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International Telecommunication Union
Development Sector

Broadband connectivity for schools in Kenya funded by the Universal Service Fund

Assessment report

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In Partnership with:

Acknowledgements

The International Telecommunication Union (ITU) would like to thank the collaborative efforts of all members of the Communications Authority of Kenya, the heads of the schools that took part in this study, Internet service operators, the invaluable insights of students and teachers and the support of the United Kingdom Foreign, Commonwealth and Development Office (FCDO). This assessment report would not have been possible without their invaluable collaboration.

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Table of contents

List of figures and tables

Figures

Tables

Foreword

I am delighted to share the assessment report on broadband connectivity for schools in Kenya funded by the universal service fund.

In an effort to support innovation and stimulate positive change, ITU has been working with the United Kingdom Foreign, Commonwealth and Development Office Digital Access Programme in Brazil, Kenya, Indonesia, Nigeria and South Africa. The joint project is working towards understanding how universal connectivity could be achieved, in particular school connectivity, and how to improve digital skills. Efforts have focused on supporting governments with regulatory analysis, capacity development, tools and frameworks to successfully explore innovative models relating to sustainable financing and technology developments.

The Communications Authority of Kenya is working hard to connect 886 public secondary schools across 47 counties. This assessment explores the overall effectiveness of the project. It compiles the lessons learnt and benefits that have been realised through connecting the schools, revealing the strategic importance of broadband connectivity as a critical enabler for teaching and learning. This work has also revealed, however, the many challenges that such projects face, from the appropriateness of technology used, unreliable power supplies, ICT skills gaps among teachers and students, and access to sources of funding.

I recommend this assessment report to national regulators and decision-makers as they work to implement the policies, regulations, technologies, and financing required to ensure that school broadband connectivity is truly universal, safe, sustainable, and equitable to all.

Dr. Cosmas Luckyson Zavazava
Director, Telecommunication Development Bureau (BDT)
International Telecommunication Union (ITU)

Foreword

Over time, universal access to basic goods and services has dominated discussions around socioeconomic growth in Kenya. Within the ICT sector, the goal of widespread availability, affordability and accessibility of ICT services to all citizens has become the hallmark and driver of socio-economic development.

The Authority drives this agenda through regulatory interventions and incentives under the Universal Service Fund (USF), established in 2009. In 2016, the Authority carried out an ICT Access Gaps study to identify the level of access to communication services in the country. Arising from this assessment, various interventions were proposed to bridge the digital divide in Kenya. The study recommended two USF priority interventions namely: Voice Infrastructure and Services – to close access gaps in voice services and Education Broadband Connectivity – to establish first step towards addressing the critical connectivity gaps in the education sector.

The Phase One (1) of the Education Connectivity project targeted a total of 886 e-ready secondary schools. The project scope included connectivity infrastructure deployment and provision of bandwidth. The Authority thereafter partnered with the United Kingdom's Foreign Commonwealth Development Office (FCDO) and the International Telecommunication Union (ITU), to undertake an end-of-term review of the project. The review was aimed at assessing both the project impact and the level of achievement of intended objectives.

The outcomes of this assessment are critical in informing planned and future connectivity projects.

I sincerely thank our partners FCDO and ITU for the incredible support offered in undertaking this end of project assessment. Our special thanks also go to the Ministry of Information, Communications and the Digital Economy, our esteemed licensees and other critical stakeholders who extended their support in diverse ways in during the project implementation or this project assessment exercise.

The Authority is committed to effective regulation of the sector and supporting Kenya government's digital transformation agenda, to ensure that No One is Left Behind.

Ezra Chiloba
Director General/Communications Authority of Kenya

List of abbreviations

CCTV	Closed circuit television
FCDO	United Kingdom Foreign, Commonwealth & Development Office
CDF	Constituency Development Fund
ESG	Economic/environmental, social and governance
ICT	Information and communication technologies
ITLET	Information technology learning education and training
ITU	International Telecommunication Union
ISOC	Internet Society
ISP	Internet service provider
KEBS	Kenya Bureau of Standards
KICD	Kenya Institute for Curriculum Development
NGO	Non-governmental organization
OECD	Organisation for Economic Co-operation and Development
STEM	Science, technology, engineering and mathematics
SMART	Specific, measurable, accurate, reliable and timely
UNICEF	United Nations Children's Fund
UNESCO	United Nations Educational, Scientific and Cultural Organization
USF	Universal service fund
VSAT	Very small aperture terminal
WISP	Wireless Internet service provider
WiMAX	Worldwide interoperability for microwave access

1 Purpose and scope of the report

1.1 Aim of the school connectivity project

The Kenya Information Communications Act, 1998, as amended in 2009, established the Universal Service Fund (USF) to complement private sector initiatives to meet universal access objectives. The USF is primarily financed by mandatory contributions from licensed operators providing communication systems and services on a commercial basis. It is managed and administered by the Communications Authority of Kenya.

USF implementation is guided by the Kenya Information and Communications (Universal Access and Services) Regulations, 2010. Its objectives are *inter alia* to promote communication infrastructure development and service roll-out in unserved and underserved communities; to ensure that communication services are available to persons with disabilities, women and other vulnerable groups; to support the development of capacity building in ICTs and technological innovation; to support the expansion of communication services to schools, health facilities and other organizations meeting public needs; and to facilitate the development of and access to a wide range of local and relevant digital content.

In 2016, the Communications Authority commissioned an ICT access gaps study to identify the level of penetration of communication services in Kenya, with a view to defining mechanisms and strategies for bridging the digital divide. The study recommended that priority be given to two USF projects, namely the voice infrastructure project and the broadband connectivity project for schools.

Under the 2017–2022 USF Strategy Implementation Plan, the USF programme had five main sub-programmes: the mobile telephone network expansion programme; community broadband initiatives; ICT content and applications; ICT capacity building and awareness; and special USF projects.

The broadband connectivity project for schools was funded through the USF under the tutelage of the Communications Authority of Kenya. It was deemed a key enabler and essential for closing the digital access gap. Schools were identified as important community institutions in which broadband connectivity should be expanded, alongside health facilities, government offices, post offices, libraries and other community facilities. The project covered all 47 counties, but regional coverage was uneven. Affirmative action was applied in some counties when selecting schools, especially in Mandera, Turkana, Wajir, Garissa, Kwale, Isiolo, Samburu and Tana River counties, to ensure that every county had a beneficiary school in the project (Communications Authority, 2022). Service providers were contracted to supply, install, test, commission and maintain connectivity in 886 public secondary schools across the country.

1.2 Implementation methodology

The school connectivity project started by identifying schools that were e-ready. The prerequisites for e-readiness included the following: connection to the national power grid or an alternative source of power; availability of a secure computer lab with at least 10 modern working computers; ICT-trained teachers; a syllabus that included computer studies as an examinable subject at the Kenya Certificate of Secondary Education level. A total of 886 public secondary schools were selected and three Tier 2 operators (Commcarrier, Liquid Telecom and Xtranet)

were awarded contracts to supply, install, test, commission and maintain Internet connectivity there, at a cost of KES 821 million. The contracts were signed in April 2017 for a period of four years. The client was expected to inspect and test the installations, and to operate them to acceptable standards of on-site access, quality of service and data speed at various times of the day. The contract stipulated minimum requirements and specifications for school site and configuration, connection bandwidth and user requirements, technical support services and ISP network performance monitoring. Commcarrier was awarded Garissa, Mandera, Nairobi, South (Muranga, Kajiado), South East (Wajir, Isiolo, Kitui, Tharaka, Makueni, Taita Taveta) and Coast. Liquid Telecom was awarded Turkana, West, West Pokot, Western Border, Narok and South West (which includes Kakamega, Trans Nzoia, Uasin Gishu, Elgeyo Marakwet, Nandi, Bungoma and Busia). Xtranet was awarded Samburu (North and Central), Laikipia, Nyandarua, Nakuru, Kiambu, Marsabit, Meru, Embu, Nyeri, Kirinyaga, Baringo and West, Kericho, Kisumu, Vihiga and Bomet.

1.3 ITU – FCDO partnership

ITU works with the United Kingdom FCDO to promote effective regulation, greater investment and innovative models for school connectivity in underserved communities, and broader digital inclusion. In support of activities to promote regulatory analysis, frameworks and tool development for digital inclusion objectives, and at the request of the Communications Authority, ITU seeks to assess USF-funded connectivity projects in Kenya with a focus on schools. It also supports the activities in Kenya of Giga, a global ITU/UNICEF initiative to connect every school to the Internet and every young person to information, opportunity and choice (giga.global).

This assessment was conducted using the ITU Universal Service Financing Efficiency Toolkit and related assessment frameworks and checklists providing strategic and practical guidance on universal service financing frameworks, USF strategy development and assessment, management and fund utilization/disbursement. It was undertaken four years after the USF-funded schools were connected, to assess the effectiveness of their connectivity. It identifies critical areas for incorporation into the USF Strategy 2023–2027, including specific areas in which other agencies have to invest to make the connectivity projects more sustainable and more responsive to end-user needs overall.

1.4 Timeframe of the assessment

The assessment was carried out from 11 November 2021 to 13 January 2022. The data were collected between 13 and 21 December 2021 and as of 4 January 2022, when schools reopened. The assessment covered instrument design (18 November 2021 - 7 December 2021), instrument testing (8 - 12 December 2021) and data analysis (7 - 12 January 2022). It comprised a mix of surveys and focus group discussions. The focus group discussions were conducted during the week of 4 January 2022, after 108 survey responses had been analysed and provided an indication of the specific questions on which the discussions should focus.

1.5 Purpose of the assessment

The purpose of the assessment was to gauge the effectiveness of broadband connectivity in the school connectivity pilot project implemented in 886 schools in Kenya's 47 counties, the aim of which was to address the gap in access to broadband connectivity in schools and to use the lessons learned as a result to broaden the scope and benefits that had accrued from the project.

While the assessment report is presented as a separate document, it should be considered in the overall context of mobile telephone network expansion, community broadband networks, ICT content and applications, capacity building and awareness. Some of the conclusions and recommendations are drawn from existing USF projects and processes.

The main question asked by the assessment concerned the overall effectiveness of the school connectivity pilot project. The following specific research questions were developed from the USF sustainability framework:

1. What was the environmental effectiveness of the school connectivity pilot project?
2. What was the social effectiveness of the school connectivity pilot project?
3. What governance issues were addressed by the school connectivity pilot project?
4. What was the economic effectiveness of the school connectivity pilot project?

It was assumed that USF funds at the macro level, the procurement and tendering process, and broadband deployment were assessed separately. The outcomes and recommendations therefore focus on school connectivity, although some aspects may broaden and strengthen the other reports on broadband deployment.

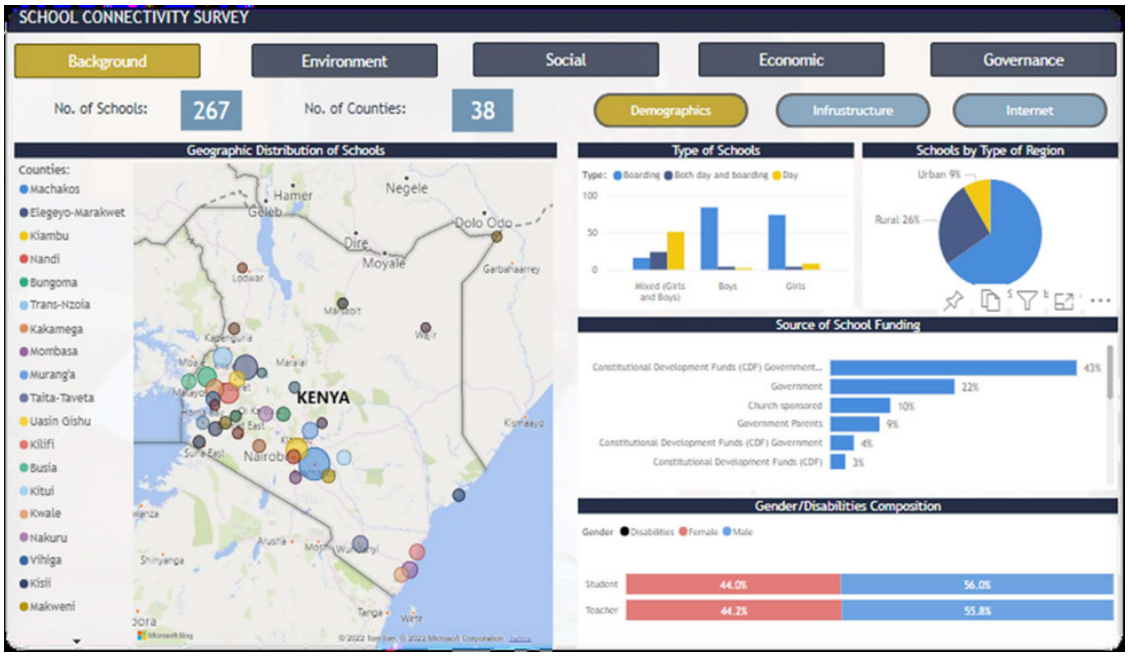
1.6 Intended outcomes of the assessment

The intended outcomes of the assessment were to improve universal service frameworks, processes, funding mechanisms, fund utilization and performance through project design, implementation, monitoring and evaluation; to review project design and selection criteria; and to measure the effectiveness of USF frameworks. To measure the effectiveness of USF frameworks, specific indicators and measures in terms of environmental, social, governance and economic aspects were provided. Other intended outcomes were to identify the actual use and performance of connectivity in schools, including the context and potential hurdles; and to provide strategic guidance on specific aspects relating to future assessments of connectivity projects, including suggestions for sustainable, affordable and accessible school connectivity.

1.7 Lessons learned from the assessment

In all, 267 schools completed the survey (see Figure 1) and focus group discussions were held in 10 schools, including one school specializing in special needs education. The sample size was 30.14 per cent. Boys' schools were surveyed in almost the same proportion as girls' schools (34 and 32 per cent, respectively); the rest were mixed schools (33 per cent). The schools were located mainly in peri-urban areas. Connectivity was provided in all 47 counties, although schools from only 38 counties responded to the survey. In many schools, operations were funded through the CDF (43 per cent) or by the government (22 per cent). More male than female students and teachers responded, a result linked to the type of school that responded. The schools were evenly represented in terms of type and nature, an indication that the selection criteria were balanced in terms of geography and gender.

Figure 1: Overview of school connectivity survey results



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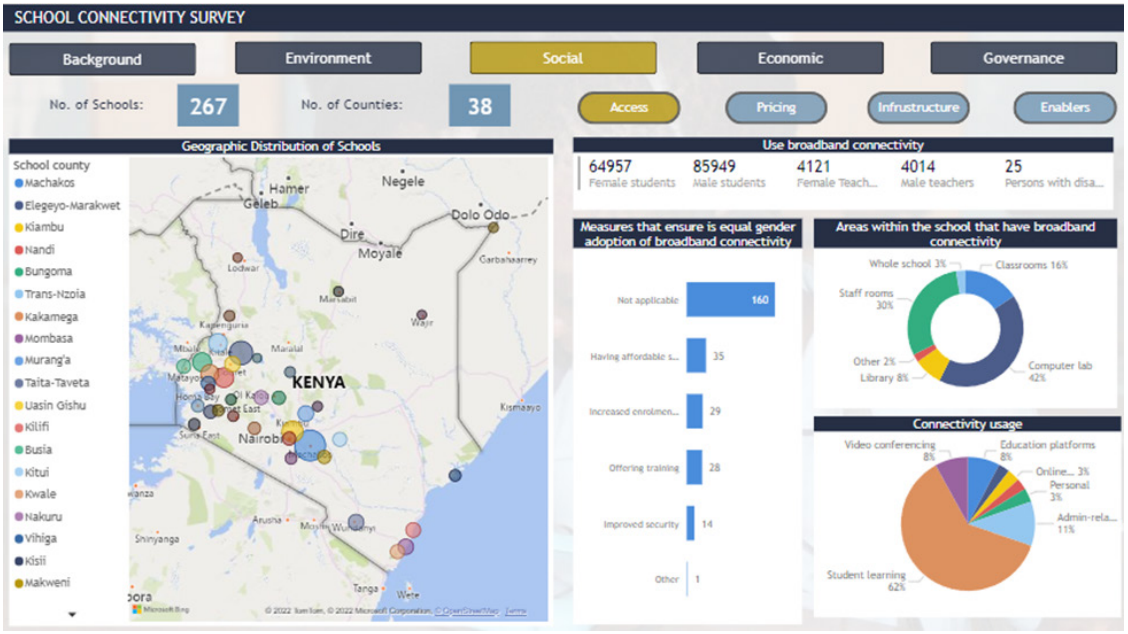
The sample also included more boarding schools, which implied that students in these schools relied mostly on Internet connectivity provided at school. According to the current ratios, more male teachers and students had access to Internet connectivity than female teachers and students, although the differences are marginal (Figure 2). Teachers could access the Internet more easily than students.

Very few of the respondents were special needs schools, implying that special attention should be paid to this type of school, to encourage greater social inclusion.

Schools must have a clear monthly budget allocation for Internet connectivity. Moreover, school budgets should include a line for the purchase of devices and Internet connectivity, so that the schools can be self-financing in the long run.

Connectivity was used mainly for teaching, learning, communicating with other schools and, in a few cases, CCTV monitoring. The social enablers for school connectivity were an established ICT policy and training in ICT use and planning. Digital literacy among teachers was low. Additional digital literacy training for teachers is needed and should include twenty-first-century skills, e-waste disposal and safe Internet use. The connectivity provided was in some cases of poor quality or inoperable, implying that the school site configuration and technical services may not have been fully implemented. Furthermore, it is important for connectivity providers to report regularly to schools on bandwidth usage, content filtered and download speeds. Although connectivity was required in administration blocks, staff rooms, computer labs and the school library, it existed mainly in computer labs. In some cases, teachers relied on their own personal Internet connection.

Figure 2: Students and teachers connected to the Internet



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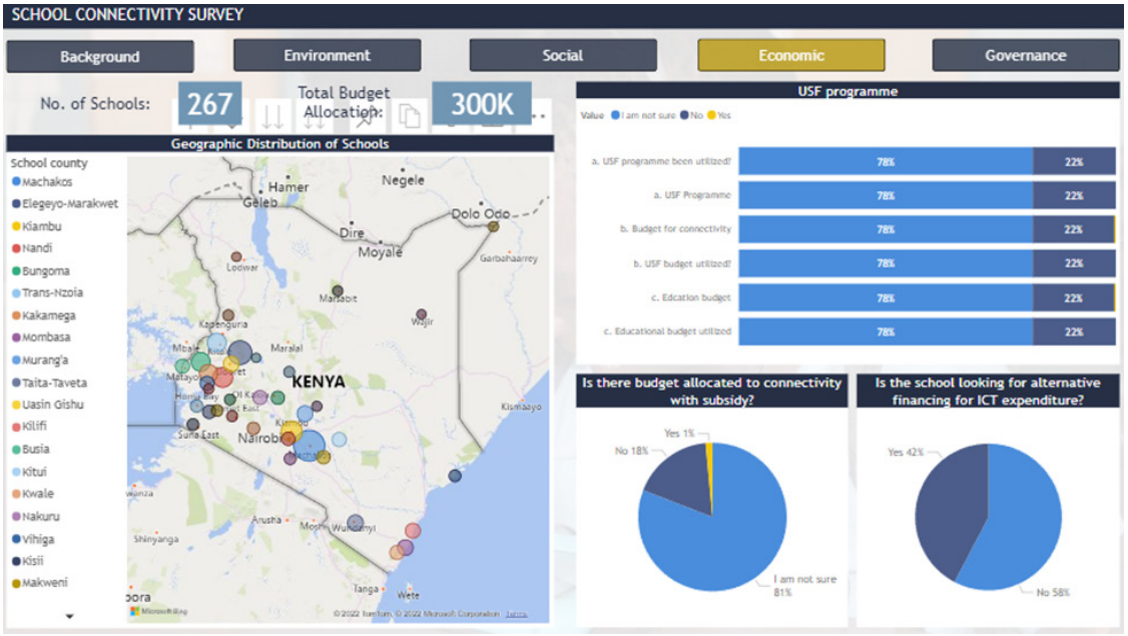
In relation to economic effectiveness, many schools were not aware what the USF was, implying low awareness-raising during project roll-out (Figure 3). Many schools had no clear understanding of what their role was in ensuring the future sustainability of the Internet connection provided. Since some schools relied on communication carriers other than the USF carriers, the implication was that, in some situations, more effective communication carriers existed in locations with signal strength and connectivity challenges.

