaul-network-expands-coverage-with-gilat-hubs/

[99] VNL (2021) "VLN teams up with Gilat for Africa Mobile Networks in Benin." http://staging.vnl.in/innovision/vnl-teams-up-with-gilat-for-africa-mobile-networks-amn-in-benin

3.4 Evolution of the satellite sector

According to the African Space Industry Annual Report 2021, the African space industry is set for significant growth. African governments are spending 9% more budget on their space industry, with several African governments developing national space programs. Six (6) African countries have launched their satellites and fifteen (15) counties planned to establish space programs soon. For example, Botswana launched a space program in December 2020, the Rwandan legislature approved the law establishing Rwanda Space Agency in March 2021, Namibia launched a National Space Science and Technology Policy in June 2021, and Burkina Faso, Djibouti, and Zambia are now developing new satellites that will launch their national space program.[100]

Through "Agenda 2063: Africa We Want" the African Union has also identified space technologies as a critical tool that can boost Africa's economic growth and development and lead to the rapid transformation of the continent[101].

3.5 **New trends in the satellite sector**

Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites play an important role in providing rural connectivity. Some MEO constellations have been in operation for years across Africa and many NGSO constellations have been announced. On the African continent, Rwanda has also submitted plans[102] for a massive LEO constellation. Any or all of these constellations can improve access to broadband in rural areas.

Similarly, new-generation High Throughput Satellites (HTS) in combination with software-defined capabilities are also likely to provide affordable broadband backhaul in rural areas. Technological developments in innovation related to low-orbit satellites, geosynchronous orbit (GSOs) and non-geostationary orbit (NGSOs) and mega-constellations (groups of satellites that work together as a system), will make satellite connectivity more affordable and accessible. In effect, satellite operators are working on making satellite connectivity more accessible and affordable.[103] Significant satellite connectivity cost reductions are also expected to be reached through forthcoming technological advancements and the launch of software-defined satellites (satellites can refresh and reconfigure themselves based on demand.)

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[100] Space in Africa (2021) "African Space Industry revenue to surpass USD 10.24 billion by 2024 despite COVID=19 setback." https://africanews.space/african-space-industry-revenue-to-surpass-usd-10-24-billion-by-2024-despite-covid-19-setback/

[101] Ibid

[102] Rwanda has submitted ITU filing for 27 orbital shells of 327,320 satellites. Space In Africa. 14 October 2021. https://africanews.space/rwanda-has-submitted-itu-filing-for-27-orbital-shells-of-327320-satellites/

[103] EngineeringNews "Low orbit satellites may improve banking for developing world." https://www.engineeringnews.co.za/article/low-orbit-satellites-may-improve-banking-for-developing-world-2022-01-13

Satellite operators have invested massively into future-proof systems, and as a result, the satellite communications sector has been through several major innovations during the last decade. Technologies adopted from the mobile sector (such as small-cell spectrum frequency reuse) have enabled higher-capacity satellites to provide lower cost services. This trend is set to continue with mobile-edge computing enhancing both network performance and the user experience for rural residents. The new generation of satellites are very high throughput, all electric, software-defined and fully interoperable with terrestrial systems, providing operators with greater flexibility over the frequencies the satellite operates and/or the capacity delivered in different locations over the lifetime of the spacecraft. Constellations of telecoms satellites deployed in NGSO today increase the overall satellite broadband offering over Europe put it on par with performance from terrestrial mobile networks. Furthermore, satellite companies are deploying an integrated mix of GSO and NGSO satellite capacity to meet all requirements on land, at sea and in the air.[104] Similarly, commercially available flat panel antennas supporting fixed and mobile service have demonstrated interoperability with both GSO and NGSO constellations, so each type of satellite system brings its advantages, and their complementarity permits to further develop the efficiency of the offering, enabling choice and redundancy for the satellite users.

The technical advances in the design of spacecraft and ground antennas, the adoption of digital and software-based components, automated satellite assembly line, in addition to reusable launch options have all contributed to unprecedented technological progress, higher performance and decrease in satellite communications costs.

[104] *See e.g.* https://www.satellitetoday.com/government-military/2021/12/07/us-army-uses-ses-meo-technology-in-multi-orbit-tests/; https://news.satnews.com/2021/11/04/intelsat-oneweb-linchpin-solutions-demo-global-multi-orbit-satellite-service-to-u-s-army-u-s-dod/; https://www.viasat.com/about/newsroom/blog/viasat-gives-u-s-military-ability-to-operate-across-multiple-satellite-networks/.

Section 4
Policy, Strategy, Legal/Regulatory Framework and Government ICT Connectivity Initiatives in Rural Areas.

Good government policies and regulations can promote greater ICT penetration, attract investment, encourage innovation, stimulate growth, and expand access to communication services for the citizenry. Consequently:

- Administrations should develop forward looking national ICT policies that have clear objectives and include measures to mitigate the risks on investment in rural areas.
- Administrations may adopt regulatory framework that promote voluntary infrastructure sharing, especially in rural areas. Cooperative infrastructure sharing can reduce the network rollout cost without hurting competition.
- National roaming can extend network coverage to rural areas and improve consumer experiences. There are case studies of Ghana and Nigeria deploying national roaming for coverage extension including rural areas.
- Provisions can be made in the legal framework for special license fees for rural communication services. For example, Ghana's Electronic Communications Act provides for special frequency and regulatory fees for services operating in rural areas. Similarly, Gambia's Information Communication Act mandates the Ministry for ICT to issue special licenses for rural service providers.
- In addition to the legal framework, Government may directly invest in the infrastructure development to serve the hard to connect areas.

4.1 Introduction

Rural communities usually have insufficient infrastructure, low-income levels, high illiteracy rates and sparse populations. These factors do not make rural communities viable markets for services, such as telecommunications that require high capital to deliver. As a result, the private sector is unlikely to extend services to rural communities due to the risk of low return or potential losses. Consequently, direct government intervention or support may be required to extend telecommunication services to rural communities.

In every country, the legal, policy and regulatory framework for electronic communications outline the government's vision and creates the enabling environment for attaining universal access. Government policy influences the decisions of all actors in the electronic communications sector, including private operators and investors. Good government policies and regulations can promote greater ICT penetration, attract investment, encourage innovation, stimulate growth, and expand access to communication services for the citizenry. Conversely, the absence of clear government policies leaves everything to chance, and delays access to affordable communication services for rural dwellers due to the peculiar challenges of rural communications markets.

Governments must design policies and regulatory measures that will provide special incentives such as tax rebates, subsidies, shared infrastructure, and funding mechanisms necessary to encourage private sector participation in rural ICT connectivity. The government may also make direct state interventions to connect the unconnected.

This section outlines some of the legal, regulatory and policy measures needed to facilitate the expansion of ICT/telecommunication services to rural/remote areas.

4.2 Recommended Approaches

4.2.1 National ICT Policies

Given the importance of ICT connectivity to economic development, governments may incorporate ICT policy into national development plans. Good and implementable national ICT policy demonstrates the government's commitment and shows a course of action in pursuit of universal Access. The policy equips decision-makers and all stakeholders with clarity in direction, which promotes collaboration and the economy of efforts.

Countries should have a holistic and futuristic vision of national broadband endeavours, as such, it is critical to focus on developing a National Broadband Policy, Strategy,

Implementation Plan and Roadmap. In addition, an Infrastructure Master Plan is essential when it comes to the deployment of national connectivity infrastructure. This will greatly help in sustaining such infrastructure and ensure effective deployment and affordable meaningful broadband connectivity.

Policies should be forward-looking and should be developed with the participation of stakeholders, including those in rural communities. In creating a good and implementable national ICT policy, the following features should be considered:

1. **Objectives** – the policy should set clear goals and define the mandates of each stakeholder to avoid duplication of roles and reduce bureaucracy. The government may consider decentralising the implementation of the policies to the local level or establishing dedicated agencies to promote rural ICT connectivity. The objectives should include measurable targets with defined timelines.

2. **Evaluation** - Conduct regular, impartial impact evaluations and adapt connectivity policies based on these insights.

3. **Innovation** – the policy must create an enabling environment for technological trials and awareness strategies to promote new systems and services. In designing national ICT policy, policymakers should consider the dynamics of innovation in rural areas. Often, innovation in rural areas may not follow standard procedures, processes and systems.

4. **Consultation and community involvement** – policymakers should actively engage stakeholders and involve community members regarding rural connectivity policies.

5. **Close usage gap** –the policy should include strategies to address and respond to the main barriers affecting internet adoption: access, affordability, knowledge and digital skills, relevance, and, safety and security.

6. **Supporting local entrepreneurs** – the policy should design strategies to mitigate the potential risks in rural network deployments while promoting local entrepreneurship within the communities. Local entrepreneurs create products or solutions to overcome market or policy failures by aggregating more minor changes primarily by learning and doing. The policy should incorporate digital literacy skills to increase the ICT competency levels of the citizens.

The following subsections discuss policies that can help to reduce the barriers in deploying services in rural areas.

4.2.1.1 Policies on Infrastructure Sharing

The cost of infrastructure is a prohibiting factor for network deployment in rural areas. Active and passive infrastructure sharing in rural areas can lower the initial cost of

building a network. It is recommended that policymakers promote all forms of infrastructure sharing in rural areas.

a. Innovative approaches to enabling sharing between operators

In rural areas, construction costs such as power supplies and access roads constitute a significant percentage of the total site build costs. In such cases, there may be an incentive for operators to voluntarily co-locate both passive and active network infrastructure to reduce the costs associated with building out sites, making it commercially viable to serve previously unprofitable areas. However, in some instances, infrastructure sharing may be impossible due to the absence of enabling regulatory frameworks, or less likely to occur in markets where, for instance, one or more operators are using coverage as a service differentiator. Regulatory frameworks that allow passive and active infrastructure sharing, as well as Policy and Regulatory incentives to share infrastructure, will enhance network rollout in rural unserved and underserved areas, as has been seen in many countries[105].

