ITU Connect2Recover: Rebuilding Digital Inclusion for the Rural Counties of Kenya

Project Report 1: Assessment of the State of Connectivity in Kakamega and Turkana County

April 2022

ACRONYMS

AP	Access Point
ASA	Authorised Shared Access
ASA/LSA	Authorise/Licensed Shared Access
ASL	Above Sea Level
CA	Communications Authority of Kenya
CPE	Customer Premises Equipment (CPE)
DSA	Dynamic Spectrum Access
GPS	Global Positioning System
ICT	Information and Communication Technology
ISM	Industrial, Scientific and Medical
ISP	Internet service provider
ITU	International Telecommunications Union
IoT	Internet of Things
LTE	Long-term Evolution
M2M	Machine-to-machine
NOFBI	National Optic Fibre Backbone Infrastructure
OSA	Opportunistic Spectrum Access
QoS	Quality of Service
RF	Radio Frequency
SDR	Software-defined Radio
UHF	Ultra-High Frequency
USAID	United States Agency International Development
TVWS	TV White Spaces
WAN	Wide Area Network
Wi-Fi	Wireless Fidelity
5G	Fifth Generation Communication Standard for Cellular Networks

DEFINITION OF TERMS

Backhaul communication	Transport of aggregate communication signals from base stations to the core network.
Bandwidth	The range of frequencies available to be occupied by signals. In analogue systems, it is measured in Hertz (Hz) and in digital systems in bits per second. The higher the bandwidth, the greater the amount of information that can be transmitted in a given time.
Base station	The common name for all the radio equipment located at one and the same used for serving one or several cells.
Broadband	High-speed Internet access
Channel	An individual path through which signals can flow.
Connectivity	The capability to provide connection to the Internet and other communication networks to end users.
Customer premises equipment	The equipment/network administered by the user.
Data rate	The amount of data transmitted over a network within a specified time period
Digital Infrastructure	Combination of digital technologies that provide the foundation for information technology and operations.
Fixed wireless access	Wireless Access (end user radio connection (s) to core networks) application in which the location of the end-user termination (the end-user radio equipment antenna) and the network access point to be connected to the end user are fixed.
Frequency band	An interval in the frequency domain, delimited by a lower frequency and an upper frequency
Internet service provider	An entity, usually a private company but in some cases, a non-profit or government owned, that provides Internet access through data connectivity using a variety of technologies such as telephone cables, coaxial cables, wireless or fibre.
Last mile network	This is where the Internet reaches end users and includes local access network, including the local loop, central office, exchanges and wireless masts. The access network reaches end-user devices, typically basic and smartphones, laptops, tablets, computers and other Internet-enabled devices.
Middle-mile network (backhaul)	This is the distribution network that connects the national backbone to a point in an outer locality/geographic area for broader distribution out to the last mile.
Universal access	Refers to reasonable telecommunication access for all. Includes universal service for those who can afford individual telephone service and widespread provision of public telephones within a reasonable distance for others.
White spaces	Unutilised frequencies within assigned frequency bands

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1. EXECUTIVE SUMMARY

There is no doubt that the COVID-19 pandemic has severely affected the state of the global economy. Ranging from loss of lives to social and economic disruption, the effect of the pandemic has been felt by everyone on the planet. Against this backdrop, a conspicuous image of the digital divide has also been brought to the fore. For instance, the reality that rural areas face greater challenges in terms of Internet access compared to their urban counterparts was laid bare when rural schools could not sustain their learning programmes with the shift to online learning as part of adhering to physical distancing requirements, particularly in the developing economies. Adding to this state of connectivity, the report from the International Telecommunications Union (ITU), in 2020, showed that nearly half of the population on the planet remained unconnected. The pandemic evidently disadvantaged the groups that were already battling connectivity challenges.

The ITU, therefore, set out on an initiative to reinforce the digital infrastructure and digital ecosystem of a number of countries. The objective of the initiative is to provide means of utilising digital technologies such as telework, e-commerce, remote learning and telemedicine to support the COVID-19 recovery efforts and preparedness for the "new normal." In August 2021, ITU extended this initiative by launching a research competition dubbed "**Connect2Recover**" whose ambition was to identify promising research proposals that can accelerate digital inclusion for COVID-19 recovery.

As a consortium of research individuals from both Kenya and the United Kingdom (UK), we submitted our proposal to this quest with the objective of contributing to ways that can enhance the digital infrastructure, the key to ensuring the resilience of healthcare and learning institutions in the wake of a pandemic. Our proposal endeavours to study the broadband challenges faced by two rural counties in Kenya at the height of COVID-19, explore the opportunity of two regulatory frameworks enacted for connectivity during the same period and the longevity of Dynamic Spectrum Access (DSA) in enhancing rural Internet access.

In this report, we present the first of our four deliverables on "Rebuilding Digital Inclusion for the Rural Counties of Kenya." The report highlights the state of the digital infrastructure in the country and for both Kakamega and Turkana counties of Kenya, particularly for the education and healthcare sectors – two major sectors heavily affected by the COVID-19 just as everywhere else in the world. The state of the digital infrastructure is considered in three parts – before the pandemic, during the pandemic and what would be the future state of connectivity post the pandemic. Further, it also notes the existing untapped opportunities of the available access technologies alongside the limitations. It concludes by sharing recommendations of the future for a stably guaranteed digital infrastructure for these two rural counties of Kenya.

2. STATE OF CONNECTIVITY IN KENYA

2.1. OVERVIEW OF KENYA'S LANDSCAPE AND POPULATION

According to the International Telecommunications Union (ITU)[1], several variables must be considered when examining connectivity: network infrastructure, skills and capacity, availability and cost of devices, cost and affordability of the Internet services, relevant content as well as the understanding of the relevance of Internet access. Underpinning these variables is the geographical landscape and the distribution of the population within a country. Kenya's geographic landscape[2] has a terrain that rises from a low-coastal plain on the Indian Ocean to mountains and plateaus in its central region with most Kenyans living in the highlands. Kenya's capital, Nairobi, has an altitude of 1700 metres above the sea level (ASL). To the west of Nairobi, the Kenyan land descends towards the Great Rift Valley which splits the highland region into two sections – the Mau Escarpment to the west and the Aberdare Range to the East. The Mau Escarpment has a westward-sloping plateau whose lowest part is occupied by Lake Victoria. This basic framework, generally divides Kenya into five geographic regions – the Lake Victoria basin, the Rift Valley and associated highlands, the eastern plateau forelands, the semi-arid and arid areas of the north and south, and the coast[3]. Kenya's terrain in general, has been described as suitable for setting up telecommunication infrastructure due to the uniformity of land surfaces for the larger part of the country.

The 2020 report of the State of Kenya's population published by the National Council for Population and Development (NCPD)[4] shows that Kenya has a population of 47.6 million people based on 2019 census although as at January 2022, Datareportal[5] reports that the population stands at 55.6 million people. The age bracket of 15-64 years accounts for 57% of the total population with the youth constituting 29% of the total population. In terms of population distribution, there is a substantial variation in the size and spatial distribution of the population in the country's 47 counties. The five counties with the highest populations are Nairobi City (4,396, 828), Kiambu (2,417,600), Nakuru (1,867,539), Kakamega (1,867,539) and Bungoma (1,670,535) while the five counties with the least populations are Lamu (143,916), Isiolo (267,993), Samburu (310,320), Tana River (315,941) and Taita Taveta (340,664). Some of the rural counties with the highest population densities (number of persons per square kilometres) are Vihiga (1,047), Kisii (958), Nyamira (675) and Kakamega (618). Marsabit county has the lowest density in the country – 6 persons per square kilometre followed by Tana River and Isiolo with 8 and 11 persons respectively. Turkana, the second largest county in Kenya occupies 77,000 sq. km of Kenyan land. Turkana's population is approximately 1,000,000[6] with a population density of 13 persons per sq. km making it one of the counties with the lowest population densities despite the large land size. The map of Kenya with all the counties is shown in Figure 1.