Figure 3: Awareness of the USF programme and school budget allocation for connectivity



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The tendering process was open, but follow-up was needed to ensure that all suppliers had met the conditions of the contract. As part of the contract, the ISPs trained at least five teachers in basic Internet connectivity management, including troubleshooting. In cases where the Internet connection provided did not work, schools spent a monthly average of KES 15 000 (about USD 142) on a 1-5 Mbit/s Internet connection and KES 500 000 (about USD 4 760) on other related ICT expenses. More computers were needed in laboratories, to ensure efficient use of Internet connectivity. A computer: student ratio of 1:10 was a minimum, with the eventual target being 1:5. Public–private partnership agreements were also needed, for additional financing for the Internet and the purchase of computing devices.

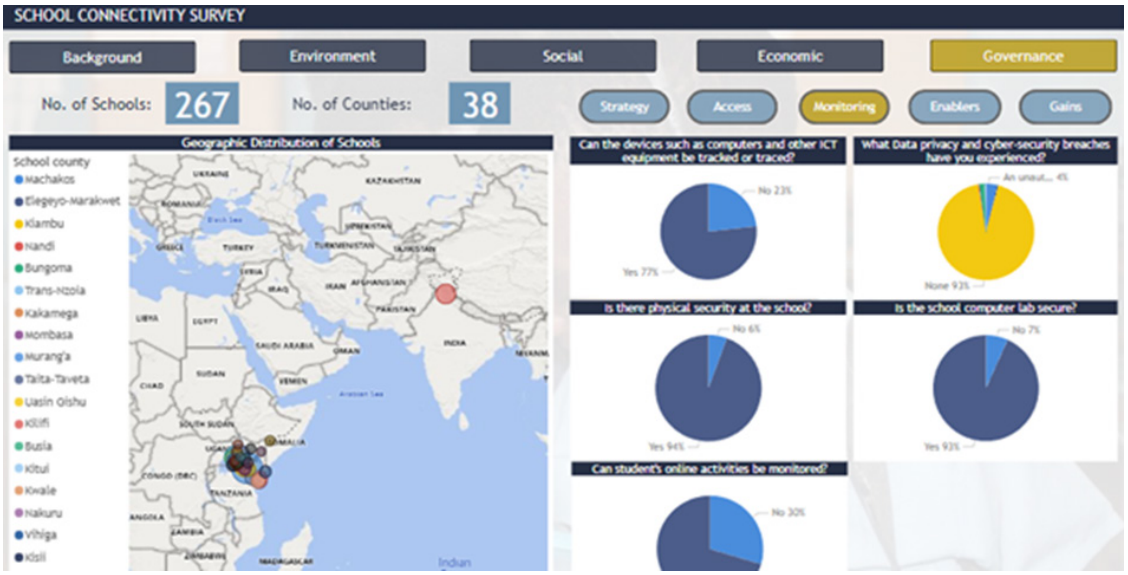
Governance effectiveness aspects within the school included the strategic importance of connectivity; the ICT agent responsible in the school for connectivity; security and privacy issues; ICT training; ICT support; the availability of online platforms for teachers and learners; and the soft skills learned thanks to the connectivity. Several schools agreed that Internet connectivity was a critical enabler of teaching and learning. Several schools had an ICT policy, although it needed updating in terms of e-waste management, cybersecurity, ICT training, information management and privacy.

In more than half the schools surveyed, the school technician was responsible for Internet connectivity. Since school technicians are less likely to be transferred than computer studies teachers and principals, training and support services should focus on them. Although schools had physical control measures limiting access to computer labs, there was no clear way to monitor cybersecurity threats (Figure 4), and many were not aware of data protection principles, despite the early training provided under the project in connectivity management; training in diagnostic tool login and continuous network service monitoring therefore needs to be undertaken regularly under the project. More training is needed on information management, tracking of student progress, cybersecurity and values-based education in the use of ICTs. The technical service training indicated in the service contract should be improved and upscaled to include more teachers.

The National Education Management Information System was used by some schools. Many schools lacked learning management and academic management systems, including a clear system for tracking the stability of the Internet connection, an indication of insufficient training or the effects of regular transfers of teachers. Some schools did not have access to the diagnostic tool for sharing experiences, reflecting the need for an online community of education practitioners that would also encourage the sharing of local digital content. Tertiary institutions in Kenya can help track and assess learner progress. Some schools provided instruction in soft skills such as communication between teachers, students and schools, critical thinking and cooperation. Most e-waste was kept in school stores and there was no clear system for tracking the amount of plastic e-waste or for recycling and reusing e-waste. Teachers and students had no knowledge of e-waste management and systems, implying a need for further training and awareness raising.

All in all, the school connectivity pilot project was worthwhile, although the design of Internet service provision, implementation in terms of service and follow-up could be greatly improved.

Figure 4: Survey results on monitoring and security



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Section 1 – summary	
1	The purpose of the assessment was to gauge the effectiveness of the school connectivity pilot project implemented in 886 schools in Kenya's 47 counties.
2	The aim of the project was to address the gap in access to broadband connectivity in schools and use the lessons learned as a result to broaden the scope and benefits that had accrued from the project.
3	Three service providers (Commcarrier, Liquid Telecom and Xtranet) were contracted to connect the schools.
4	The assessment was conducted using the ITU Universal Service Financing Efficiency Toolkit and related assessment frameworks and checklists providing strategic and practical guidance on universal service financing frameworks.
5	The assessment was carried out from 11 November 2021 to 13 January 2022.
6	The specific research questions were: 1. What was the environmental effectiveness of the project? 2. What was the social effectiveness of the project? 3. What governance issues were addressed by the project? 4. What was the economic effectiveness of the project?
7	The intended outcomes were to improve the universal service frameworks, processes, funding mechanisms, fund utilization and performance through project design, implementation, monitoring and evaluation; to review project design and selection criteria; and to measure the effectiveness of USF frameworks.
8	The project was worthwhile overall, although the design of Internet service provision, implementation of terms of service and follow-up could be greatly improved.

2 Background

2.1 School connectivity project: the backstory

In 2017, after having analysed the Odhiambo report (MoE, 2012), the government decided to institute a phased curriculum changeover. The recommendation was to move from 8-4-4 to 2-6-3-3, i.e. two years of pre-primary education, six years of primary education, three years of lower secondary education, three years of upper secondary education and three to five years of tertiary education. Implementation started in 2017, with a pilot project for pre-primary levels 1 and 2, and Grades 1 and 2, in 470 schools across the country. The pilot project was rolled out nationwide in January 2018.

Under the new curriculum, the focus shifts from content to competency. The new curriculum's guiding principles provide opportunities by identifying needs, talents and potential; excellence in areas of great interest and ability; diversity and inclusion within learning; differentiated curriculum learning; parental empowerment and engagement; and community service learning. ICT plays a central role in the achievement of differentiated and learner-centred techniques. The new curriculum places a premium on digital literacy at all levels, hence the need to provide the infrastructure, structure, policies, hardware and software required to integrate ICTs into teaching and learning. Various players – governments, NGOs, civic organizations, communities, families, educational institutions, international partners – are collaborating to enhance and ensure digital literacy that is inclusive, equitable and aligned with educational outcomes. The initiative to connect schools is one of the approaches adopted by the government together with various stakeholders.

Kenya has made great strides forward when it comes to connecting schools and tertiary institutions. These include Digischools; the Giga initiative; investments in the national backbone, with 5 500 km of fibre laid in all 47 counties; the deployment of 3G and 4G base stations; the deployment of Nokia FastMile 4G fixed wireless access broadband (a partnership between Safaricom, Nokia and UNICEF); the SchoolNet programme; and a digital learning curriculum spearheaded by the Kenya Institute for Curriculum Development.

Digischools is a government initiative to make sure that every pupil is prepared for the digital world. It targets nearly 24 000 primary schools and provides digital devices, capacity development for teachers and implementers, broadband connectivity devices and content for digital learning.

To date 379 schools in Kenya have been connected through the support of Giga. Reflecting national requirements, its priority is to connect schools to the broadband network of at least 10 Mbit/s by 2030.

The SchoolNet programme will enable 43 000 public and private schools to be connected to Internet services, via *inter alia* the national fibre-optic backbone and wireless radio links.

The Kenya Institute for Curriculum Development, for its part, has set standards for competence-based digital materials. The standards are intended for the development, curation and approval of competence-based digital course materials and enable local content providers to submit content for approval. The Institute has produced standards on e-learning and learning management system platforms, on mobile applications and on open educational resources. The Kenya Education Management Institute conducts refresher courses for teachers

on competence-based and digital technologies in collaboration with the Teachers Service Commission. The Teachers Performance Appraisal and Development programme ensures that schoolteachers are becoming more literate in the use of digital technologies.

Kenya's National Broadband Strategy 2018–2023 comprises additional elements that were not extensively covered in the National Broadband Strategy 2013–2017: cybersecurity, privacy and data protection, the Internet of Things, big data analytics and distributed ledgers. The aim is to make Kenya a globally competitive knowledge-based society enabled by affordable, secure and fast broadband connectivity by means of ten key interventions:

- access to a national fibre-optic broadband infrastructure, broadband being treated as critical infrastructure;
- harmonized infrastructure development, to reduce duplication and encourage infrastructure sharing;
- engagement of both national and county governments to heighten awareness;
- promotion of universal access to digital content and services;
- capacity building to increase digital literacy among citizens;
- adoption of technical standards to facilitate the development of regional and national Internet backbones;
- provision of an enabling environment;
- promotion the local manufacture, maintenance and recycling of devices;
- consumer protection and security when accessing broadband services;
- draft policies on the broadband ecosystem, including spectrum and private sector investment in the form, for example, of joint ventures and public–private partnerships within the ICT sector (Ministry of ICT, 2018).

The government is currently implementing a USF project in response to a 2016 report by a Canadian firm on the access gap. The report indicated that 164 out of 7 149 sub-locations remained totally uncovered, while in a further 418 sub-locations less than 50 per cent of the population was covered. Most unserved areas were in the north and east of the country, and in the south-west border counties of Kajiado and Narok. The access gap for 3G connectivity was 22 per cent of the population. Many thousands of potential broadband users – primary and secondary schools, health centres, government offices – were not yet connected. Schools were thus identified as potential points to activate through the USF broadband outreach programme, as they could greatly benefit from connectivity in the short term.

A holistic, multifaceted and nationwide approach to Internet connectivity was conceived for the nation's schools. It encompassed the identification or creation of Internet ("e-ready") schools and institutions in each county, with a special focus on secondary schools that were already teaching computer studies as an examinable Kenya Certificate of Secondary Education course; the provision of ICT training to teachers in participating institutions, to ensure that they were prepared to make use of Internet connectivity; the provision of broadband connection support to the "Education Cloud" portal (the learning management system established by the Kenya Institute of Curriculum Development), to facilitate ready access to digital content and other approved local or international education content/resources; and technical support to ensure that the schools concerned faced no obstacles to benefiting fully from broadband connectivity.

2.2 School connectivity project: methodology

The school connectivity project spanned an initial period of four years, from 2017 to 2021. However, owing to the challenges in implementing the installation milestones, the contractual installation period was extended for a period of between 2.5 and 3.5 years for the different service providers. The beneficiary schools were identified by the Ministry of Education, Science and Technology. All last-mile Internet connectivity was expected to be tendered competitively on a bidding-lot basis, to reduce unit costs from the initial estimates and allow several operators to win contracts for the supply and operation of services. The project identified three main operators: Liquid Telecom, Xtranet and Commcarrier. An initial plan to provide technical or financial assistance to several schools in the neediest counties became four-year subsidies allocated according to county and region. To be deemed e-ready, schools had to have a secure computer lab with at least 10 modern PCs; employ trained ICT teachers; participate actively in the Kenya Certificate of Secondary Education computer studies curriculum; and be connected to the national power grid or an alternative source of power.

The final contract stipulated specific aspects in relation to school site configuration, technical services and monitoring. Technical services included one half-day training session for the school's designated computer teacher and up to five other named ICT resource and subject staff, help-line support and a response time of two days. The ISPs were to provide Simple Network Management Protocol capability to poll the school router on a national basis and Multiprotocol Label Switching to enable monitoring of each school's network. The school site configuration had to comprise a minimum of two interconnected Wi-Fi sites to ensure onsite connectivity, a 5 Mbit/s download link and minimum 1 Mbit/s uplink expandable to 20 Mbit/s with no additional capital expenditure. Initially, 996 schools were identified, but some were not e-ready and the number of schools connected was ultimately 886.

2.3 Purpose of the assessment, intended outcomes and contribution to USF strategy development

The underlying concept of universal service is to ensure that ICT services are available (same level of service for all users at all times and without geographical discrimination), accessible (all subscribers treated in a non-discriminatory manner with respect to price, service and quality) and affordable (price should not limit service access) for the widest number of people (ITU, Universal Service Fund and Digial Inclusion for All, 2013).

To ensure that all Kenyans have access to ICT services, the Communications Authority of Kenya implemented several USF initiatives and enforced universal service obligations embedded in the licence conditions for service providers:

> The USF initiatives targeted the ICT access gaps identified in the Universal Service Implementation strategy for fiscal 2017/2018 to fiscal 2022/2023. The initiatives were education broadband and voice infrastructure projects. The Education Broadband Project involves provision of Internet connectivity to public secondary schools in the country while the Voice Infrastructure Project targets to provide mobile telecommunication services in 348 sub-locations, which are un-served and underserved (Communications Authority, 2019).

This assessment report focuses on the Education Broadband Project, which aligns with the fourth objective of the USF, namely to support expansion of communication services to schools, health facilities and other organizations serving public needs (Authority, 2018). The project commenced in 2017/2018. The 2016 ICT access gaps study aimed to assess the extent of communication coverage countrywide and engage with stakeholders to identify gaps in service provision. It was intended to support implementation of initial USF network expansion projects by grouping gap areas and special projects like school connectivity, provide a long-term strategy and update the USF operating manual. School connectivity was chosen because it would have the biggest potential impact on Kenya's economy and could serve as a platform for the country's digital aspirations.

The ICT access gaps study revealed that very few public schools were connected, but that a suitable environment existed for USF investment in the gradual connection of schools in that, for instance, 90 per cent of schools had electricity and computers studies was offered as an examinable subject at Form 4 (Dymond & Oestmann, 2015). Several critical stakeholders (e.g. the Kenya Education Network, the Ministry of ICT, the ICT Authority and the Ministry of Education, Science and Technology) were identified as having programmes that supported school connectivity.

One of the targets identified in the Communication Authority's Strategic Plan (projected to end in 2023) was to provide 896 schools in underserved and unserved areas with broadband connectivity. The output was therefore to connect these schools to broadband and the outcome was increased broadband access in secondary schools, in line with the first strategic initiative of universal access programmes (1.1.1).

This assessment therefore investigates the effectiveness of the school connectivity programme initiated in 2017. The objective is to provide SMART indicators, lessons and a way forward for the next strategic plan (2023–2028) in relation to the school connectivity programme, so that the process, when upscaled to several underserved schools, is as effective and efficient as possible. This report is therefore an outcome of the school connectivity assessment.

Section 2 – summary	
1	The USF project was a response to an ICT access gaps study conducted in 2016.
2	The study report indicated that 100 per cent of the population in 164 out of 7 149 sub-locations was without coverage and that less than 50 per cent in a further 418 sub-locations had coverage.
3	Most unserved areas were in the north and east of the country, and in the south-west border counties of Kajiado and Narok.
4	Schools were identified as potential points to activate through the USF broadband outreach programme.

(continued)

Section 2 – summary	
5	The objectives of the school connectivity project were to: a) promote communication infrastructure and service roll-out in unserved and underserved areas; b) ensure that communication services were available to persons with disabilities, women and other vulnerable groups; c) support the development of capacity building in ICTs and technological innovation; d) support the expansion of communication services to schools, health facilities and other organizations serving public needs; e) facilitate the development of and access to a wide range of local and relevant content.
6	The school connectivity project spanned an initial period of four years (2017–2021).
7	In 2021, the installation period for the existing service contracts was further extended for a period of between 2.5 to 3.5 years.
8	The project identified three main operators: Liquid Telecom, Xtranet and Commcarrier.
9	The plan was to include technical or financial assistance for several schools in the neediest counties.
10	The Education Broadband Project involved providing connectivity to public secondary schools in the country.
11	The report provides SMART indicators, lessons learned and a way forward for the next Communications Authority strategic plan (2023–2028) in relation to the school connectivity programme, so that the process, when upscaled to several underserved schools, is as effective and efficient as possible.

3 Implementation methodology

3.1 Introduction

This section describes the methodology used to conduct the school connectivity assessment and the collection tools, techniques and methods used to present and analyse the data, including the steps taken to ensure data quality and ethical integrity in the collection of information. In the USF financing toolkit, effectiveness and efficiency are the two most critical areas when assessing how a problem has been addressed. Effectiveness gauges whether the result has been achieved and efficiency compares results versus costs. Other aspects are sustainability (results sustained after withdrawal of external support) and relevance (whether the programme continues to meet user needs) (ITU, 2011).

3.2 Methodology

The assessment report was developed using a mixed-methods research design comprising two phases: a quantitative study (which included Power BI visualizations of the collected data) supplemented by a qualitative study. The results of the qualitative study validated the results of the quantitative study. The investigation also included a critical review of the literature on the topic. The outcomes were used to corroborate the different sections.

Phase 1: Quantitative study

A school connectivity survey (see Annex 3) was developed to examine attitudes, beliefs and opinions about the effectiveness and sustainability of the connectivity project in 886 schools. The survey was created during this study after meeting with representatives from the Universal Service Fund team in Kenya to learn more about the school project. It was divided into five sections in accordance with the ESG sustainability framework.

The survey was pegged to three frameworks: a framework for optimal techno-economic assessment of broadband access solutions and digital inclusion of rural populations in the global information society (Krizanovic, Zagar, & Grgic, 2018); *Using Blended Learning Evidence-Based Practices*

The invitation to participate highlighted the purpose of the survey, issues of discomfort/risk, the benefits accruing from the survey and issues of confidentiality. Section A served to collect information on school demographics. Section B investigated issues of social effectiveness (numbers served by broadband connectivity, including people with disabilities; gender equity in accessing broadband; broadband pricing issues; connectivity usage; social impact of broadband connectivity; digital literacy; security and privacy; quality of broadband connectivity; innovative ideas emerging thanks to broadband connectivity). Section C, on economic effectiveness, focused on the number of people with access to computers in the school, online learning readiness, additional infrastructure and pricing issues experienced by the school and ways to finance a school's digital needs (current and future). Section D covered governance and asked about the school's ICT strategy and policy, staff and equipment available to support ICT use, and level of ICT awareness and training, and the support mechanisms available to the school (infrastructure and personnel). Section E, on environmental effectiveness, asked about the amount of ICT plastic waste, how the school reused/refurbished or recycled ICT materials and whether it had adopted renewable energy sources. The questions were structured to be SMART.