Case Study: France

In 2018, at the core of a spectrum license renewal 'New Deal for Mobile'[106] , the French Regulator adopted a principle of exchange between substantial and targeted additional investments by operators for regional development and the renunciation by the State of all or part of the revenue from the use of frequencies to be renewed, and tax revenue. Through this agreement, in exchange for renewed licenses in the 900 MHz, 1800 MHz and 2.1 GHz frequency bands which were due to expire between 2021 and 2024, the operators, as a collective, undertook to accelerate their efforts to increase 4G coverage. The Government, in consultation with local authorities, decided on a list of areas to be covered through the sharing of both the passive and active equipment of the operators. This approach made it possible to improve mobile connectivity in a way that quickly became noticeable to French citizens, as 4G-population coverage increased to 96% by 2020.[107]

In addition, state authorities should develop simple and harmonised regulations and permits across local governments to reduce the bottlenecks in deploying networks in rural areas. Administrations could help network expansion through regulatory support in other ways such as:

1. **Facilitating** the acquisition of site permits,
2. **Sharing** of state-owned assets, like utility poles and reliable power sources,

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[105] See 'Appendix 1 Country Examples' here https://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf

[106] RÉDUIRE LA FRACTURE NUMÉRIQUE MOBILE Le pari du « New Deal » 4G https://www.ccomptes.fr/sites/default/files/2021-09/20210928-58-2-reduire-fracture-numerique-mobile-4G.pdf

[107] 96% of France now covered by at least one 4G operator https://www.connexionfrance.com/article/French-news/96-of-France-now-covered-by-at-least-one-4G-operator

3. **Hosting** network installations such as radio, antenna towers, and microwave links on government buildings and educational institutions.

4.2.1.2 Policies on National Roaming

National Roaming is an agreement among network operators that allows customers of one Network to access services on another operator's Network in areas where the customer's network provider does not have coverage. A National Roaming policy enables the network operators to expand their Network without the capital investment in building cell sites. Typically, a wholesale roaming rate is paid to the host network. The prices must be set such that consumers in rural areas do not pay higher tariffs than those in urban locations. Governments may adopt national roaming to increase competition and extend network coverage to underserved areas.

In some cases, National Roaming does not evolve naturally, instead, policy interventions are required to facilitate the agreement among the MNOs, establishing Quality of Service indicators and tariffs regulations. In designing a National Roaming policy, the administrations should use a balanced - regulatory approach to avoid distorting the market. The Authorities could limit national roaming to underserved and rural areas to extend coverage. In Ghana, the initial National Roaming arrangement targets underserved and unserved areas. It enables more relatively minor network operators to compete with the dominant operator in places where only the most significant operator has coverage. The arrangement provides competitive options/choices to customers in rural areas even when a single operator has network coverage.

Ghana – National Roaming Framework

The Ghana National Roaming framework provides a comprehensive guide for implementing domestic roaming. The process started with industry consultation in 2016. It was however not implemented until the year 2020 when it was announced as one of the remedial measures in the declaration of one operator as a Significant Market Power (SMP).

The regulator consulted industry stakeholders and solicited contributions to develop the National Roaming Guidelines. The processes resulted in a shared ownership of the roaming framework which encourages mutual agreement among network operators. The program has three broad objectives, namely, rural coverage expansion, network resilience and enhanced competition.

The rural coverage expansion aims to extend network coverage to unserved communities in the country. Through its Rural Telephony Project (RTP), the Universal Service Fund, Ghana Investment Fund for Electronic Communications (GIFEC), set out to build 2,016 cell sites, including a core network to connect remote parts of the country. The Mobile Network Operators (MNOs) roam on the RTP network to serve their customers in remote areas.

The roaming framework also established MNO-to-MNO roaming to enable smaller operators to provide services in markets where only the dominant operator has network coverage. The policy allows the smaller operators to expand their market without building with limited network infrastructure. People in rural areas will afford more choice on products and services.

These two objectives are being pursued in the current national roaming implementation in Ghana. The network resilience objective has been delayed due to the significant investment needed to expand the capacity of the networks to support the traffic of another network which goes down for a considerable period.

Essential lessons from the framework:

I. The industry consultation and active participation of the stakeholders ensured the smooth implementation of phase 1 of the project.
II. The stepwise approach in the implementation provided an opportunity to get feedback, learn and minimise the unintended consequences.
III. The mutual agreement in underserved areas will allow the market forces to drive competition.

4.2.1.3 Community Networks

The community network concept seeks to bridge the economic gaps while addressing the communication needs of the people. Generally, the telecom network business model often does not suit the economic conditions in most rural communities due to the unattractive return on investment. Therefore, in some situations, the only practical way of providing sustainable connectivity services is through establishing community networks with attributes of shared ownership and non-profit objectives.

The success of the community network initiative will largely depend on an enabling regulatory environment that promotes the development and operation of these local networks. Policy for community network may make provisions to:

i. **Allow** the traditional network providers to sell wholesale services such as, backhaul connectivity to the community networks at reduced rates.

ii. **Review** existing regulations to accommodate the needs and requirements of community networks and ease the usage of other technologies (satellites, HAPS, HIBS, FWA, WIFI … etc.) to spread their coverage to rural areas by reducing market access hurdles.

iii. **Use** National Roaming for small network operators in rural areas to access broader markets by leveraging the network infrastructure of the larger network operators.

The government may strengthen the local entrepreneurs operating the community networks in other ways:

1. **Facilitate** technical training programs for the operators of community networks

2. **Provide** business and financial management training
3. **Provide** financial guarantees for credit facilities
4. **Create** platforms for knowledge sharing and technology transfer
5. **Create** awareness around the success stories of these community networks to attract investors or donors.

Further, the government can design financing schemes to support community network initiatives. For example, the Universal Service Fund can dedicate a portion to support research, development and promotion of sustainable community network projects.

South Africa - Zenzeleni Community Network

Zenzeleni ("Do it yourself" in isiXhosa) is a community-owned wireless internet service provider based in rural South Africa. It offers quality, high-speed internet comparable to the country's most developed urban centres. Its model aims to significantly cut telecommunications costs, retain expenditure within communities as a form of social entrepreneurship, and support the development of a rural digital ecosystem towards bridging the digital divide[108].

Zenzeleni Community Network business model is a partnership between a Non-Profit Company (NPC) and community cooperatives[109]. The Cooperatives register as Internet Service Providers within their respective communities. The community selects members of the cooperation, which run the organisation for the benefit of the community. The ISP offers services to their community members, schools, businesses and other institutions and re-invests the income into their Network and communities. Cooperatives are also responsible for supporting initiatives that help communities to use the internet in a meaningful way. On the other hand, the NPC supports the communities with funding, training and business advisory services to run a successful business. The NPC acts as a catalyst for skills and knowledge development, focused on communities claiming the use and value of the internet within their rural contexts.

The following factors made the Zenzeleni community network model successful:

1. The Community Network is a social enterprise, which focuses on providing sustainable and meaningful services rather than working for profit.
2. The community owns, maintains and safeguards the Network. All hotspots and backbone nodes are hosted and cared for by trusted families and individuals.
3. Sharing network assets and aggregating services bring down costs.
4. Continual learning and improving. Connection with community networks and partners worldwide improves the service delivery.
5. In seeding cooperatives, the NPC accesses donor start-up capital, so communities without income do not take the weight of start-up repayments.

[108] Zenzeleni https://www.apc.org/en/member/zenzeleni-networks-npc

[109] Zenzeleni Business Model https://zenzeleni.net/our-model/

6. Introducing new activities through peer learning, volunteer work or project grants.

4.2.1.4 Policies on Tax Waivers/Subsidies for Basic User Terminal Devices

The cost of mobile devices is a major challenge for low-income earners, which predominantly are in the rural areas. Policymakers can make quick progress on device affordability by reducing taxes applicable to low-cost devices. Such interventions can reduce consumer costs, encouraging manufacturers and retailers to offer lower-priced products to qualify for the tax exemption, and decreasing prices across handset markets. To be effective, governments must design and monitor policies carefully to ensure that tax regime changes translate into lower prices for consumers. While targeted tax reductions mean lower tax revenue short term, the increase in digital activity as more people use the internet is likely to drive higher long-term economic growth. A case in point is the Republic of Zambia, which proposed tax reforms in the 2023 national budget to accelerate the country's ICT industry growth. The budget contains measures to reduce the corporate tax for telecom services providers from 40% to 35%. The policy has also exempted the supply of selected ICT and telecommunication equipment from paying Value Added Tax (VAT). In addition, the import duty for some ICT equipment has been reduced from 25% and 15% to 5% and 0% respectively for 3 years[110].

4.2.1.5 Policies on Funding of rural connectivity projects

Section 6 of this document provides details on funding mechanisms for rural ICT connectivity.

4.2.2 Legal/Regulatory Framework that promotes rural connectivity

Legal instruments that define clear mandates for actors in the communications ecosystem are necessary to empower policymakers to implement the national ICT policy objectives. Addressing the connectivity gaps may necessitate the industry regulators to make strategic decisions, and compliance may demand the regulated entities to commit significant resources towards implementation. Enforcing such directives sometimes requires legal mandates. Authorities can have explicit provisions in the law and include coverage obligations in the license conditions to accelerate rural connectivity.

4.2.2.1 Legal Provisions for Waiver of Regulatory Fees for Rural Connectivity

Stating definite objectives in the law to support rural connectivity encourages stakeholders to design and implement innovative strategies towards achieving their mandates.

For example, the Ghana Electronic Communications Act, 2008 (Act 775) mandated the National Communications Authority to waive spectrum fees and arrange special tariff

[110] Zambia Budget. 2023 budget address by Honourable Dr. Situmbeko Musokotwane. ww.parliament.gov.zm/sites/default/files/documents/articles/2023%20Budget%20Speech.pdf

rebates for rural communication services[111]. In complying with the Act, the communications authority has subsidised the spectrum fees for community and campus FM (radio broadcasting stations owned and operated by tertiary educational institutions) radio broadcasting to approximately 80% and the regulatory costs for public VSAT for rural and educational establishments to 80% and 70%, respectively.

In addition, the Gambia Information and Communication (IC) Act of 2009[112] mandates the Minister of ICT to issue exclusive licenses under the Act for the provision of telecommunication services in a rural area that did not have service at the time of submission of an application for a license, in which interconnection for that service may be required. However, a license issued shall be limited to the provision of telephony service or related in a village of five thousand or fewer permanent residents with an information and communication service penetration rate of 1% or less. Equally, to further encourage investment in broadband or internet connectivity in unserved and underserved areas, the Gambia decided to reduce the cost of spectrum fee with precondition for the operators or services providers to meet certain coverage obligations, and both quality of service (QoS) and quality of experience (QoE) requirements. The policy over the years has contributed to improving internet connectivity coverage and access in rural communities, although still there are gaps and room for improvement.