[1] The Last-mile Internet Connectivity Solutions Guide
[2] National Geographic Kids
[3] Kenya
[4] State of Kenya Population Report
[5] Digital 2022: Kenya
[6] Facts and Figures – Turkana County

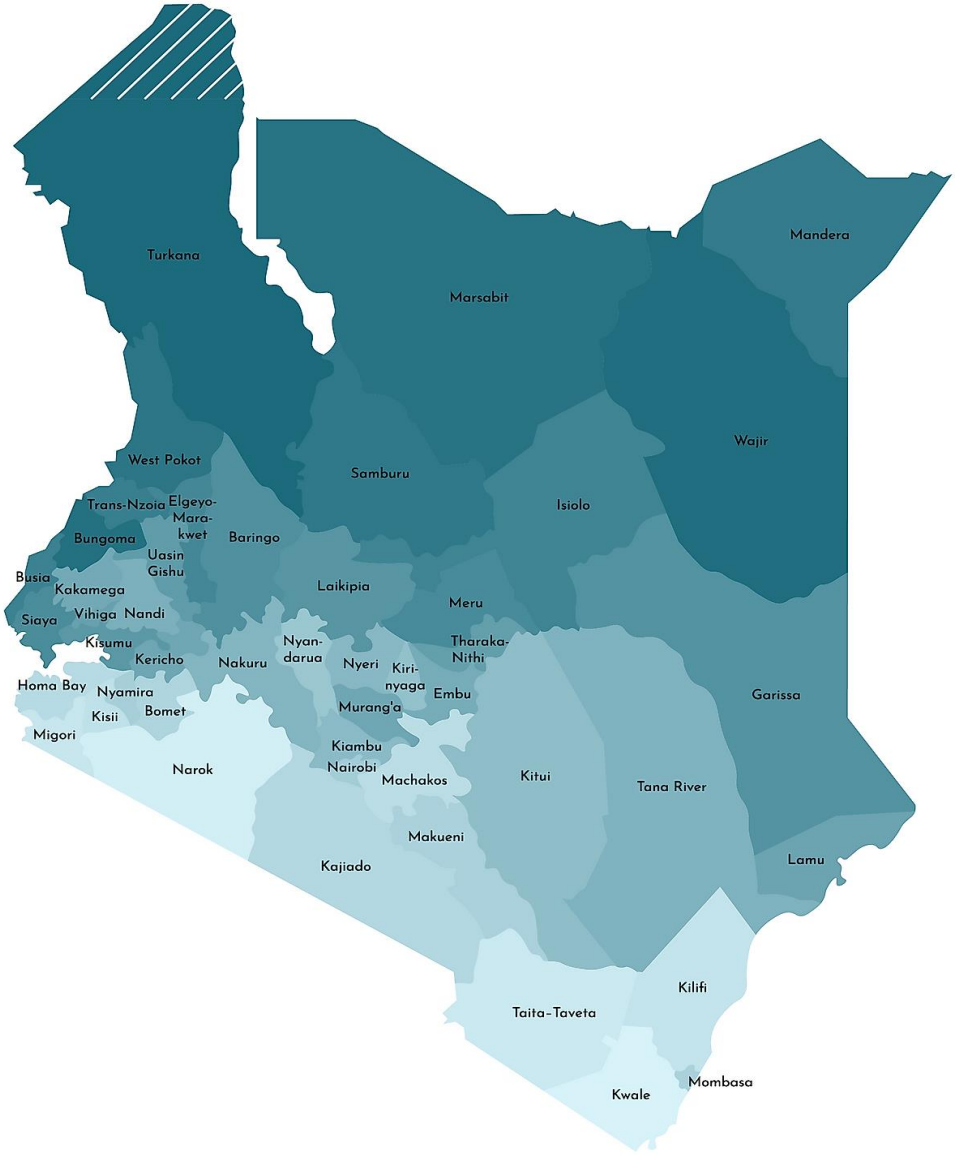

Figure 1: Kenyan Map with all the 47 Counties

Source: Worldatlas

2.2. SUMMARY OF CONNECTIVITY ACROSS THE COUNTRY 2020-2021

The COVID-19 pandemic injected a reinvigorated appreciation of how connectivity gives citizens access to multiple opportunities, allows government to deliver much needed services and enables businesses to thrive, a backbone that has sustained the activities in Kenya since March 2020 when the lockdown came into effect. The lockdown came with the measures of closing down learning institutions and certain types of businesses, restriction of movement across the country's international borders and across borders of certain counties as well as introduction of daily curfew hours, similar to many countries around the world [1].

With this unprecedented situation, the telecom players – from broadband to mobile data to data centre operators across the globe, began benefitting from a surge of traffic of data and voice with the advantage of exemption from the restrictions as telecommunications was considered an essential service[7]. In Kenya, Safaricom – Kenya's largest mobile network operator (MNO) saw a 70% surge in cellular data usage[8]. However, even with this surge, going by the definition of broadband as provided by the ITU[9], to mean a 4G equivalent connection with a target population of those aged 10 years and above, millions of students could not sustain their state of learning[10]. Safaricom's 4G coverage in 2020 was said to be at 77%[11] but the sufficient data to back this up is conspicuously missing. There is also little information on 4G coverage for the other two mobile network operators (MNOs) – Airtel and Telkom. In order to complement the existing 4G network infrastructure especially with the increased demand during the pandemic, the Communications Authority of Kenya (CA), assigned additional frequencies to both Airtel and Safaricom in both the 1900 MHz and 2100 MHz bands at a bandwidth of 10 MHz that came into effect for a period of 9 months.

The Sector Statistics report[12] published by the Communications Authority of Kenya (CA) for the Financial Year 2021/2022 shows that cellular Internet access is the leading access technology in the country. Presently, there are 64.9 million active subscribers of mobile services in Kenya and an estimated number of 45 million subscriptions to the mobile data services. These numbers are based on active SIM cards. Cellular infrastructure improvements reinforced by the availability of cheap smartphones and digitisation of crucial government services can be said to be the drivers of the large adoption of the mobile broadband. However, the cost of mobile broadband connectivity was seen as relatively high at the height of COVID-19, particularly for the rural folk where parents could not afford providing Internet access to the students who were expected to join online classes from their homes.

The fixed Internet data providers and their subscribers based on the CA's sector statistics report show that – Safaricom PLC owns 37.0% of the subscribers followed by Wananchi Group (29.2%), Jamii Telecommunications (18.9%), Poa Internet (9.1%), Liquid Intelligent Technologies (2.0%) and Mawingu Networks (1.5%). These six organisations make up approximately 98% of fixed Internet services in the country. Most of the fixed Internet services are largely concentrated in the cities and urban towns, making up a small percentage of the country's population whose 71% is located in the rural areas[13]. Predominantly this remained as the case between 2020 and 2021. Further, the top two service providers i.e. Safaricom and Wananchi Group (who own Zuku) command over 60% of the market, indicating that consumers have limited choice.

[7] COVID-19's Impact on the Global Telecommunications Industry
[8] Kenya's Safaricom jump in data usage
[9] Connecting Humanity to Internet by 2030
[10] Kenya Basic Education COVID-19 Emergency Response Plan
[11] Safaricom at a glance
[12] First Quarter Sector Statistics Report for the Financial Year 2021/222
[13] Digital 2022: Kenya

The overall picture of other access technologies is sparsely spread around the country to which the traditional challenges of their coverage persisted at the height of COVID-19 (between 2020 and 2021). For example, the fibre optic connectivity, despite their rollout under the National Optic Fibre Backbone Infrastructure (NOFBI) led by the government and a set of other stakeholders in the country, there is little coverage of it closer to the last mile to even guarantee proper backhaul or middle-mile network[14]. Notably, there is also a significant amount of "dark fibre" caused by infrequent usage and whose location to the last mile is not as farther a distance to remain unused. This state of connectivity was one of the contributors to the challenge of learning for the rural learners who make up 70% of school-going children in Kenya[15]. Moreover, students who had to go back to their rural homes expressed frustrations of accessing the online learning platforms that the government and schools had set up due to the lack of good Internet coverage.

The initiative of the High Altitude Platform Stations (HAPS), which uses high-altitude balloons or autonomous drones to host access equipment that beams connectivity down to the ground got approved by the Kenyan President Uhuru Kenyatta on March 23rd 2020 to enhance internet access to the underserved at the height of COVID-19[16]. Led by Google and Telkom Kenya, the project known as Loon was to contribute to the attainment of universal 4G coverage in Kenya during the pandemic but unfortunately did not live up to the promise with Google citing the technology as not commercially viable[17] and officially terminating it on 1st March 2021. The project had initially envisioned to connect a region spanning nearly 50,000 sq. km. in the following areas – Iten, Eldoret, Baringo, Nakuru, Kakamega, Kisii, Bomet, Kericho and Narok, which forms a significant set of the rural counties of Kenya[18].