Once the survey had been developed, a computer studies teacher in a remote school in western Kenya was asked to provide feedback. It was important to have the feedback of a computer studies teacher in order to validate the meaning of the questions (specific); identify where language was vague (measurable); ascertain that respondents would understand the questions in the same way (accurate); and relate the survey to the current school situation (timely). It was also important to select the computer studies teacher from a remote county, it being assumed that if the survey could be easily understood by teachers in such counties, it was more likely that it would be similarly understood in urban and peri-urban schools. The SMART ESG school Internet connectivity framework can be used in future to evaluate the effectiveness of school connectivity projects in other countries.

In the second round, a pilot survey was administered in four schools in the three types of regions: urban, remote and peri-urban. Overall, the survey was found to be adequate, although two questions had to be added: the limitations that weather conditions implied for broadband connectivity, and whether the schools actually used the broadband connectivity provided (the pilot phase had revealed that some schools opted not to use the connectivity provided). The initial survey target was 50 per cent, or 430 schools. In all, 267 schools from 38 counties responded, even though the expert reached out to 640 schools. Creswell (2014) and Cohen et al. (2018) suggest that for a population of 800 units and a 5 per cent confidence interval rate the ideal sample size is 260 and 269 for a population of 900. The outcome of 267 schools is within the 5 per cent confidence interval and sufficient to form general conclusions. The reasons why some schools did not respond include the following: some were reluctant because they considered that the information requested was too sensitive; in others, the principals and/or computers studies teachers had been transferred or the respondents just did not answer.

Phase 2: Qualitative study

The second-phase qualitative study consisted in focus group discussions with principals and computer studies teachers and was carried out after the data from the 108 surveys had been collated. The questions developed from the intermediate analysis provided deeper insights into issues. The main aim of the focus group discussions was to discover unanticipated findings and hidden meanings with regard to various issues in connected schools.

Ten schools, in the counties of Kisumu, Vihiga, Turkana, Taita Taveta and Kitui, were selected for the discussions. The schools tended to be in remote towns, since those located near major centres (especially Nairobi and Mombasa) were more like to have stable connectivity and power supplies. Turkana, Kitui and Taita Taveta counties face many education challenges, including low rates of formal education, literacy, ICT integration and performance, plus high drop-out rates.

Generally speaking, each focus group had 7 to 10 participants. The school connectivity was provided by the three main suppliers (Xtranet, Commcarrier and Liquid Telecom). The responses came mainly from the principals and/or computer studies teachers, although in two cases teachers of other subjects were included. The interview guidelines applied for the discussions (see Annex 4) investigated the use of Internet connectivity; the challenges posed by unstable connectivity; project sustainability during and after the USF funding period; the provision of extra computing devices (including access) in schools; and teacher training. Proxies who were known to the schools administered the interview guidelines, it being deemed that their presence would make the respondents more responsive and open to the interviewers.

The information collected was merged with the survey data to form conclusions. Given that connectivity was not provided to special needs schools, the expert went further to find out, through a telephone interview (see Annex 5) with one school located in western Kenya, what opportunities and challenges it had experienced and if it was connected to the Internet. This school had four characteristics that made it ideal: it was a girls' school, it provided education to both the deaf and the blind, it was a rural school and it had connectivity (though not as a beneficiary of the project). The overall conclusion was that Internet connectivity in special needs schools was important, but that additional points had to be considered in terms of hardware, software and pedagogy, to ensure efficient and effective Internet use.

3.3 Ethical issues

The assessment took care to aggregate data and not to present micro data, to protect the individual identity of schools. The survey and focus group discussions were both voluntary and some schools refused to participate in the survey or to answer specific questions. The data enumerator explained the rationale of the research and how the data collected would be used. Generally, issues of research benefit and justice were considered, since the ultimate beneficiaries of the assessment are schools and other education stakeholders.

Section 3 – summary	
1	The school connectivity report was developed using a mixed-methods research design.
2	The first phase was a quantitative survey of 267 schools. The second, subsequent phase was a qualitative focus group discussion in 10 schools in Kisumu, Vihiga, Turkana, Taita Taveta and Kitui counties.
3	A pilot survey was administered in four schools.
4	The focus group discussions were carried out with principals and computer studies teachers.
5	The interview guidelines applied in the discussions investigated the use of connectivity; the challenges posed by unstable connectivity; the sustainability of the project during and after the USF funding period; the provision of extra computing devices; and teacher training.
6	A special needs school was included to provide critical information on Internet connectivity in such schools.
7	Ethical standards for protecting the individual identity of schools and allowing schools to opt out of answering all or some of the questions were adhered to.

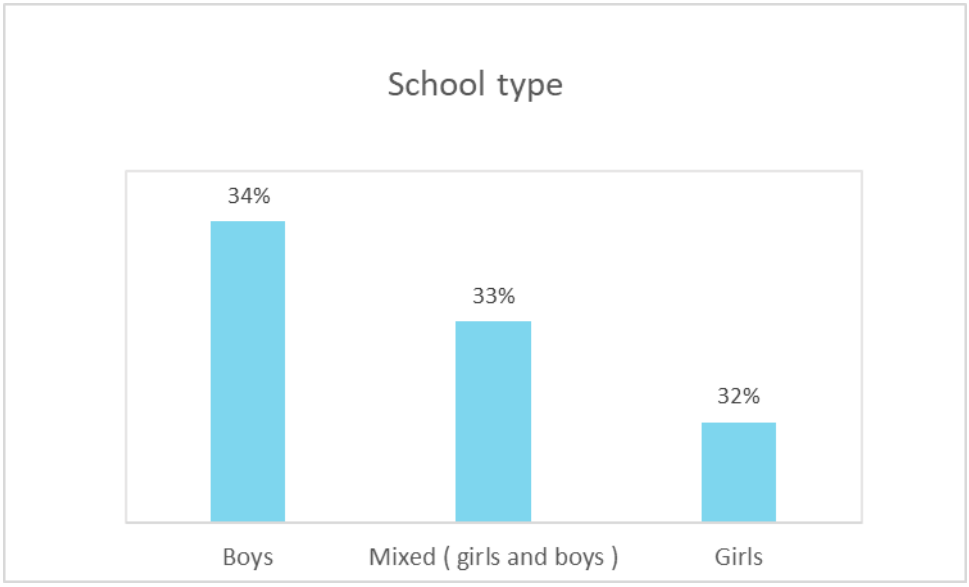
4 Outcomes of the survey and focus group discussions

This section provides the merged outcomes of the survey and focus group discussions according to five themes guided by the USF sustainability framework: background attributes, social effectiveness, economic effectiveness, governance aspects and environmental effectiveness. The population surveyed came from a wide range of schools and counties. The information in this section is fundamental for deciding whether the school connectivity project was effective.

4.1 Background aspects of the school connectivity project

The target group consisted of 886 schools in the country's 47 counties. In all, 267 schools in 38 counties responded; many (11 per cent) were from Machakos county. The respondents were divided between semi-urban (67 per cent), urban (9 per cent) and rural (24 per cent) schools and between the three different connectivity providers: Commcarrier for Garissa, Mandera, Nairobi, South (Muranga, Kajiado), South East (Wajir, Isiolo, Kitui, Tharaka, Makueni, Taita Taveta) and Coastal areas; Liquid Telecom for Turkana, West, West Pokot, Western Border, Narok and South West (including Kakamega, Trans Nzoia, Uasin Gishu, Elgeyo Marakwet, Nandi, Bungoma and Busia); Xtranet for Samburu (North and Central), Laikipia, Nyandarua, Nakuru, Kiambu, Marsabit, Meru, Embu, Nyeri, Kirinyaga, Baringo and West, Kericho, Kisumu, Vihiga and Bomet. One potential advantage of stratifying connectivity by region was economies of scale. In areas like Kakamega and Busia, the ISP selection criteria were apparently ideal, since many schools reported consistent service provision. In other regions, such as Marsabit and Narok north, schools complained that connectivity often failed – in some cases it had not worked for almost two years – and that ISP support was inadequate.

Figure 5: School types

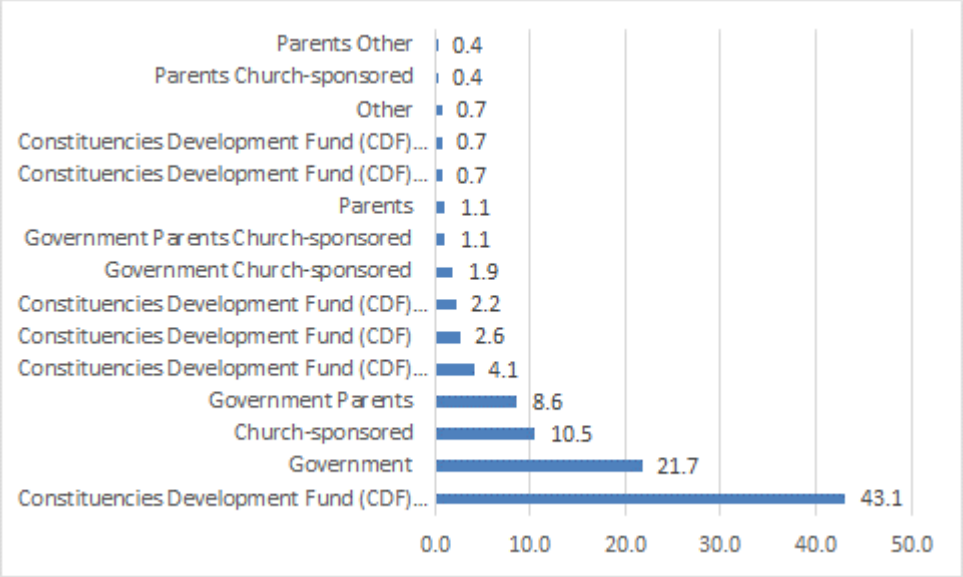


The target population identified (school selection criteria) was ideal in terms of county representation (all counties) and school region, nature and type. In terms of responses, there was an almost proportional mix of single-sex (boys 34 per cent, girls 32 per cent) and mixed schools (33 per cent) (see Figure 5). All the schools applauded their inclusion in the pilot project. Moreover, 66 per cent were boarding, 22 per cent day and 12 per cent both day and boarding schools, with the students at boarding schools relying mainly on Internet connectivity provided

at school. Therefore, the responses to the other sections by teachers and principals can be taken to allude mainly to the connectivity provided through the project. Day school and mixed day/boarding school students may have more possibilities to access connectivity services at home or elsewhere, for instance cybercafés.

The schools relied heavily on government as opposed to private funding. This may indicate a need for partnership agreements with the community and external partners to support capital or operational expenditures. According to some principals, the schools could raise funds by providing access to computing facilities when not used by students. When funding connectivity, it is important that the school connectivity funding model and the programmatic goals reflect requirements. They should also consider funding sources (see Figure 6), funding motivation and fundraising capabilities. Funding may also be obtained *inter alia* via a universal ownership approach, whereby opportunities to invest in school Internet connectivity are presented together with development banks, international organizations such as the United Nations, and NGOs, expanding the pool of resources beyond USF funds; crowdfunding through digital bonds and tokenized infrastructure, with a waiver for specific fees (Finance2Connect: Finding ways to fund connectivity, 2021); a tax waiver or reduction on connectivity and connectivity equipment; or a rural communication development fund that draws on a community development fund

Figure 6: Sources of funding



The 267 schools had a total of 7 188 teachers: 3 994 men (56 per cent) and 3 194 women (44 per cent). The total student population was 168 535. The proportion of female (43 per cent) to male students (57 per cent) (see Figure 7) was almost the same as the proportion of women to men teachers. These figures may reflect the higher response rate from boys' schools. In terms of inclusivity of students and staff with disabilities, few schools had students with disabilities, in line with the overall school population in the school selection criteria. It is therefore important to include more integrated schools in the school connectivity project.

Figure 7: Student population by gender

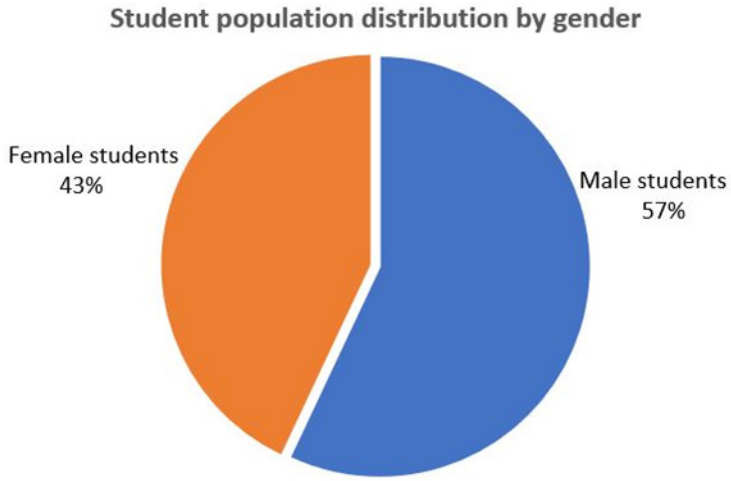


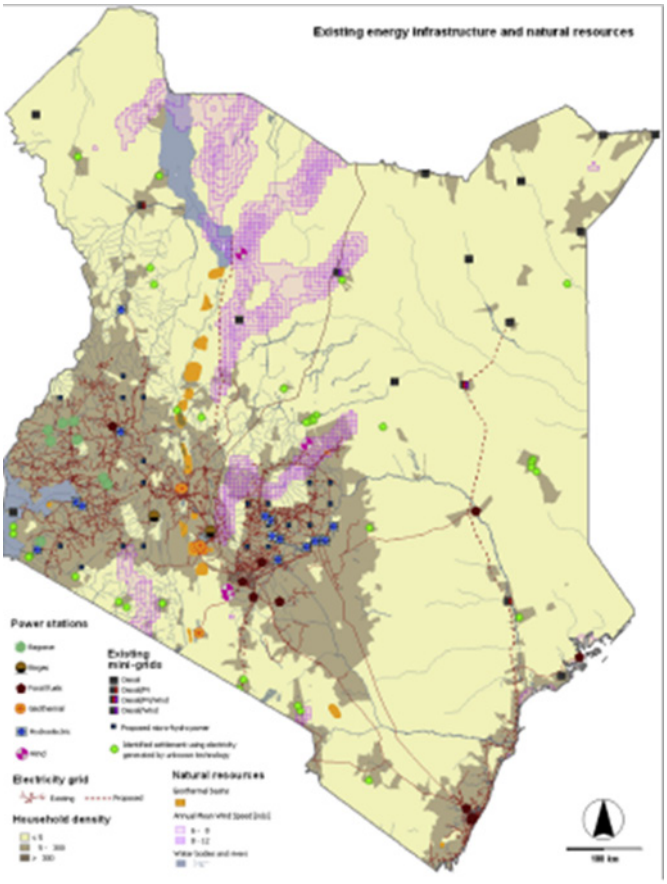
Table 1 indicates the number of students and staff with disabilities in the sample. The inclusion of students and staff with disabilities in the school connectivity project will ensure that communication services reach persons with disabilities and other vulnerable groups (one of the project objectives). This is an important measure for social inclusion. To ensure differentiated learning, some teachers resorted to peer-teaching.

Table 1: Persons with disabilities

Persons with disabilities	
Number of students with disabilities	**89**
Number of teachers with disabilities	**5**

In relation to power, most schools reported stable energy supplies, a positive indication of the steps taken by the government to connect rural and urban areas to the grid through the last-mile initiative (see Figure 8).

Figure 8: Map of existing energy infrastructure and natural resources



NOTE: The designations employed and presentation of material in this publication, including maps, do not imply the expression of any opinion whatsoever on the part of ITU concerning the legal status of any country, territory, city or area, or concerning the delimitations of its frontiers or boundaries.

Source : Moner-Girona et al., 2019

Moreover, work undertaken by the ICT Authority to connect schools to the Internet using Kenya power transmission lines may allow additional schools to be connected. Eight per cent of the schools that responded indicated frequent power cuts, 88 per cent indicated a constant supply of electricity and 4 per cent indicated that they never experienced cuts. In addition, most schools were served by murram roads (see Figure 9). The service provider was Xtranet for 13 per cent of the respondents, Commcarrier for 26 per cent and Liquid Telecom for 60 per cent. The three carriers used a variety of means to connect the schools: WiMAX, fibre, hotspots and VSATs (see Figure 10).

Figure 9: Type of connecting road

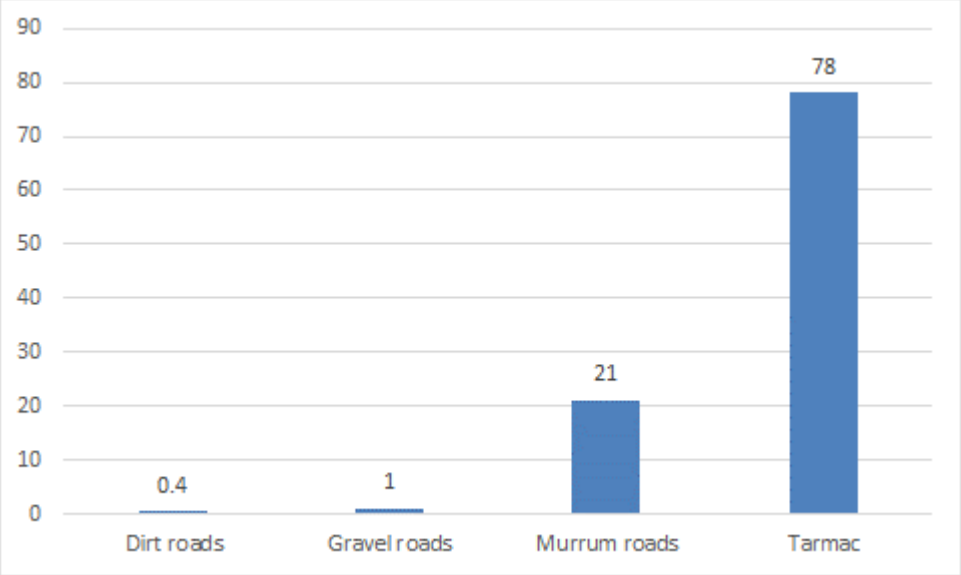
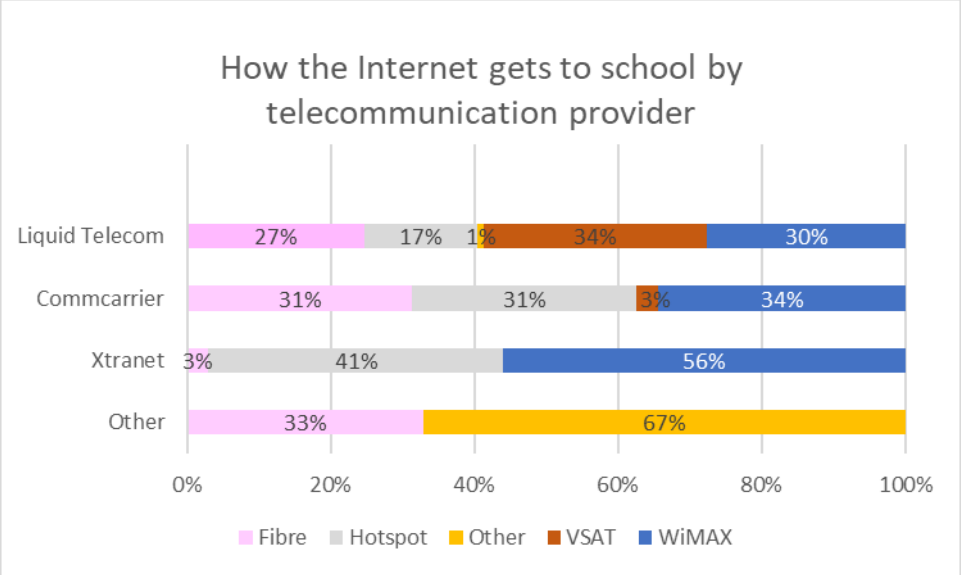
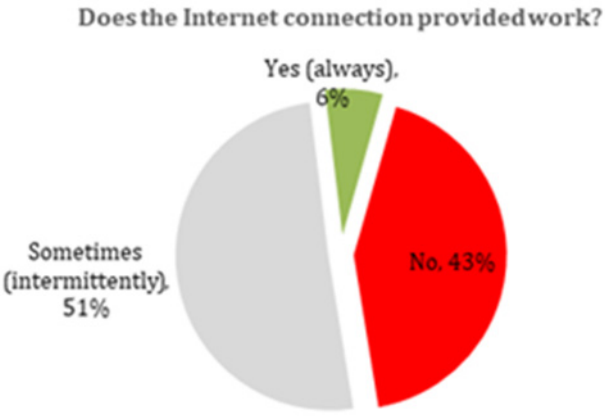