4.2.2.2 Coverage Obligations in License Conditions

Coverage obligations define specific targets in frequency license conditions to expand network coverage. Coverage targets can be determined by population size or the country's land mass. Properly designed coverage obligations in frequency license conditions with realistic targets can expand the Network to unserved areas in a country. For example, in 2010, the National Communications Authority of Ghana introduced a mandatory coverage obligation to the 3G frequency license conditions. Each licensee had a target to cover all 173-district capitals, which existed in the country within five (5) years from the date of awarding the license and 2 years to cover new district capitals created within the license period. The first 3G network rollout in Ghana started in 2010, the coverage obligation, and the introduction of UMTS in the 900MHz band helped to increase 3G coverage to approximately 87% of the population at the end of 2017 and 96% by 2021[113]. Considering that 42%[114] of the country's population live in rural areas, in effect the policy has extended network access to a significant portion of the rural dwellers.

In designing licenses coverage obligations, the Authorities should consider the following:

1. **Conduct** industry/public consultation and promote industry collaboration in achieving coverage targets

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[111] Electronic Communication Act, 2008, Ghana [sections 49&50] https://nca.org.gh/regulatory-framework/

[112] https://pura.gm/wp-content/uploads/2021/02/IC-Info-Comms-Act-2009.pdf

[113] ITU Digital Development Dashboard https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx

[114] Rural Population https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=GH

2. **Assess** the spatial needs and cost of complying with the coverage conditions taking into account other license conditions
3. **Evaluate** the options between incentive-based and mandatory coverage obligations
4. **Explore** alternative approaches, such as national roaming
5. **Consider** setting conditions for traffic offloading and network leasing, and active infrastructure sharing.

3.2.2.3 Spectrum Pricing Methods

Cost of spectrum access is a critical factor in enabling spectrum use. Ensuring that the charges for spectrum are appropriate to the context of their use is a challenge. In 2016, the ITU published guidelines[115] recommending a formula-based approach for the calculation of spectrum usage fees. Their proposed formula suggested the inclusion of the following factors:

- volume of space or geometric area occupied;
- useable results obtained from the radio equipment considered, for example the number of channels to be provided or users to be served;
- specific characteristics of range used;
- region/location of the radio station installation;
- social benefit of radio system;
- administrative spectrum management costs; and,
- level of spectrum access demand in the band in question

This approach has the virtue of appropriately adapting spectrum costs to the context of their use. However, the complexity of this approach may make it difficult to have fees that are appropriate in all circumstances.

South Africa: The South African regulator has enacted a formula-based approach to spectrum fees[116] for P2P links, very much along the lines proposed by the ITU, including such aspects as frequency, factor, geographic, and sharing factors. This has resulted in low spectrum fees in remote and underserved areas. The formula attempts to achieve a number of regulatory goals ranging from encouraging efficient use of spectrum to incentivising deployments outside of urban areas to recognising the propagation limitations of higher frequencies.

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[115] Guidelines for the review of spectrum pricing methodologies and the preparation of spectrum fee schedules (2016) https://www.itu.int/en/ITU-D/Spectrum-Broadcasting/Documents/Publications/Guidelines_SpectrumFees_Final_E.pdf

[116] ICASA - Regulations on Radio Frequency Spectrum Fees in Terms of the Electronic Communications Act, 2005 (No 26 of 2005) https://www.ellipsis.co.za/wp-content/uploads/2014/12/Radio-Frequency-Spectrum-Fees-Regulations-2015.pdf

Australia: The Australian regulator has adopted a simplified formula[117] for the calculation of fixed point-to-point (P2P) link, which uses three factors to calculate fees:

- amount of spectrum
- frequency band under consideration; and,
- geographic location.

For geographic factors, they have established four levels of population density that affect fees.

- High density
- Medium density
- Low density
- Remote density

The regulator provides easy tables for the calculation of fees. The simple tables consider various factors but also offer operators a quick mechanism for calculating frequency fees and estimating the value proposition of various frequencies.

New Zealand: In contrast to the above examples, the New Zealand regulator has adopted a highly simplified fee structure[118] for fixed P2P and PtMP links. All fixed links regardless of frequency, ranging from VHF to EHF, attract a single fixed annual fee of $150NZD or approximately $105USD per year. This does not include initial fees paid to the spectrum-licensing engineer who issues the license. This initial fee is approximately $500NZD.

In designing spectrum fee mechanisms, regulators should take into account the need for affordable fee structures for rural and underserved regions but also the value of simplicity in fee calculations in order to enable operators to easily and effectively calculate the value-proposition of various frequencies on offer.

4.2.2.4 Technology Neutral Spectrum Licensing and Spectrum re-farming

Assigning technology neutral spectrum rights is an evolving best practice. Consequently, most regulators around the world, including those in the European Union, North America, Singapore, Hong Kong, Australia, and many in Africa have adopted the principle of technology neutrality for mobile spectrum licences.

The most important development that this allows is the ability to 'gracefully re-farm' bands so they are used simultaneously for several technologies. As a result, users benefit from better mobile broadband coverage, higher data speeds and lower mobile data prices than would otherwise be the case. The socio-economic benefits stemming from these improvements make it a win-win for governments and all mobile data subscribers, consumers as well as enterprises.

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[117] ACMA Aparatus license fee schedule. October 2020. https://www.acma.gov.au/sites/default/files/2020-11/Apparatus-licence-fee-schedule_30-October-2020.pdf

[118] RSM: Fixed link licence https://www.rsm.govt.nz/licensing/licences-you-must-pay-for/fixed-location-licences/fixed-link-licence/

Introducing technology neutrality with the objective of making positive impact needs to be done whilst taking into consideration that:

- Avoiding the Technology Neutrality 'Tax' is critical. Attempts to extract additional revenue have misfired and held back the introduction of new mobile technologies and expansion of coverage;
- While a renewal process provides an opportunity to re-issue spectrum licences as neutral, regulators should not delay the introduction while waiting for the expiry dates of existing licences;
- When assigning new spectrum, regulators should do so in a technology neutral manner or at the very least not restrict the introduction of next-generation technologies.

Europe: The first commercial 3G networks were launched, in Europe, in 2003. It soon became apparent that it would be economically impossible to provide wide area 3G coverage using only 2100 MHz spectrum. Therefore, in 2005 3G was also specified in 900 MHz However, the technology specific nature of 900 MHz licences prevented operators from legally deploying 3G in those bands. Nevertheless, in 2007 Elisa in Finland launched 3G in 900 MHz with the approval of the Finnish telecoms regulatory authority, FICORA. Deploying 3G in 900 MHz was in breach of European Union regulation, but it was recognised as a pragmatic development by FICORA, which took into account a new reality. In October 2009, legislation caught up with reality with the publication of the European Commission's decision "on the harmonisation of the 900 MHz and 1800 MHz frequency bands for terrestrial systems capable of providing Pan-European electronic communications services in the Community". The decision allowed Member States to designate and make available the 900 MHz and 1800 MHz bands for UMTS (3G) and other terrestrial systems provided such systems could coexist with GSM systems and UMTS, resulting in wide geographic coverage, improved user experience and lower data prices, maximised spectral efficiency, etc.[119]

Ghana: In 2017, the National Communications Authority took a regulatory decision to permit Mobile Network Operators (MNOs) with existing 2G Licences to deploy 3G Universal Mobile Telecommunications Systems (UMTS) technology in unserved and underserved communities across the country[120]. The decision allowed MNOs to use the 900MHz frequency band, which was originally assigned for the deployment of 2G services (GSM) in Ghana, to deploy 3G in the target unserved and underserved areas. This was expected to increase data access to areas, which hitherto were not covered by MNOs with 3G services. By the end of 2018, 3G penetration had increased from 62% to 79%, and 97% by the end of 2021.

4.2.2.5 Regulatory recommendation to promote rural satellite connectivity

[119] Benefits of Technology Neutral Spectrum Licenses. GSMA 2019 https://www.gsma.com/spectrum/wp-content/uploads/2019/06/Benefits-of-Technology-Neutral-Spectrum-Licences.pdf

[120] NCA Gives Opportunity to Telcos to Deploy 3G Coverage to Rural Areas https://nca.org.gh/2017/09/07/nca-gives-opportunity-to-telcos-to-deploy-3g-coverage-to-rural-areas/

Satellite networks play a significant role in providing affordable access to broadband rural areas across Africa and the entire globe. However, their potential impact on the continent has not been fully tapped due to various regulatory constraints, high fees and administrative hurdles.

To create an enabling environment for satellite communications deployments, policymakers may wish to consider the following provisions:

1 **Set** enabling regulatory framework on terminal license: Allow blanket or class licensing or general authorization to authorize a family of satellite user terminals with given characteristics, as per ATU-R Recommendation 005 and international best practices to eliminate cumbersome and costly terminal by terminal licensing. Terminal type approval, identification, and authorization of terminals are fundamental features for the smooth operation of satellite systems. Licensing and approval processes should also be harmonised across the region.

2 **Minimize** landing rights requirements on satellite operators to offer a wide array of service offering to citizens and create a competitive market.

3 **Update** licensing and regulatory frameworks to ensure they cater for innovative technologies and make them readily available online for all interested parties.

4 **Maintain** an up-to-date spectrum database to effectively and efficiently manage spectrum. Consider publishing the databases to accelerate network deployment and enhance co-existence between incumbent and incoming users.

5 **Adopt** an administrative or cost-recovery model, which sets fees at a level sufficient to recover the administrative costs of the regulatory authorities, as opposed to a 'consumption-based' approach that seeks to reflect the economic value of the spectrum.

6 **Adopt** spectrum fees with preferential terms for rural satellite deployments e.g. reduced spectrum fees or annual fees waivers for services offering in rural areas. Reasonable spectrum fees are an important input towards making satellite communications affordable and an effective solution to the digital divide. As a general principle and a matter of good economic governance, regulatory fees are best kept to a level that allows governments to recoup administrative costs covering, among others, costs on imports of equipment, technology, type approval, licensing charges and the functioning of the national authorities.

7 **Lessen** foreign ownership restrictions and local presence requirements for satellite operators.

8 **Adopt** a streamlined equipment type approval process using mutual recognition of certifications (including type approval).

9 **Support** the satellite industry by creating a progressive regulatory framework that clearly articulates the compliance requirements and supports the satellite industry by ensuring they are provided with the required spectrum at a reasonable fee.

4.2.3 Additional Government interventions for rural connectivity

Governments can supplement the regulatory and private sector initiatives with targeted direct interventions to accelerate the deployment of ICT services in hard-to-serve locations. For example, the government could provide public finances for selected projects to deploy critical infrastructure for ICT services in remote areas. The government of Ghana supported the Universal Access Fund with approximately £155 million to build a telecommunication network infrastructure for rural communities. The project seeks to construct 2,016 cell sites to expand network coverage to unserved areas in the country[121].