Satellite and microwave technologies, on the other hand, did not have largely significant contributions between 2020 and 2021. Most often these two technologies in Kenya are used as middle-mile networks. For instance, microwave technologies are used as backhaul networks for the cellular networks [2]. They have also been previously used as the backhaul connectivity for deployment of TV White Spaces (TVWS) as demonstrated by Mawingu Networks during their TVWS pilot[19]. Nevertheless, Satellite broadband was used to enable remote learning amidst COVID-19. Avanti satellite broadband networks were used to enable iMlango's e-learning platform to be available for learners in Kilifi, Makueni, Uasin Gishu and Kajiado through the HYLAS 2 Satellite[20].

2.3. OPPORTUNITY OF NEW MODELS FOR INTERNET ACCESS

The Communications Authority of Kenya (CA) began the validation of the regulatory framework for TV White Spaces (TVWS) in January 2020 to lead the first commercial efforts of spectrum sharing in the country. When the first incident of COVID-19 was reported in Kenya on March 12, 2020, the CA was engaging stakeholders to contextually fit the draft framework for commercial adoption [3]. Although, the framework was officially ratified in May 2021[21], the opportunity of spectrum sharing (or Dynamic Spectrum Access) for provision of Internet access to the underserved had been unlocked earlier on at the onset of COVID-19 on 3rd March 2020 when CA had published the draft regulatory framework on their website[22].

[14] The National Broadband Strategy 2018-2023
[15] The Impact of COVID-19 on Education in Kenya
[16] Kenya Approves Roll out of Google Loon
[17] Alphabet shuts down Loon Internet balloon business -
[18] Telkom Kenya ends Internet balloon project -
[19] Rural Broadband Trials: Laikipia County
[20] How African Countries Used Space Technologies to Solve Developmental Challenges in 2020
[21] Dynamic Spectrum Access Framework for Authorisation of the Use of TV White Spaces

The broader view of the development of this framework was to leapfrog efforts of connectivity for the rural areas of Kenya – largely affected by the digital divide and which at the time of the pandemic, had a disproportionate need for and would disproportionately benefit from last mile connectivity efforts that CA had already identified through spectrum sharing. Nevertheless, no deployment of TVWS network went live to address the rural connectivity gap during COVID-19 despite the successful study and final pilot that Strathmore University and CA had conducted between January and March in three counties of Kenya – Kitui, Kisumu and Laikipia [3].

In May 2021, CA through an FCDO-funded project to the Association of Progressive Communications (APC) also published the licensed and shared access framework for Community Networks[23]. While there exists Community Networks (CNs) operating in Kenya (although few in number), there did not exist any guiding regulatory framework until June 2021. The previous experience of CNs in the country had demonstrated positive impact to the low-income urban communities[24] as well as other marginalised areas but challenges of cost of network infrastructure and devices, challenges of the technology – particularly Wi-Fi's congestion in the 2.4 GHz band and CAPEX investments hamper their socio-economic initiatives. With the enactment of the CNs framework, it demonstrated an opportunity to connect the unconnected in the marginalised areas with bigger support of backhaul such as TVWS and use of the 24 GHz and 60 GHz bands for wireless services.

The implementation of these two frameworks presented an opportunity that can be leveraged to drive broadband access to the unserved and underserved. Further, despite the challenges that exist for the adoption of TVWS and CNs, they would go a long way into addressing the persistently increasing demand for Internet access and provide more options of connectivity to the pressing needs of institutions such as education and healthcare – enabling rapid reconstruction of the country's digital ecosystem from the pandemic.

3. URBAN VS RURAL INTERNET ACCESS

3.1. OVERVIEW

Unlike their urban counterparts, the rural areas of Kenya happen to have many unserved and underserved areas. In January 2021, Datareportal[25] reported that 28.2% of Kenya's population lives in urban centres while 71.8% reside in rural areas. The same report noted that there were 21.75 million internet users in Kenya with the Internet penetration standing at 40.0%, clearly elucidating the gap of the digital divide. Unfortunately, during the pandemic, the rural population in places such as Garissa, Mandera, Samburu, Marsabit and West Pokot were also battling internal insecurity which had to heavily slow down the extension of the telecom infrastructure in such underserved localities[26]. In general however, before the pandemic hit in early 2020, the Kenyan population and housing census showed that 22.6% of individuals aged 3 years and above used the Internet while 10.4% used a computer. The proportion of population, aged 15 years and above who searched and bought goods and services online was 4.3%[27].

[23] Licensing and Shared Spectrum Framework for Community Networks
[24] Community Networks bring Education online in Kibera
[25] Digital 2021: Kenya
[26] COVID-19 and Insecurity slow down telecom networks expansion
[27] 2019 Kenya Population and Housing Census Reports.

While universal broadband connectivity is widely accepted to be an important enabler of economic growth and development – contextually highlighted in the National Broadband Strategy document as well – COVID-19 immensely showed the weight of the reality of the digital divide between urban and rural Kenya. Prior to the pandemic, the census report, showed that the rural Internet access stood at 13.7% compared to the urban Internet access which stood at 42.5% - more than twice the access in the rural areas!

Going by the focus of the Last Mile Connectivity (LMC), rural areas relatively suffered from the following challenges more than the urban areas at the height of the pandemic. Some of them emanate from the traditional challenges that have existed for a long period [4].

1. Capacity – Power capacity stood as a challenge to enabling the capacity of rural Internet access, particularly the rural areas that are far from shopping centres. The challenge of sufficient backhaul networks to support last mile networks such as Wi-Fi for the rural areas hampered sufficient access to the online study platforms for the rural students compared to the urban students. Moreover, working from home also seemed a challenge for the rural parents, employees and entrepreneurs.

2. Coverage – While Safaricom[28] claimed to have covered 77% of the Kenyan population with 4G network in 2020 and the statistics from both Telkom and Airtel conspicuously missing alongside missing information on the coverage of the community networks as well as rural fixed Internet services – it can be said that there is lack of clarity of how much rural Kenya is covered with Internet services. ITU, on the other hand, noted that 4G coverage in Africa stood at 22% for the rural areas in 2020 while for urban areas, the coverage was at 77%[29]. While 3G coverage seems to have a wider coverage in the rural areas (cited by ITU as 40%), its data rate is not sufficient enough to guarantee quality of service (QoS) in activities that require access to videos compared to the 4G network, further marginalising the rural communities.

3. Affordability – The challenge of 'usage gap' experienced at the height of the pandemic has been a perennial problem of the rural population due to their preference of low-cost feature phones. 14.4% of Kenyans aged 16 to 64 were said to own feature phones in April 2021[30]. Another report in December 2021 showed that the penetration level of feature phones stood at 67.9%[31]. Due to the socio-economic challenges of the pandemic, the affordability gap widened to the disadvantage of the rural areas as priority turned to more pressing needs such as food than acquiring a smart device to connect to the Internet – especially to the households that relied on informal employment. According to the Broadband Commission's ICT Price Trends 2020 report[32], although mobile broadband has been on the increase and prices have been on the decline worldwide, affordability still remains an issue. Broadband, whether fixed or mobile, is affordable to citizens only if it is less than 2% of GNI[33]. In Kenya, the cost of 2GB mobile broadband is 9% of GNI per capita and while that of fixed broadband is 15% of GNI per capita according to the ITU's ICT Price Trends 2020. This is way above the recommended 2% by the Broadband Commission. These statistics, hence, demonstrates that broadband is still not affordable to the majority of the Kenyan population and the challenge is gigantic for the low-income population.