Figure 10: Means of connecting schools



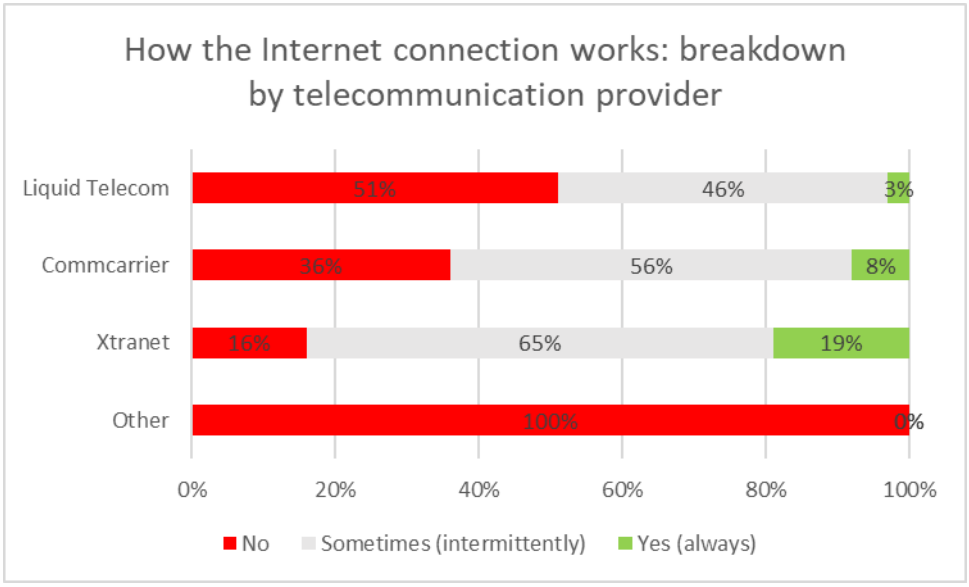
The schools used connectivity for teaching, learning, research and entertainment purposes. In some cases, they used it to facilitate the storage and processing of student grades. Classes were more engaging and students better able to retain information thanks to the variety of media sources used.

Figure 11: Connection quality



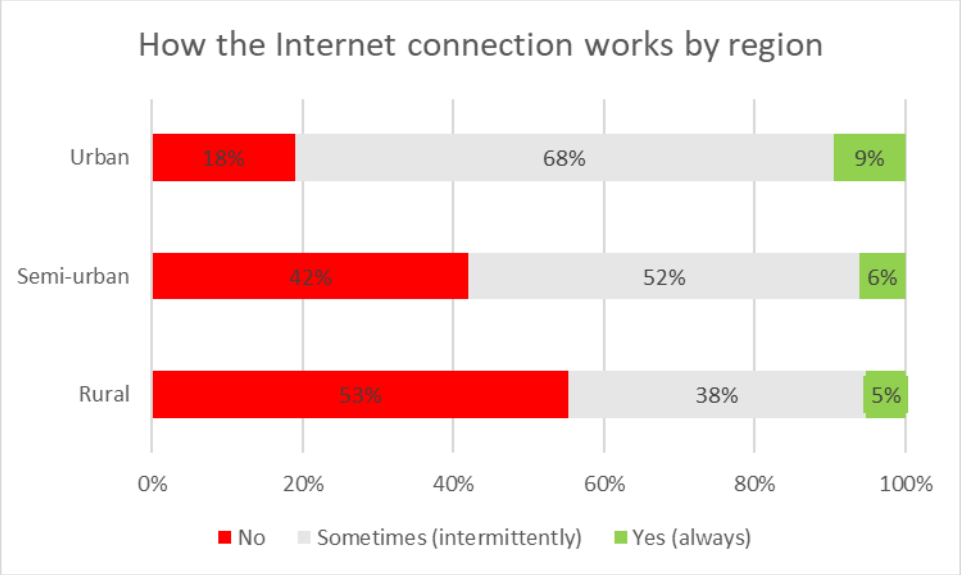
The quality of the connection varied (see Figure 11): 43 per cent said that the connection provided did not work, 6 per cent that it always worked and 51 per cent that it worked intermittently. This implies that the monitoring and evaluation process established by the ISPs and stipulated in the contracts did not work properly in many instances, including the help line, which, if it worked, was not acted on immediately. Some teachers paid for Internet bundles out of pocket and connected to ISPs with functioning broadband connectivity in their regions. The teachers, principals and technicians said that there should be a stable connection in the school administration block, library and computer lab, as stipulated in the ISP contracts, and in any science labs and resource centres. Xtranet appeared to be more reliable, with 19 per cent always and 65 per cent intermittent connectivity, compared to Commcarrier (8 and 56 per cent, respectively) and Liquid Telecom (3 and 46 per cent, respectively) (see Figure 12). Service provision must therefore be closely monitored.

Figure 12: Internet connection stability, by telecommunication provider



Internet connectivity was more stable (reliable) in urban and peri-urban areas, where it was always available 9 and 6 per cent of the time, and intermittently available 68 and 52 per cent of the time, respectively (see Figure 13). It was least stable in rural areas.

Figure 13: Internet connection stability



4.2 Social aspects of the school connectivity project

Social effectiveness was measured in terms of access, gender equality, connectivity usage, enablers, tech literacy and quality of the connection. The percentage of people with disabilities who had access to broadband connectivity was small compared to the percentage of teachers and students with no disabilities (see Table 2).

Table 2: Numbers of teachers, students and people with disabilities having broadband access

Target group	Count	Accessibility (%)
Teachers	7 188	
Teachers with broadband access	6 493	90%
Students	168 535	
Students with broadband access	139 776	83%
People with disabilities	94	
People with disabilities with broadband access	25	27%

Fewer students than teachers may have broadband access because teachers have greater economic and structural potential (within and outside the school) to access the Internet. An area of critical concern is to provide people with disabilities with more connectivity. In addition, regions like Marsabit and Narok North had Internet connectivity problems because of their location and weather. At school, the main premises where the Internet could be easily accessed were computer labs and staffrooms (see Figure 14). Liquid Telecom and Xtranet covered more school premises with Internet connectivity (see Figure 15).

Figure 14: Broadband access, by school premises

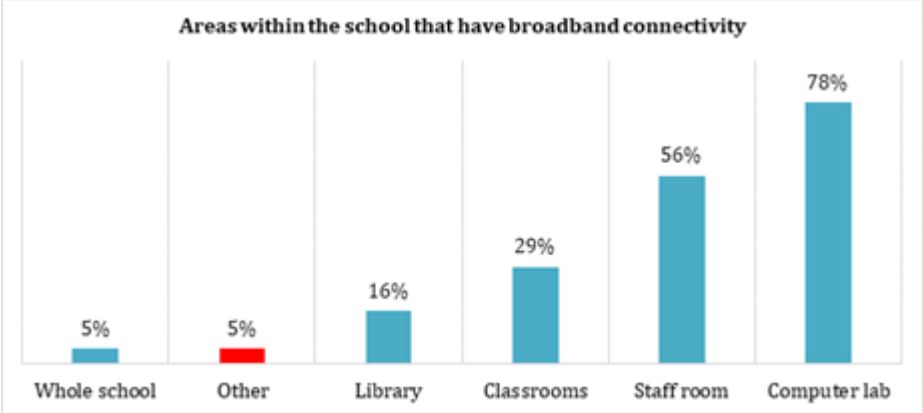
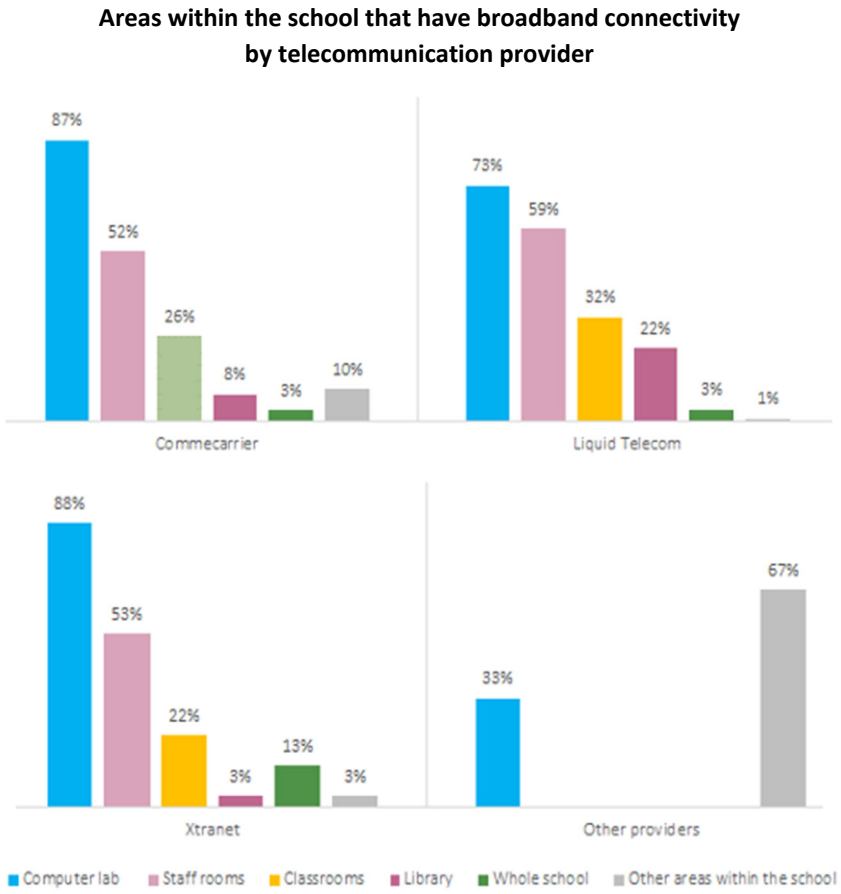


Figure 15: Broadband access, by school premise and provider



In the sample, Liquid Telecom and Xtranet had connected more premises within the schools. Nevertheless, the expectation that they would connect computer labs, staff rooms, administration blocks and libraries was not fully met, and other providers were sought out to make up for that failure. Safaricom and Airtel provided more extensive 3G/4G/5G coverage than other networks. Safaricom, for example, currently offers better service in remote communities, and other solutions are provided through community networks. The technical models of operation suggested in the 2021 access gaps study (macro, small and micro sites) will facilitate the allocation of capital and operational USF expenditure.

The issue of equality and gender inclusion arises mainly in mixed schools (girls and boys), which have taken initiatives to ensure better service delivery (see Table 3).

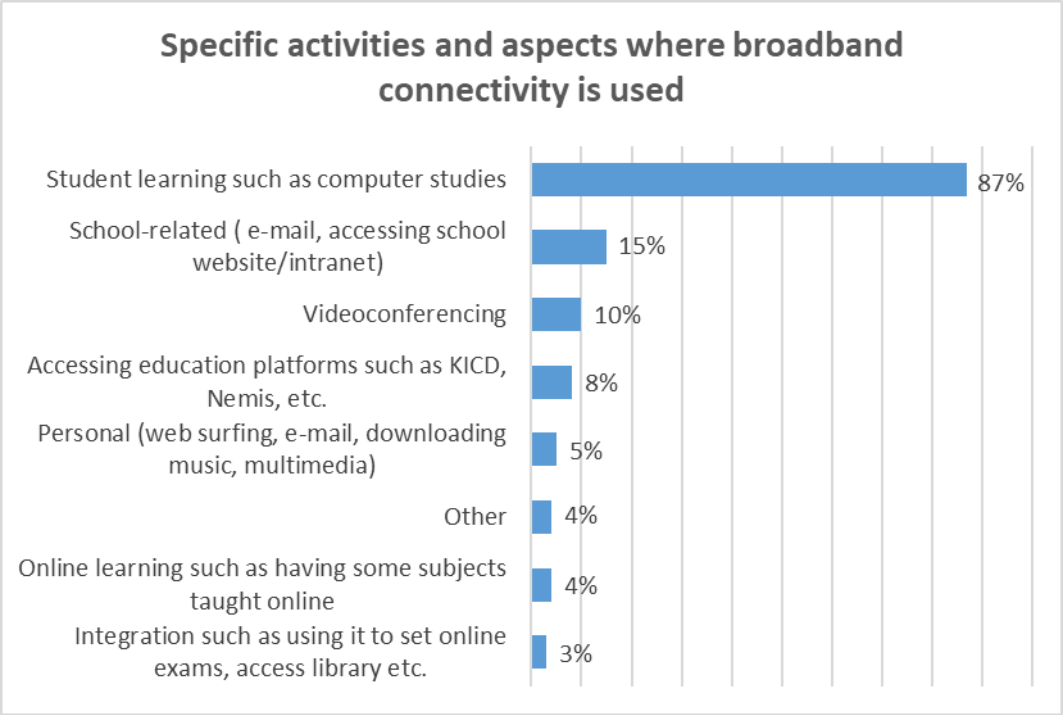
Table 3: Extra services for inclusivity (boys, girls, and mixed)

Implementation	Boys	Girls	Mixed (girls and boys)	Grand Total
Not applicable	84%	84%	15%	61%
Having affordable services	1%	3%	35%	13%
Increased enrolment at the school	0%	1%	33%	11%
Offering training	6%	10%	10%	9%
Improved security	9%	1%	6%	5%
Other	0%	0%	1%	0%

The implication is that schools were taking steps to promote inclusion, and the provision of affordable services is one such step. In addition, some schools were taking measures to ensure access by people with disabilities: five schools (1.8 per cent) said that they had special furniture and fittings, and three schools (1.1 per cent) that they had special hardware and software.

The specific reasons teachers and students used the Internet are shown in Figure 16.

Figure 16: Broadband use, by school activity



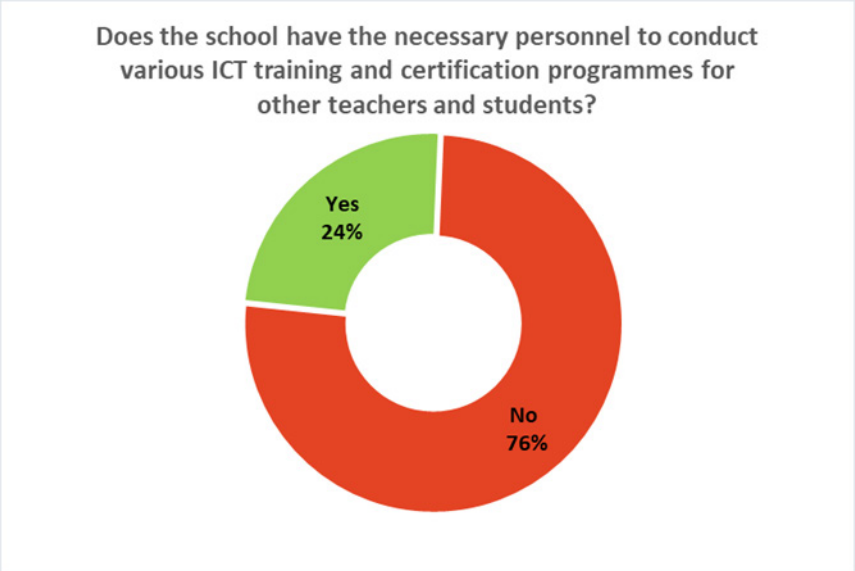
Very few schools spent money on connectivity, an important item that should be included in the school budget. Two schools (<1 per cent) spent KES 12 000 (USD 100) per annum on basic infrastructure, while one school (<1 per cent) spent less than KES 12 000 (USD 100) per annum on connectivity devices and another (<1 per cent) spent USD 200 on connectivity devices. Similarly, two schools (1 per cent) spent approximately KES 12 000 (USD 100) per annum on

capacity building and digital literacy. These low figures show that very few schools are willing to spend extra on ICT and connectivity. This implies that if USF funds were not available, many of these schools would not be connected to the Internet. It is therefore paramount to support these schools through various funding mechanisms.

During the focus group discussions, two other schools were interviewed that had not responded to the survey but spent more than KES 24 000 (USD 200) on connectivity and ICT. A few schools were able to raise extra funds from parents and other sponsors to support connectivity. The implication is that schools that are not subsidized or supported by the government will spend around KES 16 500 (USD 140) on Internet connectivity for the school, which may not always be sufficient for the school's needs. Various funding mechanisms need to be explored, together with support from parents and local communities. In addition, ISPs can provide specific connectivity packages.

The enablers of Internet connectivity are availability of ICT devices, connectivity that provides access to digital materials (47 per cent of respondents) and having a variety of Internet connection hotspots at school. Internet connectivity further enables improved communication with teachers (10 per cent) and parents (1 per cent) and makes it easy to access online materials that lead to improved performance (47 per cent). This implies that connectivity has the capability to catalyse learning. For 54 per cent of respondents, the installation of broadband connectivity had no effect in terms of resources saved or expended; for 42 per cent, the effect was positive.

Figure 17: Percentage of school personnel available to conduct ICT training programmes



In terms of tech literacy, digital literacy is now acknowledged as critical for people to perform well in society, alongside traditional literacy (i.e. reading and writing). Tech literacy is dependent on the availability of personnel with ICT training (see Figure 17) and offering computer studies as an examinable option – which all the schools did – was a critical selection criterion. Many schools responded that they did not have enough personnel to train teachers and students. There is therefore an urgent need for additional ICT training in the form of ongoing teacher professional development training sessions, thanks to which students will in turn also be able

to acquire digital and other twenty-first-century skills. The teacher training sessions can be offered annually.

In terms of quality of Internet connectivity, 89 per cent of respondents indicated that it was better in the evening (6–11 p.m.) and only 11 per cent that it was better during the day. This probably means that computer skills sessions and other activities that consume massive amounts of data took place in the evening. In some regions the quality of the connection was influenced by the weather: 69 per cent of respondents indicated that school connectivity did not depend on the weather, while 9 per cent said that it was affected by heavy rains and storms, 3 per cent by sunshine and 15 per cent by strong winds. The regions concerned require robust connectivity not affected by weather, i.e. radio signals and fixed wireless Internet (also depending on the capital expenditure allocation).

Nearly 50 per cent of schools responded in the affirmative to the question "Was the school connectivity project socially effective?". This means that much more needs to be done to address the aspects identified in this section.

4.3 Economic aspects of the school connectivity project

In terms of economic effectiveness, the assessment investigated whether the USF funds had been utilized effectively, including regarding the internal school budget and infrastructure.