[121] https://gifec.gov.gh/government-commits-e155-million-to-rural-broadband-services/

Section 5 Sustainability of Rural Telecommunications/ICT Initiatives.

The design of rural connectivity solutions must give due regard to their sustainability by considering the following issues among others:

- Sustainable rural ICT connectivity initiative must generate sufficient revenue to cover the cost of operation or appropriate funding mechanisms should be put in place for recurrent expenditure.
- Stakeholders in the beneficiary communities must actively participate in the development of the ICT projects.
- ICT projects in rural areas should include measures aimed at addressing the usage challenges in the communities, such as affordability, high illiteracy and low digital skills, and relevant content. The Government can develop digital solutions such as e-governance services to stimulate usage.
- Rural telecommunication projects should adopt technologies and solutions that will reduce both the capital and operational cost of the network to sustain the service. Case studies of innovative solutions for rural networks include Huawei Rural Star Technology, Community Wi-Fi, and Fixed Wireless Access.
- The Government can provide incentives such as tax waivers for the importation of renewal energy materials for rural ICT projects. The cost of energy is a significant problem for ICT services in rural areas.

5.1 Introduction

Many countries have made significant progress in bridging the digital divide; however, the challenging conditions in rural areas threaten the long-term sustainability of rural ICT projects. The socioeconomic and cultural characteristics of rural communities are critical factors, which affect the success of rural ICT projects. The challenges in rural settings include affordability due to lower income levels, lack of awareness of the benefits of ICT applications, lack of relevant content, low literacy and digital skills, and, in some cases, negative cultural beliefs regarding technological innovations. In addressing the usage gap, rural ICT projects should provide affordable and meaningful services to meet the needs and cultural context of the community.

Rural ICT projects should generate enough revenue to cover the recurring cost, i.e. maintenance and operational cost, while providing affordable and meaningful services for the people. Successful Rural ICT projects should address the following factors:

1. Cost-effectiveness of technology solutions to enhance affordability
2. Ease of use and or availability of training for the targeted community members
3. Acceptance and ownership/buy-in of the initiatives by the beneficiary communities.
4. Potential for new economic opportunities for indigenous individuals and small businesses.

This section discusses examples, strategies and practices that can promote the sustainability of rural ICT initiatives. In addition to the examples and practices discussed in this section, Administrations may also consider the guidelines in the ITU Last-mile Internet Connectivity Solutions Guide[122].

5.2 Recommended Approaches

5.2.1 Cost-effective and Sustainable Technology Solutions for Rural Connectivity

Rural connectivity poses two interrelated challenges for network operators. On one hand, the cost of deploying and maintaining cell sites in rural and remote areas can be significantly higher than in urban areas. Conversely, the average revenue per user (A RPU) can be substantially lower – especially when compared to urban and suburban areas. In other words, the business case is often relatively weak. Practical rural connectivity projects require deploying technologies that reduce both capital and operational costs. Energy consumption can be one of the biggest factors affecting operating costs; therefore, technology solutions, which are energy efficient, should be prioritised for deployment in rural areas.

[122] Sustainable connectivity options for unconnected sites: https://www.itu.int/dms_pub/itu-d/opb/tnd/D-TND-01-2020-PDF-E.pdf

Using relatively low radio frequencies, i.e. sub-1GHz offers the potential to cover wider areas at a lower cost in rural areas, due to the excellent propagation characteristics of such frequencies and the sparse population in rural settlements. The following checklist can help to select appropriate technology solutions for rural ICT initiatives:

1. The geographical area of the target community;
2. The population size and density; and,
3. Potential traffic.

Case Study: Ghana and Huawei Rural Star technology

RuralStar, a technology developed by Huawei, is an innovative, low-cost solution for rural micro-cell deployment using local materials and energy-efficient equipment, which reduces the cost of building a network in rural areas. The project started as a partnership between MTN Ghana and Huawei Technologies to build 406 cell sites to serve approximately 4.5 million people living in rural areas in the country. After the deployment, about 46 sites had traffic exceeding their capacities, which were subsequently upgraded to macro cell sites.

Following the successful implementation of the first phase, the government of Ghana through the Ghana Investment Fund for Electronic Communications (GIFEC) has collaborated with the mobile network operators and Huawei to deploy an additional 2,016 cell sites across the country.

Features of the technology that make it suitable for remote deployment include:

1. A non-line-of-sight (NLOS) wireless backhaul technology that uses cellular relay to connect a remote site to an existing macro-site. The NLOS backhaul uses standard UHF antennas, which is more affordable than the microwave and satellite backhaul.
2. Minimal civil works are required for the site construction. The small, lightweight radios make it possible to build the base station on guyed poles (9-24m height) rather than on high towers, lowering the overall capital costs of the deployment
3. Transporting the equipment to the site does not require heavy machinery; a small truck can transport them, reducing the cost and time in the deployment process[123].

The solution utilises a lightweight, compact base station, which provides a more focused coverage to cover specific spots or remote areas with voice and broadband services. The base station comprises the following:

1. Radio equipment specifically designed to serve targeted remote areas
2. Easy-to-build light towers with optimal height for location and low-cost build on smaller sites

[123] GSMA Rural innovation case study: Using light sites to drive rural coverage - Huawei RuralStar and MTN Ghana https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/01/Huawei_RuralStar_MTN_Ghana_Rural_Innovation_Connectivity_Case_Study_Nov.pdf

3. Transmission optimised to reduce capacity required
4. Low energy consumption allows for independent solar energy use.

Case Study: Kenya Safaricom's collaboration with Intelsat

Kenyan mobile operator Safaricom has signed a multi-year contract with Intelsat to modernise its network and expand LTE coverage across the country. Intelsat will provide Safaricom with both cellular backhaul over satellite and enterprise connectivity services for approximately 70% of Kenya's population, which lives in rural areas. This will enhance the connectivity of LTE service in hard-to-reach areas. Intelsat satellite network can reach across Africa, offering Safaricom growth opportunities as it expands into other jurisdictions.

5.2.2 Stimulating Demand for ICT Services in Rural Areas

Low demand for ICT services in rural areas is one factor that makes investments unattractive. Many issues, including affordability, low ICT literacy and digital skills, irrelevant content, lack of awareness of the benefits of ICT applications and cultural beliefs, account for the insufficient demand for ICT services in rural areas.

To attain effective and sustainable universal access, stakeholders must adopt a holistic approach that will address the demand-side factors, which inhibit rural connectivity.

Demand Stimulation Strategy

To address ICT Services demand challenges for Rural Areas, most countries are exploring the possibility of having a 'Demand Stimulation Strategy'. Such a strategy will help study markets and market dynamics, regulatory efficacy, market competition, competition forces, operators and consumer behaviours to set forth futuristic strategies on what needs to be done with flagship projects for ICT Services that would stimulate demand for ICT Services and ultimately enhance rural connectivity, particularly in rural areas.

E-government Services

Rural areas lack access to many critical amenities, such as quality education, health, and financial services. To stimulate the demand for ICT applications and solutions in rural areas, government agencies can collaborate among themselves and private entities to create ICT solutions that will improve the well-being of rural dwellers. Government agencies can develop applications to enable people to access essential public services, such as e-health, e-learning, e-registration of birth and death, passports, applications for government employment and other social services remotely. In addition, the government can support financial institutions and other entrepreneurs to leverage the ICT infrastructure to expand their business.

E-Commerce or Digital Commerce could also be a potential avenue for creating the demand side for deploying and using ICT services in rural areas, as most of the settlers are farmers producing most of the food consumed in rural areas. A platform that can provide better visibility of their products online will allow them to buy and sell online

with a higher sales and good profit margin. These can incentive rural settlers to show interest, adopt, access and use broadband connectivity.

Mobile Driven Solutions

One other way to create the demand side is the promotion and usage of Mobile First and Mobile Only digital solutions for public services, as a greater chunk of the population who are connected uses mobile internet and mobile penetration is very high in Africa, more so the Africa continent is one of the global leaders in mobile penetration. Thus, designing mobile-tailored digital solutions for rural communities to address rural challenges can spur innovation in rural communities, which can inspire more people in rural areas to look for other connectivity means such as fixed or satellite broadband to access public services or innovate on top of it to make business case.

Training and Capacity Building

Rural ICT projects should map the skills gaps and needs of the beneficiary community and design appropriate training programs to address barriers to ICT adoption. The training programs should consider the varying proficiency levels within the community. There could be modules for general ICT competency and use of ICT applications, safety and ethical behaviours, and technical training for local entrepreneurs to adopt ICT tools to enhance their business. The UNESCO digital literacy skills framework could be a good starting point[124]. To scale capacity-building efforts more rapidly, Train-the-trainer programmes can be implemented to reach adults and enable community learning through community centres, libraries or other existing social structures in rural areas. An example of this approach is implemented in the GSMA's Mobile Internet Skills Training Toolkit, 'MISTT'[125].

Public-Private Partnerships to enhance digital skills can combine commercial benefits with development objectives, and help advance digital skills projects beyond pilot stage and ensure they are sustainable.

The case of Ghana

The Government of Ghana's ICT for Girls programme has made significant impact in providing girls with digital skills. The Girls-in-ICT programme is one of the flagship digital literacy programme being implemented in Ghana by the Ministry of Communications and Digitalisation. The Government started the programme in 2012 in response to the global call by the ITU to encourage girls to develop interest and take up careers in ICT. The programme was restructured to expand its scope and celebrated on a rotational basis to provide equal opportunity to all school girls across the country, especially those residing in rural communities.

[124] Digital Literacy Global Framework. UNESCO. 2018. https://uis.unesco.org/sites/default/files/documents/ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf

[125] https://www.gsma.com/mobilefordevelopment/mistt/

Consequently, close to 10,000 school children at the Upper primary to Junior High School level have been trained in basic ICT skills including Coding[126]. The training begins with a Train-a-Trainer programme for 100 teachers who subsequently train 1000 girls in a weeklong exercise. At the end of the training, a competition is held among the trainees and the first 100 girls are awarded laptops. Additionally, the schools of the first two winners are provided with cyber laboratory to serve as ICT public access venues for other schools within the district. A mentorship seminar has been introduced to the programme to provide opportunity for the girls fraternize and hear the success stories of female achievers in the ICT sector. Following the climax, the selected best girls are brought to the capital to on an educational tour to major ICT companies to expose them to the practical insights of the ICT industry. It is expected that the programme will cover all districts in the country, especially as it is attracting support from international development agencies and some private entities.

Public Education

Many people in underserved/unserved areas have not used ICT services hence; do not have experience with the benefits of these services. Rural ICT projects can include public education to increase awareness of the potential benefits of using ICT services and applications.