4. Lack of Equipment and ICT facilities in many rural institutions: While the concept of adoptig computers for instructons in schools as studied in the past show improved attitude of students towards learning, most rural schools of Kenya seem to be missing out on this [1] [2]. During the pandemic,

[28] Safaricom at a glance
[29] Measuring digital development Facts and Figures 2021.
[30] Kenya Internet Usage lags mobile penetration
[31] Half of Kenyans own smartphones -
[32] Broadband Commission's ICT Price Trends 2020 report
[33] Broadband Commission for Sustainable Development.

they were heavily affected that the opportunity to adopt a physical distancing approach that can allow the students to share ICT facilities such as computers within an institution on a session basis, did not even exist as an option [2]. On the other hand, domains of healthcare, business and agriculture significantly lag the learning institutions in the availability of ICT equipment or devices to push for access to the Internet and services that come with it [3].

5. Lack of Sufficient Digital Skills: The importance of utilising science and technology has remarkably demonstrated economic progress in Kenya through mobile money services, access to mobile Internet as well as the urban innovation through adoption of IoT technologies as noted in the National Broadband Strategy. Unfortunately, while the rural communities have also acknowledged the value that mobile money has brought to them, even through feature-phones, there is still a huge fraction of them that do not know how to navigate a computer's interface, while some struggle with the use of mobile phones. This challenges of sufficient digital skills are and literacy are noted in the United States International Agency (USAID) report for Digital Ecosystem Country Assessment (DECA) published in October 2020[34]. The digital literacy training is not only needed by the students to access learning platforms or county officials to key in necessary data but is also required by the education officials who have pointed in the past that they are comfortable using a tablet with hands-on support. Hence, the lack of digital skills ranges from very basic digital skills such as using a device and a password protection, particularly to the rural folk, to advanced topics such as cybersecurity, cyber hygiene and data management by both the rural and urban groups.

6. Delay in enactment of policies: Kenya, similar to its neighbouring African countries notes that developments in telecommunications will contribute to social transformation and economic activity, enhance quality of life, reduce costs in rural social service delivery and support good governance and transparency. Hitherto, the Kenyan government has put together initiatives such as the Digital Economy Blueprint, E-commerce master plan, E-government plans in order to improve processes of administration within various government organs with the intention of enhancing efficiency of services to the citizens. Unfortunately, studies show that due to monopoly, corruption and underinvestment, Kenya has been slow to reform the ICT sector in practice. This is due to the lack of enthusiasm on the side of the decision-makers to push for implementation of ICT policies that are inclusive of unserved and underserved areas [3]. This was experienced during the pandemic when the release of the TVWS framework took another one year to be approved (in May 2021) even after the framework had completed validation in April 2020.

3.2. URBAN SCHOOLS VS RURAL SCHOOLS

The Government of Kenya commits over 6% of the GDP to the education sector. A major barrier to its aspirations of achieving an educated society is the perpetual disaster occurrence dominated by fire outbreaks in schools, floods in some regions, drought in others as well as pandemics. The COVID-19 pandemic disrupted learning to 18 million students in the country starting the week of 16th March and 20th March 2020 when physical learning in all the institutions across the country was suspended[35]. The measures adopted by the government to ensure learning continued included:

[34] Kenya Digital Ecosystem Country Assessment
[35] Kenya Basic Education COVID-19 Emergency Response

1. Production of online teaching and learning materials and to expand distance learning programmes.
2. Training of teachers to effectively support distance learning, including monitoring and assessment.
3. Development and implementation of intervention programmes targeting the marginalised and most vulnerable learners especially girls and learners with special needs and disabilities.
4. Provision of psychosocial support to the learners, teachers and education officials.

To successfully execute these measures, it meant that Internet would be the hinge and the pipeline that services from the government would reach the teachers, from government to the learners as well as from teachers to the learners. Largely, content was being provided to the learners through radio, television (TV) (for primary and secondary learners) and online teaching and learning as well as the expansion of the already existing university and college digital platforms to accommodate courses that were initially more physical-centric than online. Moreover, content storage platforms such as the Kenya Education Cloud also needed to be strengthened both from a software-performance perspective and cybersecurity.

A study found out that only 57% of the learners in Kenya participated in online learning[36] during the COVID 19 pandemic. According to the same study, the reasons given for not being able to participate in online learning were unavailability and inaccessibility of internet (57% of respondents), lack of electricity (20% of respondents) and lack of digital skills (22% of the respondents).

In terms of the effect and spread of the COVID-19 virus, students from the urban areas as well as tourist hotspots were more vulnerable compared to the students in the rural schools, Nairobi, Mombasa and Kilifi were the leading counties for the infections. Therefore the physical access to textbooks and other learning materials was exclusively left for the rural students due to the low rates of infection. While the online content developed by the Kenya Institute of Curriculum Development (KICD) was made available for access through various channels – radio, TV to ensure uninterrupted learning, the students from low-income areas, especially in the rural schools still faced challenges to access it due to the lack of TV sets at their homes. This furthered the advantage of the urban schools in conjunction with the advantage of many digital devices such as laptops, PCs and smartphones that many of the students from the urban schools could still use to access the content.

The Emergency Response plan from the government also highlights a disadvantage that rural schools have, particularly in terms of electricity to aid the charging of devices that the rural learners can use – a problem the urban schools (including low-income urban areas) do not face and hence were not affected with that during the pandemic. In remote parts of Kajiado, Narok, Samburu, Turkana, and Kilifi counties, for instance, electricity does not reach households, and this excluded many children from online learning[37]. According to the Kenya 2019 Census data, only 26% in the rural areas have access to electricity and less than 10% have access to digital learning devices such as computers, iPads, and laptops. For the areas prone to insecurity as well as the rural ones, they traditionally experience a shortage of teachers which compromises their quality of education compared to their urban counterparts.

[36] Effect of Covid-19 Pandemic on the Education System in Kenya – Journal of Education
[37] How school closures during COVID-19 further marginalize vulnerable children in Kenya

3.3. URBAN HOSPITALS VS RURAL HOSPITALS

The Government of Kenya launched the "Big Four" agenda in 2017 as the next phase of Vision 2030 through the Third Medium Term Plan (MTP3)[38]. The Big Four agenda – also referred to as – President Kenyatta's legacy projects to deepen affordable housing, universal healthcare, enhancing manufacturing and attaining food security by the time his second term ends in 2022[39]. While there are many objectives outlined for affordable healthcare in the April 2020 report from the State Department for Planning on the Implementation Status of the Big Four Agenda[40], this report considers the following objective which form part of the top five:

1. 18% increase in the number of health facilities in 14 counties.
2. 56% increase in the number of health workers.
3. Increase the national coverage of 36% to 100% by the year 2022.

Kenya is one of the developing countries that is gradually embracing the use of digital systems for storage of medical information to replace the paper-based systems [5]. This approach is adopting cloud-hosted systems, personal computers, mobile phones and tablet computers in an open-source technology ecosystem for a cost-effective and reliable healthcare system. With a devolved healthcare system alongside implementation of the above objectives under the Universal Health Coverage launched on December 13th 2018[41], there is definitely need for an interconnected healthcare ecosystem that leverages Internet access. Services such as patient registration, billing, outpatient, inpatient, pharmacy, laboratory, finance, human resources and comprehensive care clinics can therefore be effectively bundled up to run across the different hospital departments through cloud services linked by Internet access through both Local Area Networks (LANs) and Wide Area Networks (WANs). Unfortunately, this ecosystem has been cited to suffer electrical power interruptions particularly the rural hospitals as well as infrastructure challenges [5].

The setup of infrastructure (to mean buildings, medical technologies equipment, emergency transport and ICTs) prior to COVID-19 was already cited as a challenge across both urban and rural healthcare facilities with a specific focus of the ICTs noted as limited across the country[42]. In July 2020, the national government connected 16 Level 4 and 5 hospitals to NOFBI in order to improve hospital administration, patient care with a future vision to improve telemedicine. The connectivity was to also facilitate online and real-time data management services for the hospitals. Special economic zones such as Dogo Kundu, Kenaine, Konza and Naivasha were planned to be connected to the country's ICT network grid. During the launch, while the government applauded the 8,900 km of fibre network under all the phases of NOFBI expansion, it mentioned that lack of appropriate products and cost of ICT devices were still a challenge.[43]

The Kenya National eHealth Policy of 2016-2030[44] on the other hand, while it underscores the need for attainment of the highest standard of health through adoption and use of ICT, it boldly points out that the lack of adequate infrastructure to support quality, high-speed Internet connections is one of the reasons for poor uptake of eHealth applications in rural and remote regions. Nevertheless, it points out the need to ensure affordable broadband connectivity to all parts of the country as a policy priority for Digital Access to Healthcare that can enable online access to eHealth services and information.