In reply to the survey question on whether there was a USF programme in school connectivity, most schools (77 per cent) said that they were not sure and 23 per cent were confident that there was no such programme. This implies that there was very little awareness of the USF programme, its objectives and the roles of the various stakeholders at the school level. School principals need to be made aware of this during public meetings such as Secondary School Heads Association meetings. Very low awareness means lack of clarity about different roles. Moreover, the fact that nearly 50 per cent of schools found the school connectivity project to be social effective (see above) shows that there is a clear disconnect with knowing where the funding is coming from. The response was similar to the questions on the school budget and economic support for Internet connectivity. Many schools were not sure what aspects of school connectivity were covered by the budget (see Table 4); 77 per cent reported that they were not sure if there was a specific budget line or government budget for school connectivity. Furthermore, connectivity was an economic burden for schools.

Table 4: Budget for connectivity

Survey questions	Yes	No	Not sure
Does the school have a specific budget for connectivity?	0%	23%	77%
Is there a government budget for school connectivity?	0%	23%	77%
Is there a subsidized budget line for connectivity?	1%	17%	82%

Term and annual budgets must include a clear budget line for Internet and ICT sustainability initiatives. When schools were asked what new devices they might require to enhance broadband connectivity, many respondents reported that they needed desktops and laptops. Other items requested included tablets, smartboards and phones. The total for the 267 schools was approximately 52 744 items, costing on average approximately KES 125 203 000. In some

cases, the use of tablets was found to be viable, in others not. Viability was tied to a having a well-established usage, security, support and maintenance system.

The schools were also asked whether they were looking for other ways to finance ICT expenditure. Only 42 per cent replied in the affirmative. A list of possible funders for school projects and ICT partnership agreements should be drawn up. Currently, schools in the project face a funding crisis: few computers per student, lack of suitable alternative devices and an unsustainable post-funding period. Given the low percentage of schools seeking funds and the absence of a clear mechanism for allocating budgetary funds for ICT and connectivity, the success of the programme and its benefits to date are in jeopardy.

The school connectivity project has thus been minimally effective economically, owing to the above issues and especially in terms of sustainability and quality of existing connections; this in turn implies minimal economic effectiveness in terms of USF use. This aspect needs to be addressed via the various structural, policy and agent-related mechanisms suggested later in this report.

4.4 Governance aspects of the school connectivity project

Governance covers aspects of strategic importance, responsibility for school connectivity, security and privacy issues, ICT training, support, availability of online platforms for teachers and students, and the soft skills required.

Internet connectivity was of strategic importance in schools: 74 per cent of the respondents reported that the school community was aware of the strategic importance of broadband connectivity for administrative decisions, monitoring, supervision, teaching and learning, and reporting. However, when asked if the school vision included digital literacy and communication, only 28 per cent agreed; 72 per cent disagreed, indicating that digital literacy had to be incorporated into the school vision. The results also showed that 64 per cent of the schools had an ICT policy and that the principals, teachers, students and support staff were aware of it (see Figures 18 and 19).

Figure 18: Schools with an ICT policy

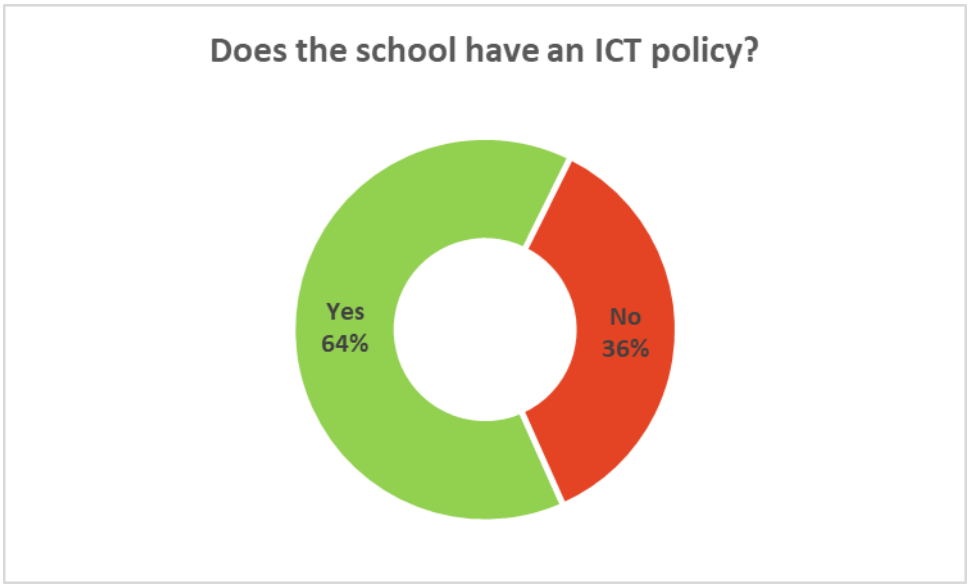
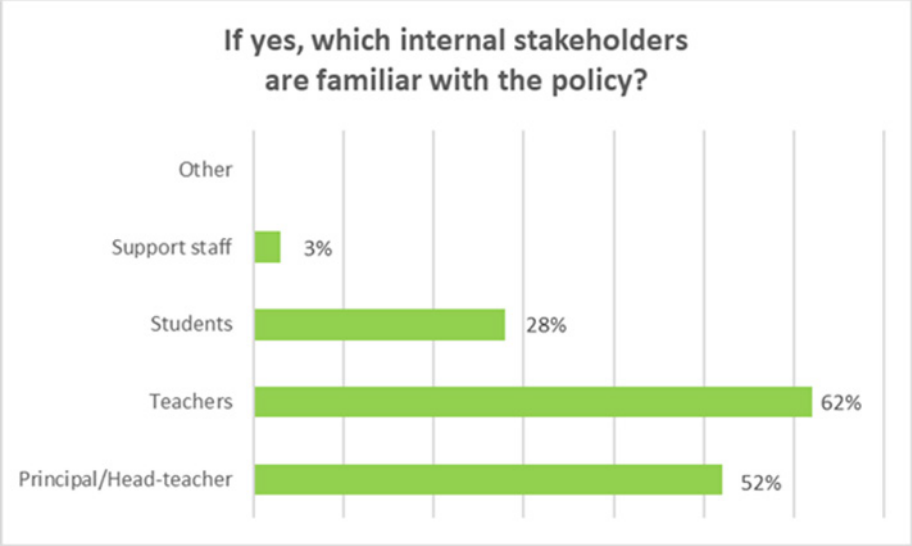


Figure 19: Internal stakeholders familiar with the ICT policy



The above implies that the schools realized that they needed an ICT policy. Such a policy should encompass not only the duties and responsibilities of teachers, students and technicians, but also other important aspects for sustainability, such as the ICT budget, ICT training, a framework for the acquisition of twenty-first-century skills through digital literacy, content, learning management and academic management systems, information security, ICT support (helpdesk) and pedagogy.

Responsibility for school connectivity should lie with principals, computer studies teacher and school management.

Five aspects were examined in relation to security and privacy (see Table 5): school physical security, computer lab security, tracking of computing devices, rules about information sharing and monitoring of students' online activities.

Table 5: ICT privacy and security

Survey questions	No	Yes
Is the school physically secure?	5%	95%
Is the school computer lab secure?	7%	93%
Can devices such as computers and other ICT equipment be tracked or traced?	23%	77%
Does the school have a way of monitoring the students' online activities?	31%	69%
Does the school have clear rules about what information students can share when they are online or using a mobile device, laptop or computer at school?	80%	20%

Certain clear steps had been taken to ensure the physical security of teachers and students, but additional measures were needed to safeguard information sharing and Internet privacy, since only 1 per cent of respondent had installed antivirus software. Soft security initiatives included firewalls (1 per cent) and antivirus software. This implies that firewalls and Internet/antivirus filters needed to be added as security mechanisms to the school's ICT policy.

Ninety-five per cent of schools indicated that they had experienced no data or security breaches. The 5 per cent that had experienced such a breach reported sending an e-mail with personal data to the wrong person or unauthorized persons gaining access to their laptops, e-mail accounts or computer. The fact that some schools reported no data breaches did not mean that no such breaches had occurred, given the absence of filters and firewalls.

Hardly any ICT training programmes were reported (see Table 6), pointing to a clear need for such programmes in schools.

Table 6: Frequency of ICT formal training at school

Survey question: How often does the school offer formal training in broadband services to teachers or students?					
	Never	**Very rarely (once a year)**	**Rarely (three times a year)**	**Often (six times a year)**	**Very often (more than six times a year)**
Teachers	92%	7%	1%		
Students	93%	3%	3%		1%
Others	97%	3%			

An average of 1 per cent of schools offering training provided certificates to the participants (see Table 7).

Table 7: Certification of broadband training

Survey question: Does the school offer certificates to those who complete broadband training?			
	Have not had training	**No**	**Yes**
Teachers	92%	6%	1%
Students	93%	6%	1%
Others	97%	2%	1%

There should be clear mechanisms for rewarding teachers and students who attend training sessions. The rewards can take the form of certificates and, for teachers, Teacher Performance Appraisal and Development points.

Fifty-four per cent of the respondents reported that they had access to an ICT helpdesk or office staffed by technicians; 57 per cent had a dedicated technician and 41 per cent turned to computer studies teachers for support. This indicates that although many teachers, principals and students may not have ICT skills, some of these skills are possessed by technicians, who can instigate training sessions. The technicians can also work with ISPs to ensure stable Internet connections. They can advise the school on ICT procurement decisions, especially where competitive and effective suppliers exist. Schools that do not have a helpdesk can ensure one is established and made a part of the ICT policy.

Ninety per cent of the respondents said that they had no online platform, academic system or learning environment – the potential in terms of connecting schools is therefore huge. Online academic platforms can serve not only as repositories, but also as channels through which a community of education practitioners and learners can be created – an important mechanism

for encouraging and distributing local content. One of the systems used by basic education institutions – albeit not always effectively – is the National Education Management Information System. Internet connectivity enables access to such services. Kenyan universities with education faculties can help schools create affordable central online platforms contextualized for Kenyan needs. The potential for educational technology providers is also huge.

In all, 6 455 out of 7 188 teachers (90 per cent) and 141 966 out of 168 535 students (84 per cent) reported that they had acquired soft skills since the introduction of broadband services. Further inquiry revealed that many viewed an improved learning experience and teaching skills as soft skills, which may be true indirectly. In the case of learners, 30 per cent said that broadband access had improved their learning skills (which may imply better content mastery and be somehow connected to deep thinking), 18 per cent their computer skills and 13 per cent their academic grades. Forty-six per cent of teachers said that broadband access had enhanced their mastery of ICT devices, 18 per cent that it had improved their digital literacy skills and 2 per cent that it had boosted communication.

The conclusion in terms of governance effectiveness is therefore that the school connectivity project enabled governance and learning at schools and was therefore critical, despite the gaps that still need to be addressed, namely additional training of learners and teachers, improved security and privacy measures, and the adoption of online learning management and academic management systems.

4.5 Environmental aspects of the school connectivity project

In terms of environmental effectiveness, the assessment focused on environmental sustainability, the amount of e-waste generated and the reuse and recycling of e-waste.

Many schools did not recycle, reuse or refurbish ICT devices. Many kept damaged e-waste in store. Schools need to be made aware about the need for a clear e-waste management system. E-waste management should be made a part not only of the procurement process but also of the school's ICT policy.

Seventy-two per cent of the respondents said that they kept damaged e-waste in store and 17 per cent that they sold it second-hand; only 8 per cent returned damaged electronic devices. Seventy per cent were not sure how many kilos they disposed of per year. This implies a need to educate both teachers and students.

While many schools had a constant energy supply, very few used renewable sources of energy (3 per cent). Public–private partnerships could be formed to encourage schools to adopt renewable sources of energy, which should be affordable, effective and easy to maintain.

Going by the responses, it is not possible to give a definite yes or no answer to the question whether the school connectivity project was environmentally effective, given that most devices were not properly discarded and full advantage had not been taken of the cost-savings implicit in renewable energies. Schools need to be educated about e-waste policies and mechanisms, which should be designed with their constraints in mind. They can obtain refurbished computers from government offices. The e-recycle mechanism should be in line with the Kenya Bureau of Standards minimum standards on information technology – learning education and training.

4.6 Summary of economic, governance, social and environmental aspects

The school connectivity project was nearly 50 per cent socially effective. Its economic effectiveness was minimal, due to the failure to incorporate broadband access into existing school budgets. It improved school governance although more could be done. In the absence of a clear e-waste disposal mechanism, it is impossible to gauge environmental effectiveness. Much needs to be done to make school agents aware of the necessity for an ideal communication infrastructure that meets each school's needs in its specific context. More attention should be given to special needs schools. Additional capacity building is required for teachers and students, and the design and adoption of online platforms that enable the creation, curation, distribution and use of local content should be encouraged. Many of the positive benefits experienced by schools in relation to Internet connectivity, where available, would not have been possible without the USF funds. Some issues nevertheless remain to be addressed.

Section 4 – Summary	
Background aspects	
1	In all, 267 schools in 38 counties responded to the survey. Many were from Machakos county (11 per cent). The respondents were peri-urban (67 per cent), urban (9 per cent) and rural (24 per cent) schools.
2	In all, 66 per cent of the respondents were boarding schools, 22 per cent day schools and 12 percent both day and boarding schools.
3	The schools relied heavily on government as opposed to private funds.
4	Among the respondents, 13 per cent were served by Xtranet, 26 per cent by Commcarrier and 60 per cent by Liquid Telecom.
5	The carriers used a variety of means to connect the schools: WiMAX, fibre, hotspots and VSATs.
6	The schools used Internet connectivity for teaching, learning, research and entertainment purposes.
7	Forty-three per cent of the respondents said that the connectivity provided did not work, 6 per cent that it always worked and 51 per cent that it worked intermittently.
8	Some teachers paid for Internet bundles out of pocket and connected to ISPs in their region.
9	Xtranet seemed to be more reliable (19 per cent of respondents said that it always worked and 65 per cent that it worked intermittently) than Commcarrier (8 and 56 per cent, respectively) and Liquid Telecom (3 and 46 per cent, respectively).
Social effectiveness	
10	More male than female teachers and students had broadband access, although the differences were marginal.
11	Very few respondents were special needs schools; such schools should be given special attention, to encourage social inclusion.
12	Schools needed to have a clear monthly broadband budget.
13	Schools might also consider adding a budget line for the purchase of devices and broadband access, so that they are self-financing.
14	Connectivity was mainly used for teaching, learning, communicating with other schools and, in a few cases, CCTV monitoring. The social enablers are having in place an ICT policy, training in ICT and planning the use of ICTs.
15	There was low digital literacy among teachers. Additional digital literacy training for teachers is needed and should include instruction in twenty-first-century skills, e-waste disposal and safe Internet use.
16	The connection provided was in some cases of poor quality and in others did not work.
Economic effectiveness	
17	Many schools were not aware what the USF was.
18	Many schools lacked a clear understanding of what the school's role is in ensuring the sustainability of the broadband access provided.

(continued)

Section 4 – Summary	
19	The tendering process was open but should be followed up to ensure that all suppliers meet their contractual conditions.
20	In cases where the Internet connection provided did not work, schools spent on average KES 15 000 (USD 142) on broadband access and KES 500 000 (USD 4 760) on other ICT-related expenses.
21	A ratio of 1 computer for 10 students was the minimum, with the eventual target being 1:5.
22	Public–private partnership agreements were needed to provide additional financing for broadband access and the purchase of computing devices.
Effectiveness in governance	
23	Several schools agreed that Internet connectivity was a critical enabler of teaching and learning.
24	Some schools had an ICT policy, which needed to be updated to reflect issues related to e-waste management, cybersecurity, ICT training, information management and privacy.
25	Although schools had physical control measures limiting access to computer labs, they had no clear way of monitoring cybersecurity threats, and many were not aware of data-protection principles.
Environmental effectiveness	
26	Many schools did not recycle or refurbish ICT devices.
27	Many schools kept damaged electronic waste in store and a few sold it second-hand.
28	Very few schools used renewable sources of energy.

5 Findings

5.1 Social aspects

5.1.1 Access

The assessment focused on both individual access to broadband connectivity and areas where connectivity existed or should exist. Teachers could access the Internet more easily than students because they had more capabilities (economic and structural). Access for special needs groups in schools should be improved. In integrated schools, this can be done by providing assistive technologies to enable content access, creation and organization, and classroom participation (Twining, et al., 2006). Such technologies, which encourage inclusion of those with visual and/or hearing disabilities, speech impairments or cognitive, psychosocial or physical disabilities (Raja, 2016), comprise text-to-speech software; applications with on-screen text and commands read aloud; equipment providing flexibility for the positioning of computer equipment; keyboard emulation; refreshable braille; and optical character recognition (Burgstahler, 2012). Broadband connectivity is needed in all areas, especially teacher staffrooms, computer and science labs, and libraries. Wi-Fi hotspots can be distributed around the school to connect classrooms. Although the service contracts stipulated specific service locations, some locations (e.g. libraries) were inactive; there should therefore be weekly reports on school network Internet speeds and router status, which in turn should be connected and monitored at county and national levels. The current speeds of 5 Mbit/s, while a good starting point, are only sufficient to open documents and videos but may not be suitable for cloud-based applications and video streams (ITU, 2021). School sites can be upgraded to 20 Mbit/s.

5.1.2 Gender equality and social inclusion

The fact that broadband connectivity featured almost perfect gender parity implies that it is a useful means of bridging the digital gender gap when it comes to accessing educational materials. In terms of access to use of digital technologies, the digital gender gap was almost the same, with both men and women teachers and students requiring similar digital skills (Kuroda, Lopez, Sasaki, & Settecase, 2019). Policies should be in place to promote greater equality and access to learning resources for disadvantaged groups, to recognize the risks that the marginalized are exposed to and to secure extra funding for the relevant schools. Schools are well placed to help children identify and reduce risks. The inclusion of digital citizenship and cybersecurity in the curriculum can help (ISOC, 2017).

5.1.3 Connectivity usage

Broadband connectivity was used for teaching, learning and communication activities, including accessing the Kenya Institute for Curriculum Development portal, a major source of curriculum materials. Connectivity can expand learning spaces beyond the confines of the brick-and-mortar school. It has the potential to catalyse many teaching and learning activities, assist in assessments and instil twenty-first-century skills (ITU, 2013), including the management of education institutions.

5.1.4 Connectivity enablers

Enablers are tools, procedures, systems and agents that provide the capacity to drive and foster digital transformation. In schools, the enablers were availability of ICT devices and digital materials online, digital literacy and connection hotspots, all of which encourage both pedagogical and managerial activities. Broadband connectivity should therefore go hand in hand with access to digital devices and portals providing easy access to a variety of teaching and learning materials.

5.1.5 Digital literacy

The lack of digital skills among teachers and students should be addressed as a matter of urgency. Teachers need skills to make effective use of Internet resources. Educational administrators need to know how to utilize the education management data provided through academic management systems and learning portals (ISOC, 2017). Content and devices that teachers can make use of should be identified and should include massive open education resources that are free for students and teachers. Open courses eliminate intellectual property constraints; teachers should therefore be taught how to access and make available information through such channels, including creative commons. Students and teachers need to be taught critical thinking and analysis skills, to contextualize information made for and in other regions/contexts (ISOC, 2017). Digital skills can be provided in-house by both computer studies teachers and technicians, to narrow existing gaps. Teachers' digital skills can be improved through annual teacher professional training courses. Universities can help provide open course materials.