Developing Relevant ICT applications and services for rural areas

General ICT applications do not always meet the unique needs and goals of people living in rural areas. Sometimes the language of the content also creates barriers for users with little literacy competencies. Governments can collaborate with private-sector actors to assist residents in producing content relevant to rural communities, such as local news, health, education, agriculture, and weather information in local languages to enhance the adoption of ICT applications.

Affordability

The cost of devices and services is a significant barrier to rural access to ICT services. The price of the cheapest smartphone in some countries is higher than the monthly salary of low-income earners. Alliance for Affordable Internet, in a survey report on the prices of devices, stated that the cost of devices in Africa is 62.8% of the average monthly income compared with 11.7% in the Americas and 16.2% in Asia Pacific (excluding India)[127]. See section 4.2.1.4 for possible solutions to reduce the cost of devices.

In ensuring affordability for devices, services, and broadband connectivity, the Gambia Government provides special investment certificates and tax breaks or tax havens to investors ready to invest in critical sectors of national development including the ICT sector, more so in areas that are not techno-economically viable for investors to invest and recoup their investments. Such initiatives could contribute to reducing the total cost

[126] Ghana Girls in ICT Programme: https://gifec.gov.gh/project/codingforkids/

[127] From luxury to lifeline: Reducing the cost of mobile devices to reach universal internet access. A4AI. 5 August 2020. https://a4ai.org/research/from-luxury-to-lifeline-reducing-the-cost-of-mobile-devices-to-reach-universal-internet-access/

of ownership (TCO) for both service providers and consumers in rural underserved or unserved communities.

5.2.3 Energy Solutions and Other Supportive Infrastructure for Rural Connectivity

Power consumption contributes significantly to the operational costs of a telecommunications network. In remote and rural areas, power expenses are higher as the connection to the electrical grid is unlikely to be available, and running generators are expensive[128]. Solar-powered solutions have minimal recurring costs and could be deployed to save energy and reduce operational expenditure. Deploying hybrid radios can minimise power consumption and upgrade the site quickly when required.

Governments can develop a national policy to integrate energy investment with other rural development projects, such as ICT for rural connectivity. The procedure may promote investment in off-grid energy solutions. The USAID Guide for Energy Options for Small-Scale Rural ICT Projects[129] can be a good reference material for Administrations that want to develop policies for alternative energy solutions for rural ICT connectivity.

Governments can also develop strategy that support sharing of energy infrastructure to extend ICT connectivity.

5.2.4 Public-Private Partnership (PPP) for Rural ICT Connectivity

A public-private partnership refers to a contractual arrangement between public (national, state or local) and private entities through which each party allocates their skills, assets, and financial resources in a complementary manner to provide optimal service delivery and value to citizens. The parties share the risks and rewards.

PPP can help governments effectively expand services and applications to unserved/remote areas with a relative assurance of an appropriate return on investment. The success of an ICT-centric PPP project depends mainly on establishing economically sustainable business models and schemes for delivering meaningful services. The Haya Karima, decent life initiative in Egypt demonstrates a great example of public private partnership in providing sustainable social services for rural communities[130].

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[128] GSMA Connected Society Report - Rural connectivity innovation case study: Using light sites to drive rural coverage - Huawei RuralStar and MTN Ghana https://www.gsma.com/mobilefordevelopment/resources/rural-connectivity-innovation-case-study-using-light-sites-to-drive-rural-coverage-huawei-ruralstar-and-mtn-ghana/

[129] Guide to Energy Options for Small-Scale Rural ICT Projects. 29 September 2004. Prepared by Winrock International under USAID Cooperative Agreement http://www.biblioite.ethz.ch/downloads/Winrock%20Energy4Rural%20ICT.pdf

[130] https://www.hayakarima.com/about_en.html

In designing a PPP for a rural connectivity project, the project manager should consider several factors, including resources and risk sharing agreement, financial planning, roles and responsibilities of the partners, using the appropriate expertise, technology and take-up of the services.

Stakeholder consultation

Before developing a PPP, it is advisable to liaise with operators and other potential stakeholders, not just for their input on technology issues but also to help understand the wide range of issues involved, e.g. commercial, regulatory, deployment, demand-side and other.

Resources and Risk Sharing

At the beginning of a partnership, it is essential to focus on agreed-upon resource and risk sharing, even where the partners may have different reasons for being involved, to ensure that the ICT project delivers its objectives[131].

Financial Planning

A clear financial plan is essential for the success of PPPs in rural ICT projects as often-large infrastructure ventures experience budget over-run, which can discourage the partners in the project.

Employing the Right Expertise

It is good practice for PPPs to use a range of appropriately qualified, independent experts to evaluate projects and ensure that all bids are considered relatively and transparently against a range of clearly defined criteria. For example, in the Dominican Republic, the Rural Broadband Connectivity Project used engineers, economists and lawyers to evaluate projects and perform on-site visits to check project validity (e.g. engineers checked if a proposed wireless link could deliver line-of-sight connectivity)[132].

5.2.5 Emerging technologies for rural connectivity (both terrestrial and space based)

5.2.5.1 Fixed Wireless Access (FWA)

Fixed Wireless Access means a broadband network connection that provides last-mile connectivity enabled by customer premises equipment (CPE) that may come in various form factors for indoor and outdoor deployment (i.e., wall mounted and on rooftops).

Fixed Wireless Access, delivered using 4G or 5G technology or using license-exempt Wi-Fi, is an increasingly cost-efficient broadband alternative in areas with limited availability of fixed-line services such as DSL, cable or fibre. Increasing capacity – allowed by more

[131] ADB BRIEFS NO. 49, PUBLIC–PRIVATE PARTNERSHIPS IN INFORMATION AND COMMUNICATION TECHNOLOGY FOR EDUCATION. OCTOBER 2015 https://www.adb.org/sites/default/files/publication/176953/ppp-ict-education.pdf.

[132] Developing Successful Public-Private PARTNERSHIPS TO FOSTER INVESTMENT IN UNIVERSAL BROADBAND NETWORKS. https://www.itu.int/ITU-D/treg/publications/SuccessfulPPPs.pdf

significant spectrum allocations and technology advancements for 4G and 5G networks – drives higher network efficiency in terms of the cost per delivered megabyte.

A rooftop antenna on the premises and an outdoor high-gain antenna can provide broadband access to an essential hotspot in a rural area, such as a school or a healthcare clinic.

This solution has low investment requirements, and the site can serve as a "hotspot" located kilometres beyond typical 2G coverage range. Hotspot in this context means that the radio site acts as the wide-area broadband connection. The terminal will also have a Wi-Fi AP, so that end users connect indoors an d in their vicinity through available Wi-Fi. The site with the rooftop antenna – the school or clinic in our example – would get reliable broadband speeds from the upgraded base station site.

FWA for rural connectivity will complement operators' revenue gr owth models. Many mobile operators are already deploying FWA as wireless fibre to expand into new markets – to serve enterprises and offer intelligent home services. In addition, the growing ecosystem may provide sustainable, affordable access to the underserved in rural areas as well.

In ITU-R WP- 5D a new report is being drafted on **Terrestrial IMT for remote sparsely populated areas providing high data rate coverage** (Document 5/95-E).

The report illustrates scenarios associated with the provisioning of enhanced mobile broadband services in rural and underserved remote areas. It discusses enhancements of user and network equipment. In addition, it proposes technical solutions deployment scenarios prevailing in certain countries and is meant to be used in accordance with the existing regulations in those countries.

Possible technical solutions that support remote areas are briefly listed as follows.

- **Usage** of dual frequency bands at the same time, (one lower band for the uplink (UL) and one higher band for the downlink (DL)).
- **Combining** spectrum bands in the mid-band range (1-6 GHz) and the low-band range (below 1 GHz) on an existing grid can provide extended capacity compared to a network only using the low-band range.
- **Careful** selection of proper locations and technical characteristics compared to configurations of suburban networks.
- **Employing** high gain antennas for IMT systems - for single frequency/band deployment, broadband can be delivered through Fixed Wireless Access type of CPEs, which can be placed appropriately to improve the link quality between Base Station and user terminal.

5.2.5.2 Satellite Networks

Several technology options exist for the backhaul of the RAN (e.g., fibre, microwave, and satellite). Satellites provide practical solutions to serve in hard-to-serve areas such as rural communities and Small Island Developing States (SIDS). Satellites can play a critical role for the provision of Internet of Things (IoT), machine-to-machine (M2M) for agricultural applications and other industrial activities in remote locations. This can include narrowband mobile satellite service systems, to support narrowband communications, as well as broadband satellite (both GSO and non-GSO). See section 3 for more information on how GSO and NGSO satellite operators are deploying solutions for rural connectivity.

5.2.5.3. Community-based Public Wi-Fi

Public Wi-Fi access points can allow multiple members of a rural community to share a single broadband Internet connection, thereby making the service more affordable and increasing Internet penetration. Community Wi-Fi models can enable individual subscriptions through support time or data-bound services to users consuming small data bundles through a publicly accessible Wi-Fi access point.

By enabling many devices to share a single broadband connection, Wi-Fi is playing a critical role in addressing the usage gap. Public Wi-Fi services run by community leaders, NGOs or businesses are proliferating across Africa. In most cases, users pay a small fee to access the Wi-Fi service on a pay-as-you-go basis – a more cost-effective option than paying for dedicated cellular connection.

In some cases, these services (and devices) may need to be subsidised by national or local governments to ensure they are affordable for those on very low incomes. Additionally, this solution is not connectivity by itself but will require investment in fixed infrastructure and backhaul capacity adequate for the target number of users.

5.2.5.4 High-altitude platform stations (HAPS)

High-altitude platform station (HAPS) systems can potentially be used to provide both fixed broadband connectivity for end-users and transmission links between the mobile and core networks used for backhauling traffic. Both types of HAPS applications would enable wireless broadband deployment in remote areas, including in mountainous, coastal, and desert areas.

HAPS, currently uses high-altitude balloons or autonomous drones to host access equipment that beams connectivity down to the ground. HAPS are stations located on an object at an altitude of 20 to 50 km and at a specified nominal, fixed point relative to the Earth. Systems using HAPS consist of a HAPS and ground stations located at the end-user termination. HAPS broadband connectivity could provide Internet access to users either directly (e.g. home access) or as a backhaul to an access. It could be an alternative solution

in areas where challenging terrain or other factors make it difficult to deploy traditional infrastructure.[133]

Because of their height, HAPS can have a range of thousands of kilometres and are suitable for delivering connectivity even to remote rural areas. Recent test deployments delivering broadband Internet access using stations approximately 20 km above ground have demonstrated their ability to provide connectivity to remote or underserved communities. HAPS trials have been taking place in some countries to demonstrate the potential of HAPS for providing broadband connectivity, backhaul links and disaster recovery communications, as well as the move toward commercial deployments[134]. This, combined with HAPS' ease of deployment, makes them attractive options for deploying emergency connectivity where necessary.