[38] Towards 2030
[39] Big Four agenda as part of Vision 2030
[40] Implementation Status of the Big Four Agenda
[41] Universal health coverage a game changer
[42] Policy Brief – Pathways to optimal health infrastructure in Kenya.
[43] State connects 16 public hospitals to internet
[44] Kenya National eHealth Policy 2016-2030

4. INTERNET ACCESS FOR KAKAMEGA COUNTY

4.1. OVERVIEW OF KAKAMEGA COUNTY

Kakamega County is one of the 47 counties of Kenya located in the Western region of the country with an area of 3,051.3 sq. km and an estimated population of 2,079,669 people and a density of 682 people per sq. kilometres. Administratively, the county has 12 sub-counties,[45] 187 village units and 400 Community Administrative areas. Bordered by 7 other counties as shown in Figure 2, the county is the 26th largest in Kenya[46]. The county's main economic activities included crop, livestock and fish farming. In 2020, Kakamega was named as the best performing county in the country based on the delivery of key services such as health, agriculture, education, roads, energy and other devolved functions[47]. While it is hard to obtain the statistics on the learning institutions in Kakamega, the list of secondary schools posted on Kenyan Life can be used to approximate the total number of schools (primary and secondary) in the county to be over 100. On the other hand, the county has only one main university – Masinde University of Science and Technology (MMUST) and a number of satellite campuses for a number of other universities – Kenyatta, Mt. Kenya and the University of Nairobi. Similar to the learning institutions, it is also quite hard to obtain the information about the number of hospitals and healthcare centres within the Kakamega County.

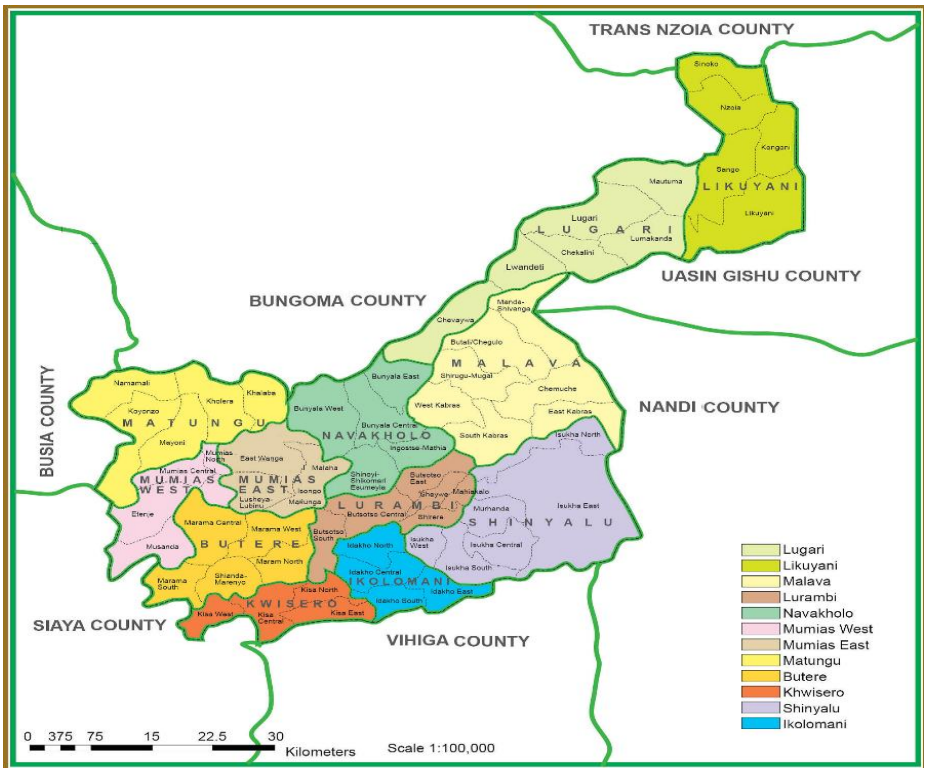

Figure 2: Map of Kakamega County

Source: Kakamega County Website

[45] About Kakamega County
[46] Counties of Kenya
[47] Kakamega ranked best performing county

4.2. INTERNET ACCESS IN KAKAMEGA PRE-PANDEMIC

In its Integrated Development Plan of between 2018-2022, the leadership of Kakamega County notes that ICT will play a pivotal role to providing long lasting solutions to both economic and environmental challenges, such as providing new job opportunities, promoting industrialisation, promoting energy efficiency and investing in research and innovation for sustainable development[48]. However, it also observes that there are many challenges hindering technological progress such as: high cost of mobile/data subscriptions, lack of knowledge and poor quality enforcement.

Prior to the pandemic, the NOFBI coverage in Kakamega had covered some areas along the main tarmac road within Kakamega town with a few institutions and organisations making use of the provided fibre connection. The county also enjoys 85% coverage of mobile telephony within the county. Hence, new products and services in the sectors of Health, Agriculture, Education and Finance were greatly improving. Nevertheless, the county underlined that the cellular network as well as the general Internet coverage needs to be improved. While the county outlines the development need for an expanded county Internet connectivity in its Development Plan of 2018-2022, apart from access to the Internet through the NOFBI network and cellular technology, there is very little information on the use of other technologies such as satellite or fixed wireless access (FWA).

Almost a year and three months before the pandemic, a blog post on the real situation of connectivity in the rural areas – western Kenya elucidated that the statistics of coverage provided by the CA do not reflect the reality in such areas[49]. Whereas it is true that Internet services are available to most people in rural Kenya, they are however of a low quality further widening the digital divide. The implication of these divide to the rural communities is that they have limited or restricted access to modern ICT services including e-government platforms such eCitizen[50] as well as services delivered over the cloud or require real-time Internet connection. The divide is further widened by electric power supply. A challenge the Integrated Development Plan for Kakamega also notes as experiencing slow pace of expansion in a number of urban centres with most of the rural locations having inadequate access to electricity.

4.3. INTERNET ACCESS IN KAKAMEGA DURING THE PANDEMIC

4.3.1. FOR THE LEARNING INSTITUTIONS

The COVID-19 pandemic laid bare the inequalities of Internet access across the country and amplified challenges of unreliable Internet connectivity, access to ICT infrastructure and lack of preparedness for online pedagogy [2]. The temporal cessation of on-campus activities to mitigate the spread of the COVID-19 virus registered an enormous impact on higher education. With the closure of the higher learning institutions, it meant that students had to attend online classes, some of them for the first time due to the fact that some universities and colleges had never before conducted online classes.

[48] Kakamega County Integrated Development Plan 2018-2022
[49] Rosy Communications Authority Statistics Mask the Digital Divide in Kenya.
[50] E-Citizen platform

The structure of higher education, most often, has students coming from various parts of the country and a significant fraction of these students come from the rural areas. Hence, with the shift to online studying and the socio-economic challenges caused by the pandemic, it meant that these students had to return back to their rural homes. To sustain the continuity of learning in higher institutions, some of the universities such as Strathmore University provided mobile data to the students to be able to join the classes from any part of the country that the pandemic had forced them to move. Unlike their urban counterparts, students who had moved to their rural homes (including Kakamega), experienced latency in accessing the online platforms such as Zoom, Teams, Webex or Google meet that were mostly used for the online classes. Sometimes, the students would get disconnected due to the dropping of their connection – mostly on cellular connection. Most of the urban students had the advantage of a fibre connection which provided them with a better quality of service.

The government's approach to ensuring continuity of learning for the public schools (primary and secondary) during the pandemic, on the other hand included broadcasting on various media such as Television, YouTube and Radio with 15 million as a targeted number of learners[51]. With the weak pre-pandemic state of connectivity for Kakamega county, this approach also benefitted the group of learners within that county. However, it was questionable whether the broadcasts were sufficient and accessible by all owing to the challenges of electric power. The further challenge was the duration of broadcasting the content which was only for an hour a day and students could also not have a point of reference after the broadcasting unlike the way they would access a recording at the end of the class or shared notes on a cloud drive. Several other initiatives such as use of WhatsApp groups was also adopted as platforms to share educational materials for the students of Kakamega County, similar to what was adopted in Daadab Refugee Camp. Nevertheless, the success of this depended on the quality of the cellular connection, which often had its challenges as well[52].