5.1.6 Quality of Internet connectivity

In many cases, broadband connectivity was reported to be inconsistent; in others, it did not work. Where available, it varied according to the time of day. The Simple Network Management Protocol can assist in polling routers and ensuring that network speeds are not below 5 Mbit/s in all secondary schools when the project is upscaled. Technicians and computer studies teachers can provide weekly reports to ISPs on connection quality. A centralized system is needed that regulates and monitors the state of connectivity in schools at the national level; at the local level, the system should be devolved and schools allowed to identify and choose appropriate ICT hardware, software and ISPs, as permitted under existing public policies and procedures. This eases the burden of responsibility on national entities and devolves responsibilities and duties to the local level. For this to be effective, there must be clear communication, and the macro, meso and micro (school) agents must be trained in their duties and responsibilities. In cases where broadband connectivity does not exist because of regional security threats, the solutions identified in the access gaps study (Communications Authority, 2021), namely to promote passive infrastructure ownership and to provide additional community investments, in order to counter resistance to the placement of communication towers, are important. This can include charging extra for maintenance and security.

Conclusion

When the project is upscaled, steps must be taken to guarantee that, in addition to ensuring gender equality, integrated schools are included. The broadband connectivity supplied to these schools must be constantly monitored to ensure consistent service. The acquisition of digital skills by both teachers and students will ensure that maximum benefits accrue.

5.2 Economic aspects

5.2.1 Effectiveness of use of USF funds

Effectiveness implies that the USF funds provided lead to consistent connectivity in schools (intended use corresponded to actual use). Very few schools understood where the funds came from and were therefore hard put to demand accountability. Given that more than 40 per cent of schools reported that the broadband connection provided did not work, a mechanism is needed by which they can provide direct feedback to a third party – not the service provider – on the status of the connection. The third party can act as an auditor of existing connectivity and fund use.

A mix of business models can be used to encourage the use and generation of extra funds. In the case of a public school in a remote area, the partnership model can be mainly public (using USF, CDF and government funds), with operational responsibility for connectivity falling to a telecommunication company. In the case of a rural school with approximately 500 students, the operating model can be a public–private partnership. In the case of an urban school, ISPs can take operational responsibility, with the partnership model involving a mix of public and private organizations (ITU, 2021).

ICT systems should not be isolated from the school's practical context (Leviakangas, Hautala, Britschgi, & Oorni, 2013). Procurement of ICT devices can be centralized or decentralized. Procurement involves solicitation, selection, awarding, tendering and electronic procurement. A centralized system puts the task of procurement, installation and disposal of ICT devices at a central point, either at the county or national level, with an ICT administration unit between the region and school. A decentralized system allows the schools to request procurement and installation of devices according to their needs. The government can agree on concessions with schools and contractors. This encourages competition, ensures that suppliers who get requests are those that provide quality services and minimizes the cost of ICTs.

Kenya can choose to adopt a decentralized system, with the Ministry of Education, Science and Technology and the Communications Authority playing a more regulatory and directive role. This has many potential benefits, from healthy competition to collaboration. Currently procurement decisions in public schools are more aligned on the centralized model and schools have minimal leeway in procurement processes. This assessment found that schools did not have leeway to decide on broadband connectivity service providers; this may to some extent explain the challenges they are currently experiencing. Furthermore, the purchase of ICT devices for schools can involve entities other than suppliers and government, such as the private sector and financiers, in a form of public–private partnership. The private sector can provide specific products (software, hardware, connectivity) and the financier can provide money after the school negotiates with the contractor. Such partnerships should be regulated by the government. The fact that workstations and computers have a lifespan of four to five years (Leviakangas, Hautala, Britschgi, & Oorni, 2013) can be used to calculate salvage value and to create mechanisms to dispose of, reuse and refurbish such devices.

5.2.2 Budget considerations

Besides the government providing specific broadband connectivity for schools in very remote regions, public schools can be given the option to invite tenders by several government-approved

suppliers. For the project to be successful, various ingredients are needed – broadband connectivity on its own does not suffice, even though it is a critical enabler of teaching and learning in educational institutions. The needs of schools and colleges need to be analysed with a view to the SMART integration of ICT devices (ISOC, 2017). The average national ratio of students to computers in developed nations is 5:1 (Leviakangas, Hautala, Britschgi, & Oorni, 2013). Schools can target a ratio of at least 10:1. This target can be met by adopting the most appropriate of various computing architectures: well-equipped centralized computer labs; computers in classrooms; school-based telecentres (Bassi , 2009), where the computer lab is open to the community outside school hours; or integrating the ownership of appropriate specific ICT devices into school fees according to different learner levels (upper primary for three years, lower primary for three years, junior secondary for three years and senior secondary for three years).

The education cycle requires various levels of ICT knowledge acquisition and the budget allocated for devices can therefore be increased as the student progresses from lower to higher levels. One proposal is for a tiered approach to ICT fund allocation within schools. At Tier 1 (senior secondary level), students specializing in STEM need more advanced equipment and good connectivity; at Tier 2 (junior/lower secondary level), schools offer computer studies as a core subject and pre-technical education; at Tier 3 (upper primary level), computers can be embedded in subjects, including science and technology; and at Tier 4 (lower primary level), students learn digital literacy skills. This approach allows students to own (according to specific ratios) cheap devices at low levels and more complex devices (with lower computer-to-student ratios) at higher levels, thus decreasing the digital unit cost per student at lower compared to upper levels.

School budgets should include ICT devices as a critical component. The focus group discussions revealed that secondary schools spent a minimum of KES 15 000 (about USD 142) per month in situations where broadband connectivity was not stable and at least KES 500 000 (about USD 4 760) per year on ICT devices. These figures can serve as the minimum budget allocations. Parent associations and public–private partnerships can provide funding for additional infrastructure and ICT devices.

The operational service provider fees per school include the cost of fibre or satellite links, wireless Internet, 4G/5G, and are calculated per end point, site and gigabit. The operational and maintenance cost per school should include the costs of electricity, operation and maintenance per transceiver or tower (ITU, 2021).

5.2.3 Infrastructure considerations

The assessment revealed an urgent need to equip secondary schools with computer devices (desktop computers, laptops, tablets), without which the advantages of broadband connectivity are curtailed. Based on a computer: student ratio of 1:10, schools with 800 to 1 000 students need 80 to 100 computers; those with 500 to 800 students need 50 to 80 computers; and those with fewer than 500 students need on average 50 computers. The cost of a refurbished computer in Kenya is KES 20 000 (USD 190). An annual budget allocation of KES 500 000 (USD 4 750) can allow a school to purchase around 25 refurbished computers. This cost can be lower if the school receives donations from government offices and other well-wishers. The computers thus obtained must be in good working condition and meet the minimum standards set by the Kenya Bureau of Standards.

Schools can estimate the number of hotspots that they need. The estimated cost of a standard wireless access point gadget is KES 20 000 (USD 190). Schools can be offered an initial subsidy for router and access points. They can also be encouraged to look for other ways to finance ICT investments. For instance, computer studies students can develop content, animated sequences and programmes – if they have been given relevant and up-to-date skills.

Conclusion

Schools must be made aware of the fact that they have USF funding and of their role in its utilization and sustainability. In addition, they need to have a clear system for monitoring Internet and ICT use, and for maintaining and acquiring connectivity equipment. Different funding models can lower the cost of broadband connectivity.

5.3 Governance aspects

5.3.1 Strategic importance of school connectivity

Broadband connectivity was strategically important in schools. It helped them achieve their teaching, learning, research and communication aims. It served to access, create and share teaching materials; to help students engage more effectively with learning materials, especially videos, which engage the senses and the content of which is therefore easier to remember. It thus improved learning outcomes. It enabled teachers to assess, develop and deploy various student evaluations and to share feedback with education agencies. It made teachers more effective. Embedding connectivity in all school functions is an effective ingredient for a better-functioning school.

5.3.2 Oversight responsibility in the school

School leadership should exercise oversight responsibility for school connectivity. It should provide a framework for ICT integration into all education services (teaching, learning and administration) through school ICT policies and procedures with clear persons in charge and timelines. A student-centred collaborative approach allows students and teachers to keep track of their own formative assessments, including teaching and learning outcomes. The principal and the Board of Management should ensure that enough funding is available from different sources to ensure proper school functioning. The principal should work closely with technicians and computers studies teachers to ensure that ICTs produce the intended benefits and work closely with ISPs. Monthly meetings can help with this.

5.3.3 Security and privacy

Internet use must be safe and secure. Since students will be exposed to various online threats, measures and mechanisms must be established to ensure their online safety. Many schools have taken measures to ensure physical security, but it is more important to guarantee software, information and Internet security. Students should be provided with in-house training on how to protect their personal information and tools. Teachers should be instructed in the various filters and tools, and in cybercrimes and how to avoid them or minimize their impact, to ensure that schools are safe spaces. Technicians and computer studies teachers should install filters, antivirus and antispyware software and other control measures. The ITU Child Online Protection Initiative

should be cascaded to all schools. Teachers and students need to familiarize themselves with the guide to online protection produced by the Communications Authority.

Internet safety can be made a part of values-based education in the new competence-based curriculum, which should include how to respond to various cybercrimes. Students and teachers need to be made aware of the implications of the Data Protection Act 2019, especially Part IV, on principles and obligations relating to personal data protection. The Kenya National Health Strategy (2015) should incorporate the online protection of children in the sections on child rights, protection and responsibilities, and on school infrastructure and environmental safety. Handbooks on safety standards for schools can provide various measures to ensure the protection of children using ICT devices and accessing the Internet. They should refer explicitly to safe use of ICT, including by children with special needs and disabilities. This should be a function of the school safety subcommittee.

5.3.4 ICT training

The Teachers Service Commission should provide annual training in specific ICT issues. The training sessions should cover the following topics: creation of educational content and applications; curriculum development, alignment and assessment; training and usage support; and security of ICT devices. The training should be cascaded to learners in schools. Providing some form of certification can be a non-monetary way to encourage participation in training sessions.

5.3.4 Support

Technicians in schools were found to be central agents providing effective support. They can work together with computer studies teachers to develop the curriculum for teachers and students and maintain broadband connectivity. This can be part of their job description. ISPs should therefore ensure that technicians receive adequate training before handing over a site. All schools should have a helpdesk to support both teachers and students. Technicians can offer the needed support.

5.3.5 Availability of online platforms for teachers and learners

Schools need integrated online platforms, provided through the Kenya Institute for Curriculum Development portal, online personal support for ICT devices and broadband connectivity. The online platforms should enable the creation of e-portfolios that can be structured consistently to enable comparisons. Suppliers can provide mechanisms to capture e-portfolios so that students are easily aided to choose their education pathways and national industrial demands (in STEM, humanities, social sciences and arts) are matched with student skills and numbers, leading to more effective governance at national, regional and local level. The collaborative approach should allow teachers to create, adapt, reuse and share resources that can be accessed through digital platforms and to form online learning communities for the different education pathways.

It is imperative that there exist several online communities of education practitioners at primary, secondary and tertiary level, to encourage the sharing of best practices and materials (Twining, et al., 2006). Effective open-source learning management and academic management systems ensure that online applications promote management, teaching and learning processes. The Kenya Institute for Curriculum Development portal can act as a gateway to suitable software.

Stable and reliable connectivity is an enabler, providing information to the regional and national education agencies through the National Education Management Information System and thereby leading to more informed education decisions. Training in the use of different platforms should be a part of teacher training sessions.

5.3.6 Soft skills required

Teachers require digital skills to use computers and software applications effectively. Internet access can enable the development of collaborative, communication, critical thinking, problem-solving, digital literacy and creativity skills. In some schools, broadband connectivity has led to digital literacy, enhanced teaching and communication skills. Students have been able to access a wide variety of materials and have thus become more creative. Teachers can show students how to analyse online content critically and enable development of critical digital skills.

ICTs have the potential to boost twenty-first-century skills (Mastercard, 2020) by providing functionalities that enhance student capacities to communicate effectively at a distance, collaborate with geographically dispersed teams, develop the faculties to analyse digital information and work creatively. They contribute to teacher development and improve assessment practices and tools (Joynes, Rossignoli, & Amonoo-Kuofi, 2019). The use of Kenya Power and Lighting Company and Kenya Electricity Transmission Company powerlines is one novel way to distribute broadband connectivity to remote schools efficiently, but it needs to be done systematically and with a clear monitoring and evaluation process.

Conclusion

Broadband connectivity has contributed to improved oversight in some schools, and enabled teaching and learning outcomes. Nevertheless, most schools continue to face issues of ICT training, information security and privacy, and support services. Open-source academic management and learning management systems can help the school leadership perform its strategic functions. Broadband connectivity can lead to the development of twenty-first-century skills and make students global knowledge citizens.

5.4 Environmental aspects

5.4.1 E-waste

Most schools did not have an elaborate mechanism for the disposal of e-waste. They stowed non-working computing devices in stores. E-waste disposal is a critical issue that needs to be integrated into the procurement process. Procurement, both of connectivity and ICT devices, should be not only about identifying needs, designing mechanisms to meet those needs, deciding on an appropriate tendering process, implementing the tender and evaluating the impact (including support); it should also include disposal of e-waste. Schools can work closely with the National Environment Management Authority to facilitate effective disposal of e-waste. It should be noted that the USF provides connectivity and related devices to the schools; the beneficiaries own these items once provided, and only they have the authority to dispose of them when the time comes. This report therefore suggests that either e-waste disposal training be incorporated into project design or schools be encouraged to collaborate closely with the National Environmental Management Authority to ensure proper e-waste disposal.

5.4.2 Reuse and recycling of e-waste

The National Environmental Management Authority provides guidelines for e-waste management, which is regulated by the Environmental Management and Co-ordination Act (2013). The act clearly stipulates the responsibilities of recyclers to receive and dismantle waste electrical and electronic equipment into hazardous and non-hazardous components and to ensure that any components that cannot be recycled locally are exported as specified in the regulations. It further stipulates the responsibilities of refurbishers and repairers to ensure that the resultant e-waste is transferred to a collection centre and recycled. This implies a coordinated system between recyclers and refurbishers. A clear list is required of registered recyclers and refurbishers, as is a mechanism to collect e-waste from schools.

In terms of e-waste control and handling, the act provides that the National Environmental Management Authority may establish a system of e-waste control and handling within Kenya and a collaborative mechanism in Africa. Such a system is required when broadband connectivity is upscaled, to recycle not only the e-waste emanating from connectivity but also the hardware used in schools. The technology exists to electronically scan conveyor belts of assorted, shredded e-waste. Once the economics are right, the widespread use of shredding and sorting equipment has the potential to virtually eliminate e-waste (Lawless, 2008).

Clear data destruction procedures are needed before disposing of e-waste. The Kenya Bureau of Standards Information Learning, Education and Technology Committee has also established clear standards on minimum requirements for computing equipment accepted in education institutions, which include devices that minimize energy consumption and clean energy. Other recommendations are to budget for a disposal fee for e-waste and to purchase the most efficient equipment (including green energy) (Clune, 2010).

5.4.3 Education on recycling of e-waste

Students and teachers can be educated about what is in the computer and its worth on today's market, how e-waste affects the environment and carbon footprints (including how to calculate them), what the waste management industry is doing to handle e-waste management, and the mechanisms in place to refurbish and recycle e-waste. This should be part of both the competence-based and the teacher training curricula. Schools can raise funds by auctioning parts and devices that remain valuable and are identified as e-waste, or donate them to specific agencies that can use them.

Conclusion

Schools need clear mechanisms for the disposal of e-waste. This can be coordinated through a centralized national agency linked to technical training institutions that can help refurbish and recycle e-waste. A multi-pronged, multisector approach is needed to handle the disposal of e-waste. Training of teachers and students will foster awareness of how to dispose of e-waste.

Section 5 –Summary	
Social aspects	
1	*Inclusion:* Internet access for special needs groups must be improved in schools. In integrated schools, this can be done by providing assistive technologies to enable access to content, content creation and organization, and classroom participation.
2	*Priority premises in schools:* Broadband connectivity is needed in all premises, but especially teacher staffrooms, computer and science labs, and libraries.
3	*Gender equality and Social Inclusion:* Policies should be in place to promote greater equality and access to learning resources for disadvantaged groups and to recognize the risks to which the marginalized are exposed.
4	*Connectivity usage:* Broadband connectivity was used for teaching, learning and communication activities, including to access the Kenya Institute for Curriculum Development portal, a major gateway to curriculum materials.
5	*Connectivity enablers:* The enablers were availability of ICT devices and online digital materials, digital literacy and Internet connection hotspots.
6	*Digital literacy:* Lack of digital skills among teachers and students is an issue that should be addressed. Teachers need skills to make effective use of Internet resources.
7	*Open education resources:* The content and devices that teachers can make use of must be identified. These include massive open education resources.
8	*Quality of connectivity:* Broadband connectivity was inconsistent. A centralized system is needed to regulate and monitor the state of connectivity in schools nationwide.
Economic aspects	
9	*Effective use of USF funds:* A mechanism is needed that enables schools to provide direct feedback on broadband connectivity to a third party, not a service provider.
10	*Procurement of ICT devices:* ICT devices can be procured using a mix of centralized and decentralized mechanisms.
11	*Budget considerations:* When providing broadband connectivity, the needs of schools and colleges must be analysed with a view to the SMART acquisition of ICT devices. Schools should target a computer: student ratio of at least 1:10.
12	*Infrastructure considerations:* Secondary schools need to be equipped with computers. Schools can be offered an initial subsidy for capital expenditure on router and access points.
13	*Other ways to raise funds:* Schools can finance ICT investments by having computer studies students develop content, animated sequences and computer programmes.
Governance aspects	
14	*Strategic importance of broadband connectivity:* Broadband connectivity can boost access to and the creation and sharing of teaching materials, including for learner engagement.
15	*Oversight responsibility in the school:* School leadership should provide a framework for ICT integration into all education services through school ICT policies and procedures, with clear persons in charge and timelines.
16	*Security and privacy:* Mechanisms are needed to ensure child online safety and security.

(continued)

Section 5 –Summary	
17	*ICT training:* Teacher training sessions should cover *inter alia* the creation of educational content and applications, curriculum development, alignment and assessment, training and usage support, and security of ICT devices.
18	*Support:* Technicians can work together with computer studies teachers to develop curriculum and maintain connectivity. Schools should have a helpdesk to support both teachers and students.
19	*Availability of online platforms for teachers and students:* Schools need integrated online platforms, provided through the Kenya Institute for Curriculum Development portal, online personal support for ICT devices and broadband connectivity.
20	*Soft skills required:* Teachers and students require digital skills to use computers and software applications effectively.
Environmental aspects	
21	*E-waste:* Procurement should include identifying needs, designing mechanisms to meet those needs, deciding on an appropriate tendering process, implementing tenders, and evaluating the impact and disposal of e-waste.
22	*Reuse and recycling of e-waste:* A coordinated system is needed between recyclers and refurbishers. Clear procedures are needed for destroying data before disposing of e-waste.
23	*Education on recycling e-waste:* Students and teachers can be educated about how e-waste affects the environment and about carbon footprints.

6 Challenges and successes

6.1 Challenges

The main challenges in terms of school broadband connectivity were unreliable connections, inconsistent power supplies, ICT skills gaps and limited funding.

6.1.1 Unreliable connectivity

In several cases, the broadband connection worked intermittently and the schools could not rely on it. In others, the connection was not available even though the routers showed an active connection. The signal was sometimes weak and therefore could not be used to download videos. In some cases, the connection was deactivated when the contract expired without notice. Such issues can be overcome by having both local and regional polling of routers, including a clear communication channel between the ISP and the school. It is important that all ISPs have a dedicated helpline, especially for schools. A clear log of connectivity status should be shared monthly with project schools and funders. Subsidized packages for schools can help with this.