5.2.5.5 High Altitude Platforms for IMT Base Stations (HIBS)

Deployment of HIBS could prove to be an effective way to meet the growing demand for mobile broadband in underserved areas[135]. HIBS offers:

1. A smaller footprint (~200 km diameter) compared to higher-orbit satellite systems that can extend the coverage provided by mobile network operators;
2. Much lower latency than higher-orbit satellite systems, including the latest "non-GSO" (non-geostationary satellite orbit) solutions;
3. Minimal ground infrastructure and maintenance requirements; and,
4. Support for existing IMT-compatible mobile devices.

5.2.5.6 Aerial Fibre

This can also be considered as last mile connectivity solution taking advantage of the extensive overland energy pylons in very remote communities. Ghana has begun exploring the aerial fiber solution in the mix technologies under the Ghana Rural Telephony and Digital Inclusion Project (GRT & DIP). The Ghana Grid Company (GRIDCO), the national power transmission company, has an extensive dark fibre network covering approximately 3,000km[136] within the country including remote and rural communities. The Universal Service Fund, Ghana Investment Fund for Electronic Communications (GIFEC) is implementing a pilot project leveraging GRIDCO's fibre network to expand internet connectivity to over 90 km in selected areas in the Western and Western North regions of Ghana.

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[133] The Last-mile Internet Connectivity Solutions Guide: Sustainable Connectivity Options for Unconnected Sites. ITU, 2020 (https://www.itu.int/dms_pub/itu-d/opb/tnd/D-TND-01-2020-PDF-E.pdf)

[134] ITU backgrounder about HAPS https://www.itu.int/en/mediacentre/backgrounders/Pages/High-altitude-platform-systems.aspx

[135] ITU-R Future Report: high altitude platform stations as IMT base stations (HIBS). IEEE CommSoc. 17 February 2021 https://techblog.comsoc.org/2021/02/17/itu-r-future-report-high-altitude-platform-stations-as-imt-base-stations-hibs/

[136] GRIDCO Fiber Network, https://gridcogh.com/gridtel/

In addition, sharing of the electricity distribution network poles with internet service providers can significantly reduce the cost of fixed network deployment.

5.2.6 Monitoring of Rural Connectivity Projects

The desire to develop innovative solutions to achieve universal access, has led to sometimes experimenting with new technologies or business models in some communities. Effective monitoring of such projects is critical to document the services' success or failures. The lessons learned from previous projects can provide useful feedback to improve future development.

Governments must implement effective monitoring mechanisms to ensure that public money invested in rural ICT initiatives delivers meaningful benefits to the people. For example, section 51 of Ghana's Electronic Communications Act 775, (2008) mandates that all projects executed or subsidised by the USF must be monitored by independent bodies to ensure the attainment of the objectives of universal access.

Administrations may design tools to evaluate the impact of each rural ICT connectivity project on the beneficiary communities. Periodic monitoring of the tasks can help identify challenges and record lessons for future ventures. The results of such monitoring initiatives should be published to promote knowledge sharing and technology transfer.

In designing tools for monitoring rural ICT connectivity projects, administrations should structure their monitoring to include:

1. Project objectives
2. Target population
3. Major economic activities
4. Existing supporting infrastructure
5. Cost of the project
6. Source of Funding
7. Delivery timelines
8. Sustainability models
9. Acceptance of the project
10. Usage of the service
11. Outcomes of the project
12. Project lifespan

Section 6
Funding Approaches for Rural Connectivity

Developing telecommunication infrastructure is capital intensive. The low-income levels of many rural areas makes it difficult for commercial operators to build a good business case for network infrastructure deployment in such areas. Consequently, there is a challenge of raising the necessary funds for rural connectivity. There is therefore the need for funding mechanisms to support connectivity deployment in rural areas including the following:

- Many African countries have established Universal Service Funds (USF) to provide the financial mechanism to expand ICT services to rural areas. The fund consists of contributions, usually a percentage of revenue, from licensed telecommunication service providers.
- Governments can design policies to enable other players in the communication ecosystem, such as digital platform service providers to contribute to the development of telecommunication infrastructure in rural areas.
- Public Private Partnership in some cases has served as an effective approach in funding rural telecommunication project.
- Countries can utilize multilateral and donor funds to expand ICT/telecommunication services to underserved and unserved areas.

6.1 Introduction

Building telecommunication infrastructure is a capital-intensive venture, which requires a sustainable return on investment to encourage investors. In 2017, the World Economic Forum estimated that it would cost approximately US$6.3 billion to connect 95% of the population in four countries in the East Africa Northern Corridor (Kenya, Uganda, South Sudan and Rwanda)[137]. However, the economic conditions in rural areas cannot guarantee a positive return on investment, posing a significant risk factor for expanding networks into remote areas.

The perceived risk of investing in rural ICT infrastructure has created a vast financing gap for connecting the underserved/unserved communities, particularly in Africa. The financing deficit calls for sustainable business models that will mitigate the risks and provide sustainable solutions for rural networks.

Many African countries have adopted the Universal Services Fund (USF) model to expand ICT services to unserved areas. An ATU survey report on spectrum policies for rural ICT connectivity indicated that 80% of African countries have USF[138]. The USF model alone is not sufficient to address the huge financing gap in rural ICT infrastructure development. Therefore, there is the need to explore alternative funding schemes including donor funds that could effectively complement the USF to accelerate digital inclusion.

This section highlights financing models that countries could adopt to address their infrastructure needs.

6.2 Recommended Approaches

Universal Service Funds (USF) Model

The USF model uses a pool of funds dedicated to investing in rural ICT infrastructure. The telecommunication network operators are the major contributors to the fund through levies.

In most cases, the contributions take the form of a levy based on a percentage of annual operating revenues. In Ghana, every network operator contributes 1% of their annual gross revenue (less Value Added Tax and Communication Service Tax) to the Universal Access Fund. Congo Republic also charges each network operator 1% of their annual gross revenue for funding universal access. In Zambia, contribution towards universal access fund is 1.5% of gross revenue for network license operators and 1% for service providers.

Kenya exempted Community Network Operators from contributing to the Universal Access Fund because the licensees largely operate in rural areas. (Other countries

[137] Internet for All White Paper-An Investment Framework for Digital Adoption. 2017 https://www3.weforum.org/docs/White_Paper_Internet_for_All_Investment_Framework_Digital_Adoption_2017.pdf

[138] ATU-R Report relating to Survey on Spectrum Policies for Rural Connectivity in Africa. 2021. https://atuuat.africa/wp-content/uploads/2022/06/ATU-R-Report-002-0.pdf

interested to have their USF mentioned in the document could indicate as such as provide text)

To ensure its public service mission and avoid the exclusion of certain categories of users or remote geographical areas economically unprofitable, Senegal introduced the notion of universal access / service through Law No. 2001-15 on the Telecommunications Code.

The Code also creates a **Universal Telecommunications Service Development Fund (FDSUT)** dedicated to the development of universal access/service and the financing of the costs of any public service useful for the development of electronic communications services and ICT. Decree No. 2019-593 of 14 February 2019 sets out the missions of the FDSUT, determines its resources and specifies its organization.

The FDSUT is financed mainly by the annual contributions of the operators of telecommunications networks open to the public set at a maximum of 3% of turnover excluding taxes net of interconnection charges paid between operators of telecommunications networks open to the public.

The resources of the FDSUT also come from the payment of 5% of the financial contribution paid following the award of a telecommunications license, support from donors, development partners, donations, or legacies.

South Africa established the he Universal Service and Access Agency (USAASA) through the Electronic Communications Act, no 36 of 2005, to ensure that " every man, woman, and child whether living in the remote areas of the Kalahari or in urban areas of Gauteng can be able to connect, speak, explore and study using ICT's.

Administrations could consider a 'pay-or-play' scheme and 'claw-back' mechanism. A 'pay or play' scheme is a system that allows operators contributing to a USF to ring-fence internal funds and use them to build rural infrastructure, rather than making the same financial contribution to the state-run fund.

Some guiding principles for effective management of USFs:

1. **Having** articulated and measurable objectives laid out for the fund, with a focus on the ongoing sustainability of the fund.
2. **Transparency** in disbursing the funds.
3. **Using** needs mapping to select appropriate technologies and solutions for each rural ICT project.
4. **Using** a competitive bidding process to award contracts for universal access projects.
5. **Periodic** monitoring and evaluation of the projects.
6. **Reporting** on USF-funded projects with details on the success rate in achieving universal access.
7. **Making** all connectivity solutions eligible for USF funding.

Note: details of the case studies of USFs in Africa can be found in the GSMA Report, Universal Service Funds in Africa: policy reforms to enhance effectiveness[139].

Policy to Broaden the Contribution Base

Development in the communications industry particularly, the technology convergence has increased the number of players in the ICT ecosystem. In most administrations, the telecommunication network operators have obligations to expand services to rural areas. In contrast, the digital platform service providers, which businesses leverage the ICT infrastructure do not have explicit mandates to fund infrastructural development.

Considering the high growth rate of digital service providers and other vertical service providers, their contributions can accelerate the attainment of universal access. Countries should develop frameworks that will encourage and incentivise the online service providers such as Content Application Providers to contribute to funding rural ICT infrastructure initiatives. Regional Groups such as Africa may consider developing and adopting a common framework that will facilitate the digital service providers, which are not network operators, to share the funding cost of rural ICT infrastructure in the region.

Other potential sources of funding are Tower Companies, which have emerged and hold significant revenue.

Blended Financing

This model consists of financing a project with various sources of funds from contributors with different but compatible interests (private investors, public, and donor funds). Combining private investments with public funds minimises the perceived risk of investing in rural communities.

Usually, such layering of financing is done by international organisations or funds, whose support also adds credibility (and thus viability) to the project, attracting further investments. The borrowers of such funds are MNOs, infrastructure companies, or even governments[140].

Infrastructure mutualisation model

In this model, two or more operators share their telecoms infrastructure in areas where demand is low but sufficient to make such sharing commercially sustainable and where deploying redundant infrastructure would not be economically viable.