4.3.2. FOR THE HEALTHCARE INSTITUTIONS

In general, the healthcare system of Kenya has made significant progress in dealing with issues such as high child and maternal mortality rates despite the various challenges it faces. With the implementation of devolution in 2013, the steps the government is taking to improve the health of the population cascades to all the 47 counties to which Kakamega forms part. The government has also significantly increased budget allocations towards health. For instance, in the 2021/2022 budget, the health sector was allocated $1.05 billion[53]compared to the preceding years[54]. With strengths such as economic growth, a growing health budget allocation, a young population, a dynamic private sector, a skilled workforce, improved infrastructure and the country's strategic position in East Africa, Kenya has the potential of being one of Africa's success stories[55].

The COVID-19 pandemic, however, exposed the weaknesses that exist in the Kenyan health system, especially on financing and governance. For example, the unpreparedness of the healthcare ecosystem at the county level, limited capacity of healthcare workers, inefficiency and integrity of the public health sector supply chain and the extent and hidden impact of non-communicable diseases (NCDs). An argument was presented at the height of the pandemic that if the full effect of the COVID-19 pandemic had been felt, the healthcare system in the country would have totally collapsed. The pandemic, hence, underscored the importance of primary healthcare. Home care was introduced as an alternative to hospitalisation[56]. Key to the

[51] Responding to COVID-19 Crisis: A Critique of the 2020 Basic Education Response Plan in Kenya.
[52] Our Children can learn online if we have the will.
[53] Highlights of the FY 21/22 National Budget and the Finance Bill 2021.
[54] Is Kenya Allocating Enough Funds for Healthcare?
[55] The World Bank in Kenya – Overview.
[56] 2021 Kenya Medical Devices eHealth.

success of this and the traditional supply chain challenges is the use of ICT equipment as well as reliable Internet connection.

With very little specific information on keeping the health system connected or enhancing its access to manage issues such as contact tracing at the height of the pandemic for Kakamega County, the national plans and COVID-19 directives by the Ministry of Health (MoH) took precedent. The MoH developed an App known as Jitenge[57] during the pandemic for travellers who were coming into the country to minimise a lot of the physical interactions at the airport and to also be used for self-quarantine to report on any potential symptoms for COVID-19 as well as the general surveillance of the travellers. MoH also provided guidelines for staying safe during COVID-19 and travel information[58] on their website alongside the real-time closure or opening of places, offices and zones throughout the pandemic. Although this information was largely accessible to the literate groups with better Internet access, mostly based in the urban centres, the rural groups depended a lot more on information broadcasted over Radio FM or Television.

Kenya is ranked second after South Africa on eHealth innovation in Africa. While the Kenya e-Health Strategy 2016-2030 is anchored on the achievement of vision 2030 with identified specific eHealth needs and demands composed of mHealth, Telemedicine, eLearning and Health Information Systems, there is little data on existing collaboration of healthcare centres, health research facilities and clinics around the country to leapfrog these needs. We envisage that this would inform better on the Internet access across the health spectrum in the country. Moreover, county-based records of healthcare collaboration such as healthcare facilities within Kakamega County during the pandemic hardly showed a clear outline of Internet access linking them. This would have helped improve efficiency in managing and sharing resources among themselves at the height of the pandemic to even collaborate in handling the geographical spread of the virus.

5. INTERNET ACCESS FOR TURKANA COUNTY

5.1. OVERVIEW OF TURKANA COUNTY

While the Ministry of Devolution describes Turkana County as the largest county in Kenya by land area[59], many other information sources describe it as the second largest county[6061]. The county occupies 13% of Kenya's surface in the northwest. It is traversed by the extensive Eastern Africa Rift System. The topography of Turkana varies between semi-arid and arid landscapes consisting of low-lying plains and isolated hills and mountain ranges [4]. With its County Government Headquarters in Lodwar Town, the county internally borders five counties as well as three neighbouring countries of Kenya – South Sudan, Ethiopia and Uganda as shown in figure 5.1 and constitutes of seven Sub-Counties. The main economic activities of Turkana are: Pastoral farming (Cattle, Camel, Donkey, Sheep and Goats), Fishing as well as Irrigation farming. For quite some time, oil prospecting and exploration activities have also been ongoing in the county as huge oil deposits have potentially been seen to exist in Turkana[62]. According to the Kenya National Bureau of Statistics (KNBS) based on the 2019 Kenya Population and Housing Census, Turkana has an estimated population of 930,000 people sparsely spread around the vast Turkana land with a population density of 14 persons per sq.

[57] Jitenge System
[58] COVID-19 travel related FAQs
[59] General County Information
[60] Overview – Turkana County.
[61] Turkana County: CIDP II (2018-2022)
[62] Overview – Turkana County.

km. As a county in general, Turkana is mostly seen as the most rural county in the country and struggles with challenges of drought and climate change, inadequate social services, poor physical infrastructure, dispersed human settlements, gender bias and negative cultural practices. Turkana forms part of the 80% of Kenya's landmass (made up of roughly 36% of the population) that is heavily composed of Arid and Semi-Arid Lands (ASALs)[63].

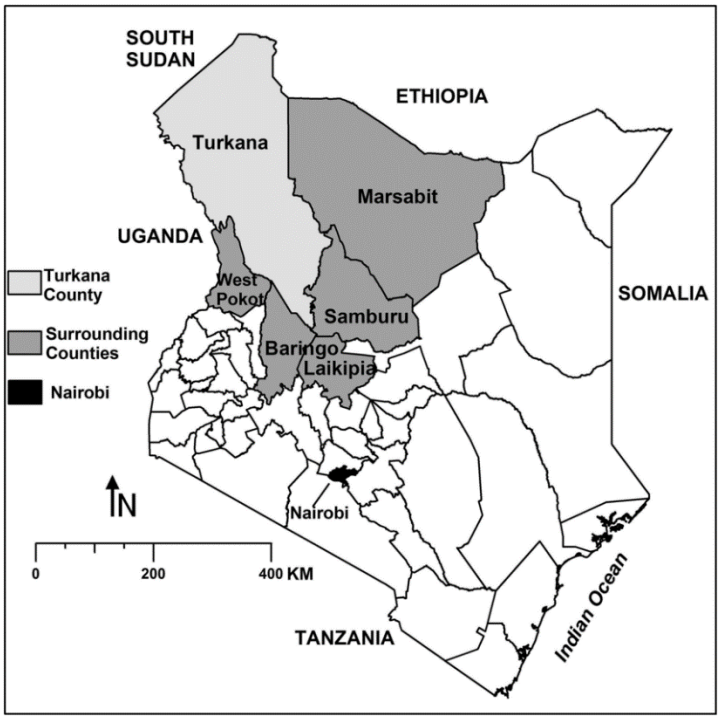

Figure 5. 1: Kenya's map showing the location of Turkana County

Source: ResearchGate

5.2. INTERNET ACCESS IN TURKANA PRE-PANDEMIC

The socio-economic status of Turkana as a County in general is described as one of the main reasons why the county has a unique disproportionate access to the Internet compared to many other counties with the consideration of the following variables: education level, employment status and income levels [5]. The County's Integrated Development plan (CIDP II 2018-2022), stipulates that, the county is faced with high dropout rates and low transition rates from primary to secondary school as well as secondary school to tertiary levels[64]. Notably, livelihoods, human well-being and landscapes are integrally linked in the County.

Safaricom, Airtel and Telkom are the three mobile network operators in Turkana County. Safaricom has the largest network coverage followed by Airtel. While the network coverage, prior to the pandemic, seemed to steadily grow, the Turkana County government noted that there were still significant areas of the county without access to the cellular signal, hampering voice communication and development. In fact, the National Broadband Strategy highlighted a challenge of citizens in counties such as Turkana (ASALs) walking more than 2 kilometres to access mobile cellular signal with access to Internet and data services still a mirage. Nonetheless, the specifics on available access technologies for Internet and data across Turkana County are conspicuously missing. In 2019, the experience of improved connectivity through 3G enabled access of many

[63] ASALs Info.
[64] Turkana County: CIDP II (2018-2022)

schools to online content and also provided teachers a platform to inform the community and the relevant authorities of occurrence of disasters such as flash floods[65].