This report acknowledges that unreliable connectivity and poor user experience may be attributed in part to the low capacity provided, i.e. 5 Mbit/s, versus the large number of users; inadequate or lack of basic troubleshooting skills among teachers; and the technology used, which may be a factor where VSAT was provided, because VSAT is more affected by weather.

6.1.2 Inconsistent power supply

Some schools experienced an inconsistent power supply. They need alternative energy sources and backup devices. Partnerships with governmental agencies and NGOs (e.g. Ovo Energy, We Share Solar and the Rural Electrification and Renewable Energy Corporation) can lead to sustainable off-grid solutions, especially for remote schools.

6.1.3 ICT skills gaps

There was a dearth of ICT skills among teachers and students. This meant that, even in situations where the computer devices were few, they were not used optimally. The ICT skills gaps can be resolved by having in-house and out-of-school training sessions for teachers. In the case of students, ICT skills can be embedded into specific courses. Skills training needs to include critical thinking and writing skills, to contextualize and create new materials. Other skills that can be embedded are self-control in the use of the Internet and safe online surfing.

6.1.4 Limited funding sources

Very few schools ventured to access other sources of funding to support ICT expenditure. This affects the long-term sustainability of ICT projects. In addition, the lack of clear budget allocations for ICT and connectivity expenditure implies that schools will continue to depend mainly on government and other external agencies. School leadership needs to be convinced of the importance of ICT expenditure in improving teaching and learning outcomes. Schools must be made aware of how much to allocate in the light of school size and location. Schools offering computer studies should ensure that students create solutions that either alleviate some of the challenges facing the school or generate revenues for it, by creating animated

sequences or videos and engaging in crowdfunding. For schools to do this effectively, some of these funding initiatives should be incorporated into training sessions. Subsidized connectivity and ICT devices can greatly assist schools:

> Public national or regional broadband plans, public tenders and networks provided through private–public partnerships, as well as the promotion of competition and private investment, coupled with the design and implementation of suitable regulations can help enhance both access and affordability. Coverage, especially in remote areas, can be promoted by means of competitive pricing strategies in public tenders, through public–private partnerships. (OECD, 2018)

6.2 Successes

Despite the challenges, broadband connectivity yielded several successes in schools. It has made it easier to access information, enabled support of learning activities, including evaluations, and improved graduation and retention rates.

6.2.1 Ease of information access

Broadband connectivity made it easier to obtain quality information and materials produced both locally and internationally. In some schools, it enabled access to efficient data and exam management systems. Communication between local schools was made easier, thereby facilitating school management.

6.2.2 Support for learning activities

Schools that previously could not access the National Education Management Information System were able to do so and therefore provide updated school statistics, to inform better decision-making at national level. Students were able to access extra material and therefore improve their research skills and grades. In addition, teachers could access more questions from question banks. It became easier to monitor performance and student conduct in schools.

6.2.3 Improved graduation and retention rates

Computer studies students were able to access more information, manage classrooms and engage more with practice videos. Some teachers used the connectivity provided for personal professional development, attending, for instance, online post-graduate courses. Connectivity therefore ensured that they could continue their studies. Improved classroom engagement was linked to improved graduation rates for students. Digital gender equality was achieved by providing the same access to connectivity and digital materials in schools for boys and girls. The broadband connectivity provided enabled the achievement of Sustainable Development Goal 9c (connect each woman to the Internet by 2020). The project thus had a strong capacity to improve the employability of both girls and boys, opening new economic opportunities.

6.3 Limitations and possible engagement opportunities

The assessment did not examine relations at the micro and meso levels, i.e. between various national State and non-State actors, or processes and activities between meso-level participants,

i.e. the procurement and tendering processes/procedures between State actors and connectivity providers, a critical project success factor. The tendering process requires a separate, deeper examination by an independent public procurement authority (capable of making decisions free of political and other unwarranted influences) (UNESCO, 2015; Nyeck, 2016) and should examine whether statutory law and administrative rules and procedures were followed; the tendering process itself (opening and bidding process, translation of the functional into technical specifications); the process for assessing tenders and awarding contracts; contract management; procurement risk (Edquist , Vonortas, Zabala-Iturriagagoitia, & Edler, 2015); whether public interest criteria were considered; market engagement; budgetary aspects (capital and operational expenditure); whether Kenyan public procurement policy, strategy and targets were met; management of USF funds by ISPs; risk management in service provision; e-procurement standards and procedures; adherence to standards for procurement, innovation and coordination; communication; and capacity-building standards. These matters can be addressed in other reports.

The assessment did not cover specific State actors, i.e. external school stakeholders, who are critical in ensuring that the broadband connectivity provided benefits to all internal stakeholders and include the Teachers Service Commission; the Kenya Education Management Institute; the Kenya Primary Schools Head Teachers and Secondary School Heads Associations; and the Kenya Institute of Curriculum Development. The Teachers Service Commission registers trained teachers, recruits and employs registered teachers, promotes and transfers teachers, and arranges teacher training sessions in liaison with the Kenya Education Management Institute. The Commission is important since, for any connectivity project to be a success, teachers must be assigned to an institution for some time to build an institutional culture and memory. The transfer of principals and computer studies teachers before the project was launched may have had a debilitating effect.

In addition, the Kenya Education Management Institute is instrumental when it comes to incorporating the suggestions for capacity development contained in this report. Its views, combined with those of the Teachers Service Commission, can result in a more holistic approach to the issues and challenges identified. It is therefore imperative to obtain the views of both institutions on this report and to bring them on board as critical stakeholders. The Kenya Primary Schools Head Teachers and Secondary School Heads Associations can provide regular (biannual) status reports on the state of broadband connectivity in schools when the project is upscaled. Their views on the report are important to ensure buy-in by school heads. The Kenya Institute for Curriculum Development is critical in ensuring digitization, appropriate policy formulation relating to curriculum development and alignment with the Competency-based Curriculum to include soft skills. It is also instrumental in providing a unified gateway, not only to the curriculum materials but also to the other materials required for effective management of schools. It is therefore imperative to include the views of all these stakeholders.

In terms of contextual scope, it is important to conduct a deeper qualitative study of the special needs of integrated schools, so as to obtain greater insight in terms of the schools' needs for digital hardware, connectivity and software, and of the resulting annual budget considerations. This will lead to greater social inclusivity. The assessment also did not examine the various procurement processes used, since the choice of service providers was restricted.

Section 6 – Summary	
1	The challenges were an intermittent (unreliable) broadband connection; an inconsistent power supply; a dearth of ICT skills among teachers and students; and the failure of most schools to access other sources of funding.
2	The successes included the following: broadband connectivity made it easier to obtain quality information and materials produced both locally and internationally; schools that previously could not access the National Education Management Information System were able to do so and provide updated school statistics to inform decision-making; computer studies students were able to access more information and engage more with practice videos.
3	The assessment was limited in that it did not examine relations at the micro and meso levels or the tendering process, which requires a separate, more in-depth examination by an independent public procurement authority. It did not obtain the views of specific State actors (external stakeholders) playing a critical role in ensuring that the broadband connectivity provided benefits all internal stakeholders.

7 Conclusion and lessons learned

The USF framework provided in the annex 2 was drawn up based on the comments of ITU staff and consultants, a review of existing frameworks, and Kenya's 2021 access gaps study. It identified more aspects to the objectives of the USF project and expanded the project to include other indicators and measures relating to, for instance, environmental sustainability, infrastructure, policies and ICT devices required. It can therefore be adopted and adapted in other countries to measure the effectiveness of a USF project in schools.

Broadband connectivity was taken to be a critical resource in all schools. The critical question was: is the school connectivity project a success? The answer varied depending on the context. Remote schools faced greater challenges than those that were closer to urban areas. In addition, the project covered very few integrated schools, which should be broadband-enabled for persons with disabilities. Women and men (girls' and boys' schools), according to the sample selected, faced similar challenges in terms of broadband connectivity and use. Many schools applauded the project and found it timely.

7.1 Good practices for USF project design

The suggestions in terms of good practices for universal service fund (USF) project design are based on the outcomes of the project assessment and guidance provided in the ITU Universal Service Efficiency Toolkit.

7.1.1 Pre-project design

School connectivity should be designed first according to type of geographic region and subsequently according to type of school. The geographic region can be rural, peri-urban or urban. Peri-urban schools are located in dynamic zones of transition between rural and urban areas (Rauws & de Roo, 2011) and determined by daily commuting distance to the central business districts of a nearby city (Mandere, Ness, & Anderberg, 2010). Most schools were in peri-urban areas and had well-established voice, data and electricity connections. Of the roughly 37 930 primary and secondary schools mapped in the access gaps report, 2 703 were located within 2 km, 15 722 (41.5 per cent) within 10 km and 75 per cent within 20 km of a fibre node (CA, Kenya's Voice and Data Access gap study, 2021). Student numbers in many of the peri-urban secondary schools ranged between 300 and 800.

The aim was to offer the schools 200 GB of data per month at speeds of between 10 and 20 Mbit/s (ITU, 2021). The Giga initiative new definition of meaningful connectivity is 10 Mbit/s per school, but it is advisable to target 20 Mbit/s per school where possible (10 Mbit/s is sufficient to work on documents, take exams, give feedback and watch online videos; 20 Mbit/s are needed to run several videostreams per school and cloud-based applications). Students with access to more than 20 Mbit/s at school and to 2 Mbit/s at home were able to videostream in class, sit exams and watch videos. In the case of larger schools, the target was 1 Mbit/s for 20 students. This implied an average speed of 15 Mbit/s for a school of 300 students.

The minimum monthly data package was 100 GB. Giga advises a target of 200 GB per month. Even in the case of small schools, the target of 10 Mbit/s per school should be the minimum. Giga's download speed for meaningful connection is 10 Mbit/s; the upload speed is 2.5 Mbit/s. Giga advises that the minimum download and upload speeds be doubled. The infrastructure

currently being set up by service providers can be expanded to 20 Mbit/s download speed and 5 Mbit/s upload speed if extra funding is made available.

Broadband access needs to be provided on an equal basis to boys', girls' and mixed schools. Peri-urban and urban areas have the capacity for fibre and wireless ISPs. USF funds can be allocated to remote areas according to energy, connectivity and security criteria. Remote areas without a power supply or connectivity should be given additional (last-mile) funding by the government, and public–private partnerships should be used to extend connectivity to them. Areas without a power supply or connectivity and in which security is a concern need to be provided with last-mile connectivity after community consultations and once administrative police posts have been set up close to the schools, to prevent arson and theft. The connectivity should be set up to serve multiple purposes, for instance to help open business opportunities and administrative offices. The initial subsidies can gradually be phased out and the responsibility for connectivity slowly transferred to the schools.

In terms of distributing Internet connectivity, peri-urban and urban schools can be allowed to tender as per the procurement manual for schools. Operational responsibility can fall to both the ISPs and technicians. Remote schools need additional funding and Internet service provided by telecommunication companies according to network reach. The funding should come from both the government and public–private partnerships, and take the form in particular of tax relief and subsidies.

Fibre, WISP and 4G connectivity are more viable for urban and peri-urban schools. Fibre requires more capital expenditure than WISP and 4G (and at times has higher operational costs) and therefore provides more efficient opportunities for schools. Satellite connectivity can be explored in extreme cases where schools are very remote or in insecure areas, and where there is a very strong case to support other economic activities. In such cases, an in-depth needs assessment involving community stakeholders must be carried out.

In relation to funding models, many of the schools assessed relied on government and CDF funds. The most viable options are thus those that combine government and commercial providers. In this case, the most viable and sustainable funding model for broadband access in most schools in Kenya will be public–private partnerships. The government needs to provide subsidies and tax incentives to enable companies/businesses to support education institutions. Development finance institutions and multilateral development banks can also provide additional funding. Furthermore, companies can be encouraged to consider subsidizing broadband access connectivity for schools located nearby, in a form of corporate social responsibility. Schools in remote and insecure areas, on the other hand, should adopt a full ecosystem model. Communities can provide an indirect non-monetary contribution by ensuring that communication equipment is guarded. Both the project design and the contract should clearly stipulate the roles of each specific entity involved, the objectives and deliverables, timelines, costs, school site configuration, details of technical services, and how the whole process will be monitored and evaluated. The public tendering process for schools should also be competitive, clear and consistent with school needs.

7.1.2 During implementation

During implementation, all stakeholders need to be involved. The school leadership needs to know its responsibilities and duties in terms of ensuring that connectivity is consistent and that ICT requirements are met. This can be spelled out in ICT policies. The ISPs need to provide

regular (weekly) reports to funders and schools on equipment, bandwidth management, utilization and content filtering. This includes polling reports that detail download and upload speeds. A site should not be transferred to the user until the service has been tested and meets the agreed standard. Technicians and computer studies teachers should be trained to manage the network. They should also be provided with information on which school sites are active, on their monitoring and how to upgrade and expand them. Training to provide technical services should be longer than one half day and extended to one week; it should be extended to at least five other staff members, as per the current contractual arrangements. There should be a clear reporting mechanism for network outages and schools should know who specifically they should contact when problems arise. A regional (county) reporting centre linked to each educational institution can help compile national statistics and yearly reports on the state of broadband connectivity in educational institutions. It also enables effective allocation of national resources.

7.1.3 Post implementation

There should be a clear post-implementation follow-up mechanism. Teachers and students should be constantly trained and attend regular training sessions to learn new digital skills. A post-implementation review should be conducted biannually and should include a checklist that gauges the quality of connectivity as per the project scope (speeds, reliability, coverage) and of the support provided (performance); complaints and liabilities (what did not work); successes and opportunities (what worked); connectivity audits; procedural audits; project costs and benefits; skill sets acquired; lessons learned; and recommendations. One person in the school should be responsible for conducting the post-implementation reviews and should be answerable to the school leadership. The post-implementation reviews should be part of the annual school reporting plan.

7.1.4 Sustainability

The assessment raised questions about the sustainability of broadband connectivity post-implementation. The initial costs of connectivity to public schools can be funded through local and international sources (government funds, USF, debt financing, development money). In time, however, the schools will need to be able to pay the costs of connectivity themselves, partially or in full. This is why school connectivity needs to be linked to other opportunities outside the school. Businesses and other organizations (e.g. health facilities, administrative offices, public libraries) need to understand that using the connectivity nodes can translate to increased profits. Communities can also benefit from improved connectivity and should therefore be enabled to set up businesses that rely on the Internet. Cross-subsidization and other tax reduction mechanisms can make connectivity more affordable for schools, which can also distribute the cost of connectivity within the school's term fee structure.

In the long term, the funding method depends on the school's ability to monetize Internet access and receive government funding. It can range from making a percentage of connected persons part of the licence agreement to Build Operate Transfer arrangements for network infrastructure, government co-investment with a service provider, coverage as a service through revenue sharing, coverage as a service (capital expenditure model) and community collaboration. The private sector is an important agent for funding connectivity (ITU, 2021). The subsidies identified in the Voice and Data Access Gaps study (Communications Authority, 2021), divided between Tier 2 (Passive) and Tier 1 (Active) bidders, can lead to a reduction in rental charges well below

the commercial benchmark (CA, Kenya's Voice and Data Access gap study, 2021). Annex 7 provides a design overview.

7.2 Practical and policy recommendations

The Policy Framework for Science, Technology and Innovation 2012 refers to ICT as a national priority area for policy intervention and the development of the ICT industry as a means of discharging the mandates set out in the Constitution of Kenya 2010 and Vision 2030. The seventh objective of Sessional Paper No. 1 of 2019, A Policy Framework for Reforming Education and Training for Sustainable Development in Kenya, is to integrate ICT into curriculum delivery and management in education and training. This implies that learning and academic management systems have to be used to manage educational institutions, either in terms of pedagogy or purely from the management point of view. It is therefore critical to provide these applications when enhancing education delivery in schools alongside connectivity. Furthermore, Chapter 5 identifies ICT as a foundation for socio-economic transformation, referring to the current inadequacies in Internet connectivity, capacity among educators, digital content and ICT standards and guidelines in content delivery (both in curriculum delivery and assessment). These specific issues have not changed since the release of the sessional paper, as demonstrated by this assessment, and all public and private agencies therefore need to act on them. Public–private partnerships are important to address these critical challenges.

Furthermore, the Basic Education Curriculum Framework 2016, in line with the section on curriculum reform, identified digital literacy as a core competency. This means that, apart from ICT connectivity, basic ICT connection devices should be provided from lower to higher levels of education. The framework foresees the design of curriculum within a collaborative digital application to support flexible and self-paced learning, which requires appropriate investment in infrastructure. This implicitly assumes access to learning management systems such as open-source software and open educational resources, which can enrich the teaching and learning experience in schools. It also requires that teachers be equipped with skills that allow students to learn at their own pace. Some of these skills can be provided in teacher training sessions.

In relation to disaster management, the Education Sector Disaster Management Policy 2017 should include the integration of ICT in all school operations, since it is critical school infrastructure. It should detail what should happen if a disaster occurs and critical ICT infrastructure is disabled or destroyed. The principles of the same policy should include the right to digital connectivity, and section 2.1.8, on child protection, should add online child protection as an important aspect and incorporate ICT into disaster recovery plans. Child safety manuals can incorporate child online protection in consonance with Principle IV of the framework, on promoting sound moral and religious values.

The knowledge and skills acquired at various levels should include self-discipline and self-control in the use of online content and information by both teachers and students. Chapter 3 of the Mentorship Policy Manual 2019, on policy provisions, provides for the possibility of ICT mentorship for learners and for persons with disabilities. It explicitly states that mentorship is needed to educate learners in the safe use of ICT, especially because of the new challenges of misleading information, moral degradation and antisocial behaviour. Teachers can mentor learners on self-control in the use of ICT equipment and the need to follow specific regulations. This can be embedded in the values-based educational content of the new curriculum and should include how to respond to various forms of cybercrime. Students and teachers need

to be made aware of the implications of the Data Protection Act 2019, especially Part IV, on personal data protection principles and obligations. The Kenya National Health Strategy (2015) should incorporate the online protection of children in the sections on child rights, protection and responsibilities, and on school infrastructure and environmental safety. Handbooks on safety standards for schools can stipulate various measures to ensure the protection of children using ICT devices and accessing the Internet. They should refer explicitly to safe use of ICT, including by children with special needs and disabilities.

On social inclusivity, under the Sector Policy for Learners and Trainees with Disabilities 2018, the Kenya Institute of Special Education works together with partners such as the Teachers Service Commission to ensure that teachers can incorporate ICT as and when needed. Furthermore, the sector policy for learners with disabilities, specifically Article 35 of the Persons with Disabilities Act (2003), stipulates an allowance on tax, demurrage, port charges, value-added tax and other government levies for materials, articles and equipment to be used by individuals with disabilities, institutions and persons. This encourages public–private partnerships to support integrated schools and remote school budgets. The Persons with Disabilities Act explicitly states that the Ministry of Education, Science and Technology is to facilitate the maintenance of specialized learning resources, assistive devices and technologies, including trained ICT experts, at all levels of education. The Education Sector Gender Policy 2015 clearly states that ICT use is to be facilitated and encouraged in all education areas, in line with the Basic Education Curriculum Framework, in order to expand access to gender-sensitive and responsive education. The easy-to-read version of the Education Policy on Trainees and Learners with disabilities 2018 indicates that the Ministry of Education, Science and Technology will make sure that learners with and without disabilities learn together and that teachers have training in special needs education – which will therefore have to be included in teacher performance and development training.