The sharing can occur in many ways: passive sharing, where non-active telecom equipment such as towers are shared, or active sharing, where functional telecom equipment, and sometimes even spectrum, is shared. Often, sharing is managed through

[139] https://www.gsma.com/subsaharanafrica/wp-content/uploads/2023/10/USF-Africa.pdf

[140] 21st Century Financing Models - Broadband Commission https://broadbandcommission.org/wp-content/uploads/dlm_uploads/2021/11/21st-Century-Financing-Models-Broadband-Commission.pdf

independent infrastructure companies, where these third-party network providers build the Network and lease it to operators.[141]

Multilateral and Donor Funds

The government can seek long-term loans from international development organisations such as World Bank, African Development Bank and other Donor Agencies to support the private operators. UKAID has funded the GSMA to establish its Connected Society Innovation Fund for Rural Connectivity. The Fund provided grants of up to £330,000 each, to two vendors who won the innovation competition, NuRAN Wireless and iSat Africa, to implement their solutions in rural areas. NuRAN Wireless partnered with Vodafone Ghana and iSat African partnered with MTN Uganda to deploy networks in rural communities in their respective countries[142].

[141] 21st Century Financing Models - Broadband Commission https://broadbandcommission.org/wp-content/uploads/dlm_uploads/2021/11/21st-Century-Financing-Models-Broadband-Commission.pdf

[142] GSMA Connected Society Innovation Fund for Rural Connnectivity https://www.gsma.com/mobilefordevelopment/connected-society/innovation-funds/rural-connectivity/

Annex – Case Studies and Company specific innovations that promote Rural Connectivity

1. *Democratic Republic of Congo (DRC) Ultra-modern satellite solutions through O3b Medium Earth Orbit (MEO) Capacity.*

a) Description of the Project

The DRC is a vast country with enormous resources. With an approximate area of 2.3 million square kilometres and a population of about 96 million, it is the second-largest country in Africa and the eleventh in the world. It maintains just a disproportionate 40 kilometres of coastline on the Atlantic Ocean but is otherwise a landlocked country. The DRC has scored poorly in recent times per World Bank rankings and relies heavily on an efficiently powered digital economy to harness its resources.

One of the earliest indicators in this direction is the partnership between SES Networks and Gilat Telecoms in 2017, which enabled the latter to expand its satellite capacity and extend connectivity over two focal locations, Kinshasa, and Lubumbashi, respectively. Secondly, the partnership has achieved a diverse routine solution to facilitate increased network uptime and availability. With this solution, ground terminals were placed in multiple locations throughout the region, and an advanced intelligent routing platform was implemented to enable intelligent switching across multiple satellite links resulting in extremely high link availability. By 2020, SES was able to provide first-class capacity connections in Kinshasa, the country's capital, and systematically expanded both in bandwidth and in presence, reaching unserved or underserved Kisangani, Mbuji-Mayi and Bunia.

The highlight of these efforts is underscored by the provision of service via SES's O3b Medium Earth Orbit ("MEO") satellite fleet. SES launched the first O3b satellites in 2013 and by the following year was up and running in the DRC. The DRC was the first country in Africa to get O3b and the second country in the world to achieve a connection to this groundbreaking constellation.

While the O3b Satellite provides fibre-like services, it features additional unique capacities such as the provision of low-latency broadband connectivity to remote areas for mobile network operators and internet service providers. This is equally complimented by its ability to enable the performance of wireless devices on mobile platforms in challenging environments without reliance on land-based links.

b) Spectrum highlights

SES is providing satellite connectivity solutions via GEO satellite NSS7 (using C-band) + O3b MEO constellation (using Ka-band spectrum).

c) Cost and funding models where possible

This project is based on a commercial relationship between SES and its Customer, Gilat Telecom. The costs are prescribed according to the consideration determined in the contracts between the parties.

d) Sustainability model (mechanism for sustaining the project)

The sustainability model adopted for this project is a derivative of the SES' general Environmental, Social, and Governance ("ESG") strategy, which conforms to the United Nations Sustainable Development Goals ("SDG") and is geared specifically towards the DRC as demanded by local conditions. SES strives relentlessly to empower communities to thrive with services that help meet critical human needs, save lives, and create inclusive and equitable opportunities in the DRC.

To meet these needs, SES is directing the innovation of its O3b satellites and partnership with Gilat Telecom to expand access to educational, health and informational services in the DRC. It will continue to ensure resilient and reliable access to content and connectivity in remote and isolated regions in the DRC.

e) Outcomes (data on the results of the project)

I. Bridging the digital divide

O3b has introduced reliable high-speed connectivity and its provision of a critical connection to core network internet access points ensures that rural and remote areas in the DRC enjoy a quality experience as their counterparts in the cities. It has guaranteed digital access to both unserved and underserved communities while transforming lives through improved broadband access.

II. Provision of increased satellite capacity

The addition of the O3b MEO capacity to the pre-existing capacity over SES's Geostationary Earth Orbit (GEO) satellite has stimulated a growing consumption of bandwidth in the fixed data, mobility, and government markets in the DRC. The expanded capabilities enabled by SES's multi-orbit fleet have allowed Gilat Telecom to deploy 4G/LTE networks, even in the remotest areas of the DRC.

III. Stability of satellite connectivity

O3b has satisfied the test for the assurance of an uninterrupted satellite connection in the DRC. In February 2020, high-performance internet connectivity was restored in the Democratic Republic of Congo (DRC) within just four days of disruptive connection after the West Africa Cable System (WACS) undersea cable was damaged. The swift restoration

to bring the service back to Gilat Telecom's DRC customers was achieved by leveraging unparalleled high-throughput, low-latency O3b MEO satellite capabilities.

IV. Facilitation of economic growth

With O3b, the DRC has attained a cyber-evolution through effective satellite network deployment and utilization. Through stable, cutting-edge connection to the O3b satellite constellation, millions of people have experienced unprecedented connection and digital transformation. By the last quarter of 2020, O3b capacity expedited the leap from 2G to 4G in the country, connecting about 25 million locals, and continues to drive economic growth in the country.

2. InterSAT use case - Connecting possibilities across Africa

Summary of the project

a) Description of the project

InterSAT is one of Africa's leading internet providers. They have partnered with SES to enhance connectivity for major organizations, government institutions, broadcasters and businesses in 32 African countries.

Various large and small communities in Africa have an increasing need for faster, more reliable broadband to support business growth, as well as critical social services such as healthcare and educational services. This growing demand for internet connectivity from rural communities and remote businesses has motivated InterSAT to expand its coverage capabilities.

Leveraging a wide range of technologies such as terrestrial fibre, wireless and satellite technologies, InterSAT is increasing the communications networks density and reach. Partnering with SES has enabled InterSAT to deliver high-performance connectivity and expand their coverage including to multiple rural villages and to larger, se mi-urban areas, while also improving network resilience and intelligence. InterSAT is also enhancing the end-user quality of experience for essential cloud services, providing enterprises in Africa with the essential means to thrive.

b) Spectrum highlights

SES is providing satellite connectivity solutions in Africa, relying on both GEO (NSS-12 with C- and Ku-band FSS spectrum) and O3b MEO constellations (using Ka-band FSS spectrum)

c) Cost and funding models where possible

This project is based on a commercial relationship between SES and its Customer, InterSAT. The costs are prescribed according to the consideration determined in the contracts between the parties.

d) Sustainability model (mechanism for sustaining the project)

The sustainability model adopted for this project is a derivative of the SES' general Environmental, Social, and Governance ("ESG") strategy, which conforms to the United Nations Sustainable Development Goals ("SDG"). SES strives relentlessly to empower communities to thrive with services that help meet critical human needs, save lives, and create inclusive and equitable opportunities in Eastern Africa. To meet these needs, SES is directing the innovation of its combination of GEO+MEO satellites and partnership with InterSAT to expand access to educational, farming and informational services in Eastern Africa, ensuring resilient and reliable access to content and connectivity in remote and isolated areas of the region.

e) Outcomes (data on the results of the project)

I. Delivering broadcast and streaming service to East Africa

Satellite connectivity services provided by SES and InterSAT enable Next Media, a leader in East Africa multimedia with businesses in broadcasting, to deliver high-quality content that connects people to reliable and accurate news, sports and intelligence. High-throughput, low-latency, fibre-like connectivity solutions provide the speed and reliability which Next Media needs for the transmission of live broadcasts, delivered on multiple devices. This includes football games broadcasts, live news reports and special events.

II. Innovation in Farming

Lentera Africa is an agriculture technology company enabling farmers with customized smart solutions, a necessity for adapting to climate change and increasing farming productivity. With data on thousands of farms collected every five days, Lentera's algorithm highlights problems with the growth in crops and provides insights on areas that need chemical soil analysis. SES and InterSAT deliver the high-throughput connectivity, which Lentera needs to ensure timely decisions. Their technology provides constant monitoring of farm sensors and analysis of satellite-enabled farm imaging and other customized inputs.

III. Developing a new generation of impact entrepreneurs in Africa

E4Impact is an initiative supporting the start-up and business growth of entrepreneurs in Africa. The Foundation provides training, connections with local investors and international businesses, seed funding, ICT and satellite communication services. SES and InterSAT provides Internet connectivity services that enable E4Impact to connect schools, libraries, institutions and businesses around Africa to improve each project's results. The solutions have helped E4Impact contribute to the continent's economic development ecosystem by generating job creation and wealth.

3. Ghana Rural Connectivity Project

a) Description of the project

In Ghana, Huawei's Ruralstar technology has been deployed to address the rural connectivity challenge. RuralStar is a lightweight rural network coverage solution supporting 2G, 3G and 4G connectivity. Rather than using satellite or microwave backhaul, RuralStar introduces a more affordable non-line-of sight (NLOS) wireless backhaul technology with 10 to 40km of reach via a cellular relay, linking connectivity from a 'donor' site (i.e. an existing macro-site). This is a useful function in emerging market geographies (e.g. with mountainous, dessert, or island terrain) that makes it possible to build the base station on guyed poles (9-24m height), rather than on high towers, which makes the site lightweight, reduces its physical footprint to 2m x 3m, and allows for concrete free foundations. The Ghana Investment Fund for Electronic Communications (GIFEC) is rolling out 2,016 new sites in rural areas utilising Huawei's RuralStar solution.

b) Spectrum highlights

RuralStar Technology uses the existing licensed frequency of the network operators in the UHF band, i.e. the 800MHz LTE frequency for the backhaul network.

c) Cost and funding models where possible

The initial project was funded by a partnership between the mobile network operator, MTN and Huawei, the equipment manufacturer.