Besides the cellular coverage for Internet access, there also exists service providers of Internet through the fibre and satellite connections such as Turkom[66] albeit information on their extent of coverage as well as uptake of their services based on the stipulated prices in Turkana[67] is not publicly available. Notably, prior to the pandemic, the Government's NOFBI network for fibre connectivity had not reached Turkana yet[68].

5.3. INTERNET ACCESS IN TURKANA DURING THE PANDEMIC

5.3.1. FOR THE LEARNING INSTITUTIONS

Similar to the challenges of Internet access experienced in Kakamega County at the height of the pandemic, Turkana also faced the same, only on a broader scale considering the state of infrastructure before the pandemic. For example, while Kakamega County could benefit from a fibre Point of Presence (PoP) before the pandemic in the major urban centres, Turkana did not have such a connection until the last quarter of 2020. The 144 core fibre optic cable (launched in October 2020 and commissioned in 2021)[69] running from Eldoret Town to Nakodok in Turkana County was meant to complement the existing submarine cable with a bigger vision of enhancing Internet access to 306 institutions which include 180 schools, 126 government institutions and 86 other public facilities[70].

With the installation of the fibre network happening during the pandemic, the ICT Authority noted that restrictions of movement had underscored the importance of strengthening the "new normal." Unfortunately the students of Turkana County could not enjoy online learning and had limited access to academic material like their counterparts in Nairobi at the height of the pandemic given the period of the launch and commissioning of the fibre network[71]. Therefore, the initiatives of the National Government through the Ministry of Education to increase academic access through radio and TV remained heavily relevant in Turkana at the height of the pandemic[72].

The provision of the government's cloud-based Ed-tech platform provided by the Kenya Institute of Curriculum Development (KICD) also significantly supported access to content. However, for the marginalised in the remote parts of Turkana, where electricity does not reach the households and connectivity is a challenge, these efforts proved futile[73]. Moreover, where electricity and technology do exist, the cost of Internet seemed prohibitive compounding to the challenge of low-income that cannot afford any Internet-capable device (e.g. smartphone) in a household[74].

[65] Connecting Kenyans: Impact of Improved Network Coverage in Turkana and Marsabit Counties.
[66] Turkom
[67] Turkom – Internet pricing
[68] Governor Nanok Launches Installation of Fibre Optic Cable
[69] ICT Authority Making the Digital Economy a Reality in Northern Kenya.
[70] State begins laying Internet cable to boost access in North Western region.
[71] Turkana's Young People are not waiting for the oil.
[72] Emergency Appeal Kenya.
[73] Magoha should give our children a break…and laptops.
[74] How school closures during COVID-19 further marginalised vulnerable children in Kenya.

5.1.1. FOR THE HEALTHCARE INSTITUTIONS

A study conducted under a project dubbed "Utawala Bora Kwa Mafuta Bora" on enabling good governance in Kenya's oil sector in May 2021, at the peak of the third wave of COVID-19, found that COVID-19 had a devastating impact on the oil host communities in Turkana South and East sub-counties[75]. Measures that included nationwide curfews, national and international travel bans, a ban on public gatherings and the closure of places of worship and educational institutions were already in place when the first case of COVID-19 was reported in Turkana on the 24th of May 2020 in Turkana West's Kakuma Refugee Camp. With such a scenario, managing the spread of the virus in a congested place of a refugee camp with nationwide restricted movement, made it a bit difficult to implement contact tracing. On the other hand, the response measures also led to increased unemployment, reduced business activity and increased lack of access to food within Turkana and other neighbouring counties – resulting to more health challenges caused by malnutrition[76] as such counties were already suffering from consecutive climate-related disasters including drought, floods and a locust invasion that began forming swarms in April 2020.

Turkana's vast arid and semi-arid land is also said to be a perennial limiting factor of accessibility to healthcare facilities[77]. Considering this alongside the climatic challenges and the COVID-19 containment measures, it is largely evident that the healthcare ecosystem did not sufficiently meet the needs of Turkana citizens during the extreme period of the pandemic (2020-2021). While Internet access helped to ensure continuity of supply of services or online ordering of medical supplies or food in places such as Nairobi or Mombasa, Turkana County, unfortunately could not match that due to poor connectivity in both healthcare facilities as well as public access. While variables of income levels and levels of knowledge are also cited as major contributor to Internet access, the general state of Internet coverage in Turkana, at the height of the pandemic, could still not meet the demand inspired by such variables and also support connectivity that could assist medical personnel to manage patient issues in real time[78].

5.4. REBUILDING DIGITAL INCLUSION FOR KAKAMEGA AND TURKANA COUNTY

5.4.1. OVERVIEW

This segment presents the potential digital opportunities identified within this study that can be leveraged to rebuild the digital inclusivity of both Kakamega and Turkana Counties. Although the two counties have varying discrepancies of demographics, geography, climate, infrastructure, culture, levels of education among other factors, their challenges in terms of rural Internet appear similarly close. Kakamega, on one hand is regarded as a "richer" county in terms of fertile lands for farming while Turkana harbours potential of oil mining on the other hand with livestock farming occupying a greater percentage of its economic activity. Moreover, the availability of adequate road infrastructure for Kakamega County makes it easy to traverse its area of 3,051.3 sq. km compared to Turkana's semi-arid and arid area of 71,597.8 sq. km which has poor

[75] Impact of COVID-19 in Turkana – Oil host communities and local businesses.
[76] Impact of COVID-19 on Food, Security and Livelihoods in Mandera, Turkana and Wajir Counties.
[77] Access to Education and Health among Minority and Indigenous Communities in Kenya: Assessment of Baringo, Trans-Nzoia, Elgeyo Marakwet and Turkana Counties.
[78] Interim Guidelines on Management of COVID-19 in Kenya.

road infrastructure. Further, the population density of Kakamega County (682 people per sq.) makes it easy for services to reach many people within a small area compared to Turkana's 14 persons per sq. km. Kakamega County's great NOFBI coverage experience puts it at an advantage point of a middle-mile network/backhaul within its area compared to the newly launched NOFBI coverage in Turkana at the height of the pandemic. However, there are reports of dark fibre in Turkana County that existed prior to the pandemic[79] - something that needs to be studied further and considered.

Rebuilding digital inclusivity for both Kakamega and Turkana undoubtedly depends on a number of variables beyond the focus of technology and policy although this study only focuses on technology and policy, particularly the technologies based on new policies that have already been enacted in Kenya to leapfrog spectrum sharing. While variables such as gaps in skills and ability, availability and cost of the network services and devices, electricity coverage, levels of income and government initiatives to address challenges of food, drought, flooding, insecurity, infrastructure, ICT centres etc form a significant part to holistically address digital inclusivity in the realm of the two verticals of healthcare and education, this study does not cover them.

As a background, despite the developments and evolutions of the cellular network technologies to the present fifth generation of mobile communication (5G) trials in Kenya[80], the CA, while noting a tremendously growing demand for wireless communications across the country, has also discovered that the allocated and assigned radio frequency (R.F.) spectrum is scarcely occupied in many locations in the country and most of the time[81]. This has prompted the quest for dynamic spectrum access (DSA) in Kenya under the slogan "Use it or Share it" that is gradually becoming a new default policy for spectrum management across the world[82].

Dynamic Spectrum Access (DSA) refers to the use of a portion of spectrum which is not being used at a given time and within a given geographic area, and may be available for use by a radiocommunication application, operating in accordance with the existing radio regulations. The radio systems implementing DSA also need to ensure the protection of the incumbent services sharing the same band or operating in the adjacent bands[83]. Kenya published its first DSA framework through TV White Spaces in May 2021[84] marking a major milestone to enhance Internet access for the rural areas of Kenya through spectrum innovation. During the same month (May 2021), the CA also published the Licensing and Shared Spectrum Framework for Community Networks to further address barriers facing communities in underserved areas and drive more efficient utilisation of the RF spectrum[85].