The Government of Ghana through the Ghana Investment Fund for Electronic Communications (GIFEC) has funded the deployment of 2,016 new sites in rural areas utilising Huawei's RuralStar solution.

d) Sustainability model (mechanism for sustaining the project)

The Ruralstar technology uses relatively low-cost design including the following:

- Lightweight materials, which eliminates the cost of building expensive towers.
- The backhaul uses standard UHF antennas, which is more affordable than microwave and satellite backhaul.
- Customised radio equipment designed to serve targeted remote areas.
- Low energy consumption allows for independent solar energy use.
- Transmission optimised to reduce capacity required.

The network operators utilise the rural network sites through national roaming and they pay a rate for the use of the sites by their customers.

e) Outcomes (data on the results of the project)

As part of efforts in extending fast and reliable mobile telephony connectivity in rural areas in Ghana, the Ghana Investment Fund for Electronic Communications (GIFEC) is

rolling out 2,016 new sites in rural areas utilising Huawei's RuralStar solution. As of March 2024, 625 out of the 1010 sites are on air carrying voice and data traffic of all MNOs in Ghana.

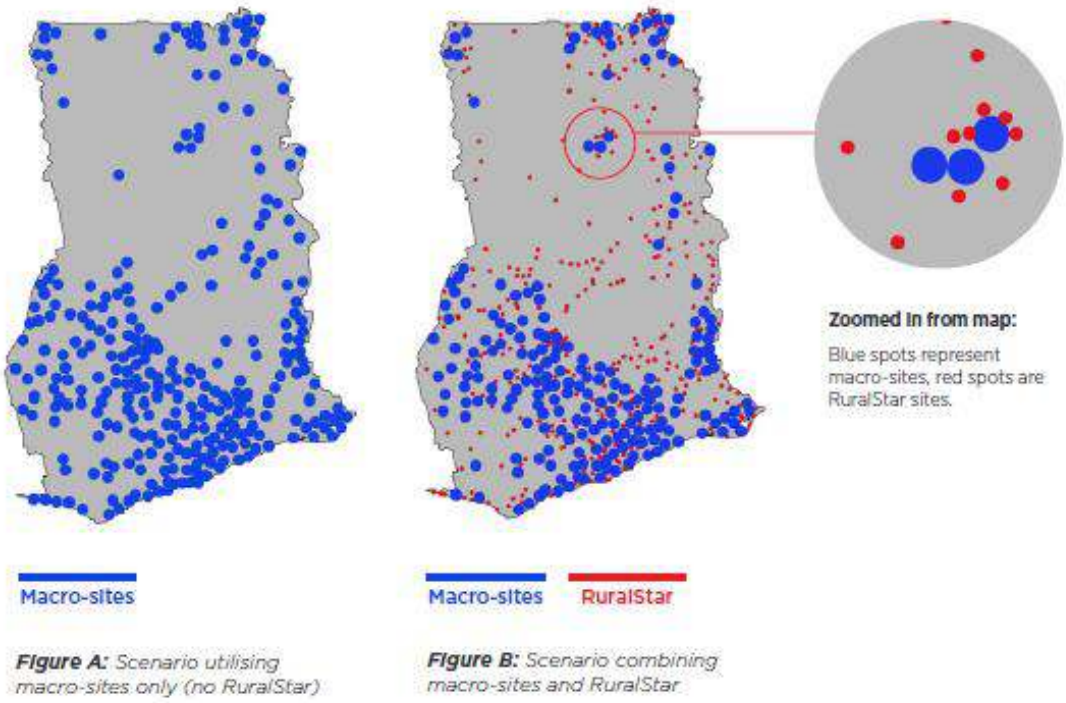

Figure 2. ***Population Coverage scenarios of Ghana with / without MTN-RuralStar deployments (2018)***

4. MTN Uganda and iSat Africa

a) Description of the project

In partnership with MTN Uganda, iSAT Africa, a GSMA Innovation Fund[143] grantee, deployed five mobile network sites in the Karenga district of north-eastern Uganda that were not previously connected, providing connectivity to almost 30,000 people in the communities of Kadepo, Kawalakol, Moriuta, Lomanok and Lobeluna. The main site, Kadepo, was almost 30 kilometres away from the nearest mobile network at the start of the grant. iSAT Africa's project implemented an innovative solution that used concrete less towers, solar power and an open radio access network (RAN) to provide 2G and 3G connectivity. iSAT also installed two smart poles in the town centres that provide solar street lighting, charging ports for mobile devices and Wi-Fi.

iSAT used the mobile coverage maps[144] for Uganda to estimate the link distance between villages, to design the point to-multipoint (PMP) terrestrial network with a near-line-of-sight (NLoS) solution and very small aperture terminal (VSAT) connectivity, and to

[143] https://www.gsma.com/mobilefordevelopment/gsma-innovation-fund-mobile-internet-adoption/
[144] https://www.mobilecoveragemaps.com/

determine the tower height for each location. Depending on village size and concentration, tower heights of 10, 15 and 30 metres were selected. These concrete less towers can be easily moved to different sites as required. iSAT Africa deployed a combination of satellite and terrestrial links to backhaul the traffic to the MTN Uganda Data Centre. A licensed microwave link was installed to connect the main site (Kadepo), where there were more than 3,500 people, to the existing MTN tower 30 km away.

b) Spectrum highlights

iSAT Africa deployed a combination of satellite and terrestrial links to backhaul the traffic to the MTN Uganda Data Centre. The terrestrial links comprises of licensed microwave links and ISM band frequencies.

c) Cost and funding models where possible

The project got a seed fund through the GSMA Innovation fund

d) Sustainability model (mechanism for sustaining the project)

- iSAT Africa used local partners and contractors for all the activities and ensured their contractors employed local community members to help build the sites so that the community would benefit from the project and have a sense of ownership.
- iSAT Africa's project implemented an innovative solution that used concrete less towers, solar power and an open radio access network (RAN) to provide 2G and 3G connectivity.
- They also held outreach sessions to raise awareness of the benefits of mobile, how to use mobile and mobile internet services and the types of information that can be accessed via mobile internet that would be relevant to their lives (e.g. to support farming activities and connect with friends and family).

e) Outcomes (data on the results of the project)

The 18-month pilot found that the combination of backhaul using different technologies proved to be successful in connecting the five sites, which generated around $9,000 per month in total revenue. MTN Uganda subsequently contracted iSAT Africa to continue managing and operating the sites on a commercial basis[145].

5. Ugandan start-up Ensibuuko

a) Description of the project

Ensibuuko, another GSMA Innovation Fund grantee, is a Ugandan fintech company working to promote the adoption of digital financial products and improve access to devices and mobile services in rural areas. They use an innovative digital ledger platform

[145] https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2023/01/Accelerating-Rural-Connectivity.pdf

that automates transactions and operations of community banking schemes, and provision of tailored, affordable and relevant digital financial services that connect users to the wider digital financial ecosystem. Ensibuuko also layered digital skills training for users based on the GSMA's Mobile Internet Skills Training Toolkit (MISTT) [146], adapted and localised for rural customers.

b) Spectrum highlights

This project did not require frequency spectrum.

c) Cost and funding models where possible

The project got a seed fund through the GSMA Innovation fund

d) Sustainability model (mechanism for sustaining the project)

- Ensibuuko introduced a basic mobile digital skills training, based on the GSMA Mobile Internet Skills Training Toolkit (MISTT) [147]. The training program was localised and simplified for low literate users to increase the digital litraracy ((e.g. included images and icons).
- Ensibuuko also maintains a network of field agents who train users and provide ongoing refresher training with the digital skills training kit.
- In addition, the project created digital community entrepreneurs (DCEs) who are trained as digital agents to equip others with digital skills and raise awareness of Ensibuuko's offerings. The DCE model fosters ownership and provides users with the ongoing support they need to build their confidence and overcome their fears about digital solutions.

e) Outcomes (data on the results of the project)

Ensibuuko's innovative approach has brought about success, mainly with low-income users and women who have on boarded, 60% of whom are first-time mobile internet users.[148]

6. Instacash: refurbished phone marketplace using a C2B2B[149] model

a) Description of the project

Instacash is a company that buys used smartphones then refurbishes and resells them to distributors, wholesalers and retailers. It has a presence in

[146] https://www.gsma.com/mobilefordevelopment/%20connected-society/mistt/
[147] https://www.gsma.com/mobilefordevelopment/mistt/
[148] https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2023/02/Driving-mobile-internet-use-in-low-and-middle-income-countries.pdf
[149] Instacash buys the handsets from individual customers and then resells the refurbishes phones to distributors that, in turn, sell them to wholesalers and retailers

seven Asian markets (India, Malaysia, Singapore, Hong Kong, Vietnam, Philippines and Taiwan). Their main innovation is an app that diagnoses a phone and proposes a price. If the seller agrees, an Instacash agent collects the phone and delivers it to an Instacash refurbishing workshop. In India, for example, phone sellers are primarily in wealthier cities and buyers in lower-income areas. Instacash is enabling people in the largest cities to upgrade their phones (and enhance their connectivity experience) by trading in their old phones and increasing their buying power. This also enables people in smaller cities to access a better quality, refurbished smartphone with a guarantee at an affordable price.

b) Spectrum highlights

This project did not require frequency spectrum.

c) Cost and funding models where possible

There is no information available.

d) Sustainability model (mechanism for sustaining the project)

For some customers, purchasing a refurbished phone from Instacash gives them access to their first smartphone while others can upgrade from a low-end smartphone to a higher performing one. Instacash notes that their refurbished phones are particularly appealing to Indian women.

e) Outcomes (data on the results of the project)

Instacash has sold more than 300,000 phones since 2017.

7. The Shared Rural Network (SRN) in UK

a) Description of the project

The SRN is a collaboration between the UK government and the four mobile network operators, EE, Three, VMO2 and Vodafone that have joined resources to expand 4G LTE geographic coverage to 95%.

b) Spectrum highlights

The four network operators will use their existing licensed frequencies.

c) Cost and funding models where possible

The UK government provided a grant of £500m to build new masts in hard to reach areas, and the four MNOs will invest £532m in underserved areas to increase consumer choices[150].

d) Sustainability model (mechanism for sustaining the project)

The SRN is a sustainable approach to the challenge of delivering rural mobile coverage. The programme will transform 4G coverage without duplicating infrastructure, minimising the impact on our countryside.

e) Outcomes (data on the results of the project)

Two Hundred (200) rural locations across the UK now receiving fast and reliable Vodafone 4G through Shared Rural Network (SRN) programme[151].

[150] https://srn.org.uk/about/

[151] https://srn.org.uk/200-rural-locations-across-the-uk-now-receiving-fast-and-reliable-vodafone-4g-through-shared-rural-network-srn-programme/

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