5.4.2. FOR BOTH LEARNING AND HEALTHCARE INSTITUTIONS

While *White Space*s refer to those *idle RF spectrums* that are unused in particular locations and particular times, TV White Spaces (TVWS) refer to the idle frequencies in the Very High Frequency (VHF) and Ultra-High Frequency (UHF) TV broadcast bands that are either unassigned or unused by existing TV broadcast licensees [6]. In Kenya, the band authorised for the use of TVWS is the 470-694 MHz UHF spectrum band. Exploitation of TVWS for provision of wireless Internet services in Kenya must comply with the existing regulatory framework and should guarantee protection of the licensed incumbents using the 470-694 MHz

[79] Turkana's Young People are not waiting for the oil.
[80] Kenya Launches Trials for 5G Technology.
[81] Summary of the Regulatory Framework for TV White Spaces in Kenya.
[82] Use it or Share it – A New Default Policy for Spectrum Management.
[83] ITU-R Report SM05-1
[84] DSA Framework for Authorisation of the Use of TV White Spaces
[85] Licensing and Shared Spectrum Framework for Community Networks

band (the incumbents in this band are the Digital Terrestrial Television services). TVWS has superior propagation characteristics due to its operation in both the VHF and UHF bands. This allows it longer communication distance and better penetration through obstacles, making it attractive for rural connectivity [7]. The experience of TVWS pilots in Kenya prior to the release of the regulatory framework showed that point-to-multipoint (PtMp) setup could cover 14 kilometres with the TVWS base stations operating at 2.5 watts EIRP. Multiple 90-degrees base stations were used to sufficiently serve 235 sq. kilometres of an area, delivering a network of 16 Mbps Internet speeds on a single 8 MHz channel. The TVWS technology supported various media streaming protocols such as video streaming, allowed access to emails (enjoyed by the Red Cross) as well as video conferences[86].

TVWS application would therefore fit well in the context of both learning and healthcare in both counties of Kakamega and Turkana considering the present levels of Internet penetration in both counties. With the current NOFBI coverage implemented in both counties, TVWS would benefit from it as a backhaul to extend connectivity to the last mile for both schools and healthcare centres. The deployment of TVWS in Turkana will also relatively drive the CAPEX cost down in connecting the County's learning and healthcare institutions compared to extending connectivity through the fibre connection, adopting satellite or even expanding cellular coverage. Primarily, TVWS also has its cons such as uncertain business cases that have struggled across the world as noted by ITU[87] and limited international momentum which has harmed the development of a strong equipment ecosystem as noted by GSMA[88]. However, the capability of the TVWS network infrastructure to be easily supported with off-grid power systems such as solar energy makes it a more viable solution in rebuilding digital inclusivity for both counties which currently face electricity challenges.

On the other hand, the framework for community networks has cemented the trajectory of Kenya towards inclusive broadband access driven by DSA. Traditionally, the CNs have utilised Wi-Fi technologies both for backhaul and for hotpots on license-exempt spectrum across the globe. However, with the challenges of congestion and signal interference on the 2.4 GHz and 5 GHz band, the quality of connectivity is always affected. CA, therefore proposes a different set of methodologies to spur growth of community networks in Kenya to expand Internet access to unserved and underserved communities. Some of these methodologies, which we consider relevant to rebuilding digital inclusivity for both Turkana and Kakamega are highlighted below. Presently, both counties do not have any Community Network[89] that would push for public access through Intranet services that meet the local needs of both counties, distribute locally relevant content and increase digital literacy to maximise the opportunities from the services to benefit both learning and healthcare institutes.

1. Elimination of regulatory barriers to enhance set up of small-scale and not-for-profit Community Networks that can enable Internet access to the marginalised communities and educational institutions.
2. Integration of a new license category for Community Networks within the Unified Licensing Framework.
3. Reviewing the current guidelines on the use of Radiofrequency spectrum by Short Range Devices (SRDs) to amend EIRP limits for 2.4 and 5 GHz Wi-Fi for Point-to-Point(PtP) and Point-to-Multipoint (PtMP).
4. Reviewing the options for lowering barriers to access and usage of other license-exempt bands for PtP and PPtMP use in bands such as the 24 GHz and 60 GHz.

[86] Rural Broadband Trials – Laikipia County Kenya
[87] The Last-mile Internet Connectivity Solutions Guide
[88] Spectrum Sharing – GSMA Public Policy Position
[89] Kenya School of Community Networks

5. Expansion of the range of frequencies available for license-exempt use, particularly for 5-6 GHz band as well as other licensed IMT spectrum.
6. Creation of awareness on how to build self-provisioned communication infrastructure that can enable community access to the Internet.

6. CONCLUSIONS

The reality of the Digital gap[90] was immensely felt across the country at the height of the COVID-19 pandemic. COVID-19 can hence be described to have completely reshaped the rural view of Internet access in Kenya with both schools and healthcare centres changing their perception on the relevance of the Internet. As the efforts to rebuild rural counties such as Kakamega and Turkana pick up momentum, all the stakeholders need to consider Internet access as a great torque to drive the "new normal's" economic development. An assessment of the state of connectivity in both Turkana and Kakamega pre-pandemic and during the pandemic, however, is hard to actually quantify due to lack of available data or official publication on the available access technologies supporting Internet access, the precise area that is currently covered by the Internet and the details of how Internet services are actually delivered in both counties. Most often, the available data generically paints a picture of lack of coverage in many areas, particularly to the institutions or a "super coverage" by the cellular network based on the records from CA. The approach of estimated household survey, just as globally adopted often times on Internet access also need to be reconsidered to obtain precise information on connectivity, especially with the disruption the coronavirus pandemic has caused to the normal patterns and trends in ICT statistics. For example, the approach of working or learning without physical contact with other people will require a new consideration when assessing the state of Internet access. Anyway, there is definitely a need for precise mapping to fully understand the connectivity situation on the ground for both Kakamega and Turkana. This lack of mapping elucidates a scenario of dark fibre that seems unexplainable at the moment. Nevertheless, to fully address connectivity, it is also equally important to address the state of electricity connection that presently seems to adversely affect the residents of the rural areas far from the main roads, particularly in Turkana. Therefore, the recommendation by the government to provide alternative off-grid power sources such as solar will enable both Kakamega and Turkana to rebuild rapidly from the pandemic. Further, it would also enable DSA networks such as TVWS to be easily deployed in such areas of need to allow transformation of the regulations to real practice. Moreover, a unique support for Community Networks also needs to be studied for providing Internet services to institutions in these two counties especially with the regulations in place.

7. RECOMMENDATIONS

Although the Emergency Response Plan from the government highlights the need to build resilience of broadcasting education content as an e-learning platform, it also implements a gap for a lack of a platform that students can easily refer to after the lesson periods are done due to the challenge of real-time access to the Internet. We therefore broadly recommend the following based on this study:

1. The government should expand access to electricity across the country to reduce the inequality that exists between the urban and rural areas. This would even allow equal access to educational content if it is to be broadcasted over radio or television in future. Further, this would also enable ease of deploying Internet to the last mile by the service providers.
2. As an alternative to grid power, more initiatives on off-grid power through solar power need to be supported and funded to allow last mile deployments that can support last mile connectivity efforts.
3. Initiatives to increase access to the Internet in marginalised areas such as through TVWS should be classed in the same category as Community Networks and be sufficiently subsidised or incentivised to enable entrepreneurs or service providers deliver on the public good of enabling hard-to-reach areas to be brought online.
4. An assessment needs to be conducted on the dark fibre in the country to determine the extent of fibre-connected PoPs that can be leveraged, from a more informed perspective, to extend Internet access to both Kakamega and Turkana Counties.
5. Provision of online platforms such as the one spearhead by KICD should be integrated within the framework of Community Networks (CNs) to enable expansion and equal access of academic material by all the primary and secondary schools across the country.
6. Mapping of the connectivity for schools and healthcare centres in the country needs to be conducted to enable efficiency and effectiveness in responding to the connectivity challenges facing both educational and healthcare sectors in Kakamega and County. It would also help to strengthen the available options of connectivity for both counties.
7. More technology studies inclusive of software-defined radios, cognitive radios, opportunistic spectrum access, geolocation databases, automated frequency coordination as well as coexistence studies need to be conducted to validate the implemented policies on Dynamic Spectrum Access (DSA) to properly inform the future enactment of policies that can sustainably and contextual fit the connectivity needs in Turkana, Kakamega and the other forty five counties of Kenya.

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