Under Article 57 of the Public Procurement and Asset Disposal Act 2016, the head of the procurement function of a procuring entity maintains and updates lists of registered suppliers, contractors and consultants in the categories of goods, works or services; these can include ICT vendors of hardware, software and connectivity, notwithstanding the standard procurement and disposal procedures promoting fairness, equitability, transparency, cost-effectiveness and competition. The inclusion of more suppliers makes it easier to meet the various public procurement values. The methods of procurement are listed in Part IX of the act and include open tenders, two-stage tendering, design completion, restricted tendering, direct procurement, request for quotations, low-value procurement, force accounts, electronic reverse auctions and competitive negotiations. The procurement methods are not restricted to tendering but include direct procurement, requests for proposal, requests for quotation, low-level procurement and specially permitted procurement. The procurement manual for schools and colleges should reflect these diverse procurement methods. The same manual encourages open and competitive procurement (under the head of department), in line with the subsequently formulated Public Procurement Act 2016. It therefore follows that procurement of school connectivity and devices can be open and competitive.

Lastly, each school should have a sophisticated e-waste management policy. The policy should be supported at the meso level, to facilitate the process of receiving and disposing of e-waste. The existence of a national framework and legislation is a critical enabler for e-waste management.

7.3 Perspectives

Areas for future investigation include the impact of a more open socialization process, enabled by broadband connectivity, on students' academic performance and life skills, given that connectivity has both social and academic effects; and the impact of a decentralized procurement process involving varied procurement methods at national level. In addition, once specific digital skill sets have been included in teacher training, a longitudinal study should be conducted of how this has affected teaching and learning outcomes.

A central education office should be established to collect information on cybersecurity in education institutions. The office could act as a focal point for research on cybersecurity and computer misuse, and provide timely suggestions to education institutions on additional content for curricula. Its terms of reference could be expanded to include tracking e-waste management in education institutions, with a view to the establishment of a recycling and refurbishment system.

The instruments developed in the school connectivity assessment should be encoded on an appropriate platform such as the National Education Management Information System, so as to obtain annual feedback from education institutions. A national monitoring education office for Internet connectivity can facilitate the formation of appropriate future policies and mechanisms for ICT connectivity and support.

Section 7 – Summary	
Good practices for USF project design	
1	Pre-project design: School connectivity should be designed first according to geographic region and subsequently according to type of school. A speed of 10 Mbit/s is sufficient to work on documents, take exams, give feedback and watch online videos. Speeds of 20 Mbit/s are sufficient to run several videostream stations per school and cloud-based applications. In the case of larger schools, 1 Mbit/s for every 20 students is the target. This implies an average speed of 15 Mbit/s for a school of 300 students. The monthly minimum data package is 100 GB. The Giga initiative advises a target of 200 GB per month. Even in the case of small schools, the target per school of 10 Mbit/s should be the minimum. Giga's download speed for meaningful connection is 10 Mbit/s, with an upload speed of 2.5 Mbit/s. Giga further advises that the minimum download and upload speeds be doubled.
2	During implementation: The school leadership needs to know its responsibilities and duties in terms of ensuring that connectivity is consistent and that ICT requirements are met. ISPs need to provide regular weekly reports to funders and schools on equipment, bandwidth management, utilization and content filtering. This includes polling reports that detail download and upload speeds. A site should not be transferred to the user until the service has been tested and is declared to meet specified standards.
3	Post-implementation: Post-implementation reviews should be conducted biannually and include a checklist that gauges the quality of connectivity as per the project scope and of the support provided; complaints and liabilities; successes and opportunities; connectivity audits; procedural audits; project costs and benefits; skill sets acquired; lessons learned; and future recommendations.

(continued)

Section 7 – Summary	
4	Sustainability: The initial costs of connectivity for public schools can be funded through local and international sources (government funds, USF, debt financing, development money). In time, however, schools will have to meet the costs of connectivity themselves, partially or in full. School connectivity needs to be linked to other opportunities outside the school.
Practical and policy recommendations	
	The Basic Education Curriculum Framework requires schools to have access to learning management systems. It requires teachers with skills that can allow students to learn at their own pace. Some of these skills can be provided in teacher performance and development training sessions. The following policies should be update: Education Sector Disaster Management Policy 2017; Mentorship Policy Manual 2019, Chapter 3; Sector Policy for Learners and Trainees with Disabilities 2018; E-waste Policy. Other documents that need updating to reflect ICT use and issues of child safety are the Child Safety Manual and the Safety Standard Manuals for Schools.

Annexes

Annex 1: References

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Annex 2: Sustainable model for a school connectivity project (framework used to develop the survey)

Sustainable dimensions	Aspects to be measured	Measurement
Environmental	Analysis of broadband connectivity at schools in terms of environment/landscape, disposal, health	Amount of plastic and waste from ICT and communication equipment at schools; use of materials that can be reused/recycled or refurbished; use of renewable forms of energy in communication
Social	Analysis of geo-demographic factors Population of students and teachers; location; type of school (mixed or single sex); ownership of school Analysis of socio-demographic factors Services and content application (quality of service, affordability, consumer protection, disruptive technologies, net neutrality, data protection, competition, language, child online protection, digitization of curriculum, intellectual property rights, public key fields) Learner readiness/skills IT and Internet experience of learners Ability to cope with different learners' IT skills Self-efficacy of learners Location of learners Privacy and security (infrastructure, detection, enforcement) Instructor readiness/ability to facilitate discussion and willingness to contact and follow up students Ability to promote online learning and different assessments	Geographical aspects/counties and locations of schools to be connected Internal stakeholders, i.e. teachers, students and other community members who can benefit and documentation of actual benefits Clear numbers of stakeholders who have benefited from the project at school level and ways they have benefitted Amount of money spent by the school for services and content Ability of schools to continuously use broadband connectivity for educational aims Type of protection given to school users accessing and using broadband (privacy) Can safety software be updated remotely? Can devices and equipment be traced/tracked? Are the schools physically secure? Measures in place to ensure that students/staff with disabilities can use the solutions provided on an equal basis Equal gender adoption basis (security, enrolment levels (is education compulsory?), literacy, affordability Amount and type of digitized content accessed (Kenya Institute for Curriculum Development or other) Number of teachers who can and actually do use the broadband network Type and number of new ideas/innovations at school level

(continued)

Sustainable dimensions	Aspects to be measured	Measurement
	Self-efficacy of teachers Location of teachers/trainers Integration of Internet use into normal subjects Use of ICT-enabled communication media and forms of communication	Number of training sessions on sustainable use of broadband connectivity Number of learners who use broadband connectivity vis-à-vis intended number Type and form of use of broadband connectivity Number of training sessions in broadband use
Governance	Strategic agenda (global market/country competitiveness; sustainable development; new areas) Sector agenda (new agendas; penetration and growth; adoption and usage) Infrastructure and connectivity theme Affordability for the school, spectrum management, type of rural broadband infrastructure Capacity building and innovation at school level (local professional certification/ training in critical broadband premises within the school; intellectual property rights) Institutional support (micro)/adequate technical support, resources for faculty/teachers to plan and design learning, embedding instructional technologies; institutional technical support; library support Infrastructural readiness (availability of a reliable and robust online platform system; Internet connection standards; form of Internet access) Availability of course content: technical and soft skill training to use content	Communication to school community of strategic importance of broadband Commitment of school to use broadband shown in terms of type, % and form of use % use of broadband connection in the school and premises where it is used Where is the access (in a classroom? library? computer lab? whole campus?) Number of training sessions per school and certification of teachers and students who use broadband Number of support staff available per school; resources available and generated for use in teaching and learning; training in instructional design Number, % and type of broadband connectivity at school level; availability of access to an online platform for both teachers and learners; clear safety standards for learners and teachers at school level (procedures/rules and safety equipment) % of useful content made available by broadband Number of learners and teachers who have developed new soft skills thanks to broadband Form and type of soft skills developed

(continued)

Sustainable dimensions	Aspects to be measured	Measurement
Economic	Operators' business model aligned to school/user's requirement Devices (quality and accessibility) Finance and investment (integrated infrastructure development, special purpose vehicles, design, implementation, operation, maintenance) Content readiness: adapting or adopting of content according to cost considerations School budget to purchase resources Infrastructure available at school Access to computer resources at school Number and quantity of computer resources	Broadband efficiency (in terms of resource use) aligned with school needs (teachers and students) Type and number of devices Cost and affordability of new types of devices required for broadband connectivity Is the school aware of USF subsidy programmes? Of department of education subsidy programmes? Of operator subsidy programmes? Provision of extra sources of financing for schools without broadband connectivity or devices (form, amount, type) Cost of maintaining broadband connectivity at school level Capacity of school to produce online learning content Capacity of school to use online learning content Number of students who access computers at school and for how long

Annex 3: School connectivity survey

School connectivity survey

Invitation

We would like to invite you to take part in the ITU connectivity survey by completing this questionnaire. You have been identified as a potential respondent by ITU. Participation is entirely voluntary, but your responses would be valued and appreciated. This form is to be filled in by the principals and/or computer studies teachers.

Introduction

ITU, the United Nations specialized agency for ICTs, and the United Kingdom FCDO share a vision for digital inclusion and a keen desire to implement a diversity of programmes in service of this vision. ITU is working with the FCDO Digital Access Programme to promote effective regulation, greater investment and innovative models for school connectivity in underserved communities. In support of the work under Activity area 1, on Regulatory Analysis, Framework and Tool Development to support digital inclusion objectives, ITU seeks to assess the school connectivity project funded by the Universal Service Fund in Kenya. Your school has been identified as one of the schools connected to the Internet through Kenya's Universal Service Fund. We would therefore ask you to spare 25 minutes to complete this survey, the purpose of which is to evaluate the effectiveness of the school connectivity project. It is hoped that your answers will enable us to provide you with further support for using the connectivity and help us to develop lessons for enhanced connectivity across the country. The survey has five sections: background information; social effectiveness; economic effectiveness; governance aspects; and environmental effectiveness.

Discomfort and risk

There are no risks or discomforts of any kind involved in the collection of data.

Benefits

The information obtained from this survey may be used by the ITU and the Kenya Communications Authority for data analytics and to formulate policies to enable better connectivity in schools.

Reward

Your participation is voluntary and you may choose to participate or not to participate without any reward or penalty. It is within your right to answer or not to answer any question in the survey.

Confidentiality

This research and your responses will be considered strictly confidential. Your identity will be kept anonymous. Please note that this survey only requires biographical details (e.g. gender, name of the school, county, age, type and form of school and education system) to help us produce summary statistics but these will not be used in any attempt to reveal your identity. Data management principles encourage researchers to share the information that they collect

and that information can be held for 10 years or more, but we will never share anything with any other person that names you or identifies you in any way, without your explicit consent.

Contact information

For any queries or clarification, you can contact the following persons: Dr Alfred Kitawi (akitawi@strathmore.edu) or Ms Regina Nkonge (regina.nkonge@itu.int).

Survey instructions

It is not a must to answer all the questions in the survey and respondents should feel free to complete the survey selectively.

Glossary of terms

CDF	Constituency Development Funds, central government funds given to members of parliament for expenditure on their constituencies
Commcarrier	Licensed regional telecommunication operator headquartered in Nairobi, Kenya
Computer	A programmable device (e.g. desktop, laptop) that stores and processes data
Computer studies	An optional subject in the final secondary examinations, sometimes referred to as ICT
Cybersecurity	The practice of protecting computers, servers, mobile devices, electronic systems, networks and data from malicious attacks Also known as information technology security or electronic information security
Data privacy/security	The process of protecting data from unauthorized access and data corruption
Digital literacy	The skills needed to live, learn and work in a society where people increasingly communicate and access information through digital technologies such as Internet platforms, social media and mobile devices Communication is a key aspect of digital literacy.
Electronic/e-waste	Discarded electrical or electronic devices Used electronics destined for refurbishment, reuse, resale, salvage, recycling through material recovery or disposal are also considered e-waste.
ICT/information and communication technology	The infrastructure and components that enable modern computing or technology; also includes devices, networking components, applications and systems that combined allow people and organizations to use technology
ISP/Internet service provider	An organization that provides services for accessing, using or participating on the Internet
LMS/learning management system portal	A portal designed to enable administrators and content creators to create, distribute and manage training content

(continued)

Liquid Telcom	A technology group that provides digital solutions to businesses in the public and private sectors across the continent
Mbit/s or Megabits per second	A measure of broadband speed (the higher the number of Mbit/s, the speedier the online activity)
Soft skills	Interpersonal skills that characterize a person's relationships with other people
Telecommunication carrier	An operator that covers all entities that provide some form of telecommunication service to consumers, such as telephony or data communication access
USF/Universal Service Fund	A fund for ensuring that telecommunication services are accessible to the widest number of people at affordable prices
VSAT	A small-sized earth station with a very-small-aperture terminal, used to transmit/receive data, voice and video signals over a satellite communication network, excluding broadcast television
WiMAX	A telecommunication technology providing wireless data over long distances in a variety of ways, from point-to-point links to full mobile cellular type access; the final leg in the delivery of wireless broadband connectivity from a communication provider to a customer and an alternative to cable and DSL
Xtranet	A provider of integrated communication, business and technology solutions

Section A: Background information

School information

1. Name of the school (use the listing provided)
2. School county (drop-down bar)
3. Geographic classification of school
    - o Urban
    - o Peri-urban
    - o Rural

4. Nature of school
    - o Day
    - o Boarding
    - o Both day and boarding
    - o Other (please specify) _____

5. Type of school
    - Girls'
    - Boys'
    - Mixed: girls' and boys'

6. School funded through
    - CDF
    - Government
    - Parents
    - CDF and Government
    - Parents and Government
    - CDF and parents
    - Parents, Government and CDF
    - Church-sponsored
    - Other (please specify) _____

Teachers and student information

7. Total number of teachers at the school: _____

8. Number of male teachers at the school: _____

9. Number of female teachers at the school: _____

10. Number of female students at the school: _____

11. Number of male students at the school: _____

12. Number of students with disabilities at the school: _____

13. Number of teachers with disabilities at the school: _____

Infrastructure

14. Type of road leading to the school:

- o Dirt road
- o Tarmac
- o Gravel road
- o Murrum road
- o National highway
- o Concrete roads
- o Other (please specify) _____

15. Describe the power supply at your school.

- o Excellent: constant supply of electricity
- o Good: mostly constant supply with few interruptions
- o Poor: the electricity often breaks down or is interrupted
- o No electricity

16. Which materials do you access from the Kenya Institute of Curriculum Development portal?

- o KICD library
- o Kenya Education Cloud
- o Open Educational Resources
- o Learning management system portal
- o Other (please specify) _____
- o None

17. Please specify the telecommunication provider.

- o Commcarrier
- o Liquid Telecom
- o Xtranet
- o Other (please specify) _____

18. Please specify how the Internet connection gets to the school?

- o VSAT
- o Fibre
- o WiMAX

- o Other (please specify) _____

19. Please specify how the Internet connection is distributed in the school?

- o Local area network cables
- o Wi-Fi connection
- o Other (please specify) _____

20. Please specify the number of ICT hardware devices in your school and the support received through funds.

ICT	Count of ICT devices	Specify the support received through funds
Desktops		
Laptops		
Tablets		
Phones		
Other (please specify) _____		

Section B: Social effectiveness

Have access

21. Approximately how many students, and teachers currently use broadband connectivity?

Designation	Number
Female students	
Male students	
Female teachers	
Male teachers	
Persons with disabilities	
Other (please specify) _____	

22. Please list the school premises that have broadband connectivity (tick all that apply).

- o Library
- o Classrooms
- o Staffrooms
- o Computer lab
- o Other (please specify) _____
- o Whole school

Gender equality and social inclusion

23. Specify the measures taken to ensure gender-equal adoption of broadband connectivity.

- o Increased enrolment at the school
- o Improved security
- o Training
- o Affordable services
- o Not applicable
- o Other (please specify) _____

The section below is to be completed by respondents who reported having students and staff with disabilities in questions 12 and 13.

24. Specify what the school has done to ensure that students and staff with disabilities can use the broadband solutions provided on an equal basis?

- o Increased enrolment at the school
- o Improved security
- o Training
- o Affordable services
- o Special software and hardware
- o Special furniture and fittings as separate options
- o Not applicable
- o Other (please specify) _____

Pricing

25. How much does the school spend per annum on the following?

	100% subsidized	KES 11 000 (USD 100) or more per annum	KES 11 000 to 22 000 (USD 100 to 200) per annum	KES 22 000 to 33 000 (USD 200 to 300) per annum	KES 33 000 to 44 000 (USD 300 to 400) per annum	More than KES 44 000 (USD 400)	Not applica-ble	Who subsi-dizes the aspects labelled (a) to (h)?
(a) Connectivity – providing basic infrastructure (roll-out or expan-sion)								
(b) Connectivity – providing access, ICT devices, equipment and facilities								
(c) Capacity building/digital liter-acy training								
(d) Internet costs								
(e) Facilitating inclusion of persons with disabilities and other identified marginalized communities								
(f) Maintenance (e.g. device replacement)								
(g) Data security and privacy								
(h) Other (please specify) _____								

Connectivity usage

26. For which applications is broadband connectivity used (tick all that apply)?

- o School-related (e-mail, accessing school website/intranet)
- o Personal (web surfing, e-mail, downloading music, multimedia)
- o Student learning (e.g. computer studies)
- o Videoconferencing
- o Online learning
- o Integration (e.g. for online exams, library access)
- o Accessing education platforms
- o Other (please specify) _____

Enablers

27. In what ways has the network infrastructure improved **teaching activities?**

- o Access to more online materials
- o Incorporated into teaching
- o Used for assessment
- o Other (please specify) _____
- o Did not improve teaching activities, they are the same as before

28. In what ways has the network infrastructure improved **management activitie**s?

- o Improved communication with parents
- o Improved communication with teachers
- o Improved performance of students
- o Other (please specify) _____
- o Did not improve management activities, they are the same as before

29. In what ways has the network infrastructure improved **learning activities**?

- o More access to learning materials
- o Online assessment
- o Communication with students
- o Other (please specify) _____
- o Did not improve learning activities, they are the same as before

30. Please specify the amount saved/expended on ICT expenditure in Kenya shillings per year?

- o Amount saved _____

- o Increased expenditure _____

31. Please specify the number of new ideas in terms of teaching, learning and support services that have emerged in your school thanks to the project, if any.

Number of innovative ideas	Describe the innovative idea(s)
o None	
o 1	
o 2	
o 3	
o 4	

Tech literacy

32. Does the school have the personnel needed to conduct ICT training and certification programmes for other teachers and students?

- o Yes
- o No

33. Does the school offer computer studies as an examinable option?

- o Yes
- o No

Quality of connectivity

34. Does the quality of your school connectivity vary depending on the time of the day?

- o Yes, the quality changes throughout the day
- o No, the quality is always the same (skip to question 37)

35. If you answered yes to question 34, when is the connectivity better?

- o Early (6–9 a.m.)
- o Daytime (9 a.m.–6 p.m.)
- o Evening (6–11 p.m.)
- o Nighttime (11 p.m.–6 a.m.)

36. Does the quality of your school connectivity vary depending on the weather?

- o Yes, during heavy rains and storms
- o Yes, during strong winds

- o Yes, during sunshine
- o Does not change
- o Not sure

Section C: Economic effectiveness

Universal Service Fund

37. Please select the best answer to the following questions on the USF programme.

Aspects of the USF programme	Yes	No	I am not sure
a) Is there a specific USF programme for school connectivity?			
If yes, has the USF programme for school connectivity been utilized in this project?			
b) Is there a specific USF budget for school connectivity?			
If yes, has the USF budget for school connectivity been utilized in this project?			
c) Is there a government budget for school connectivity?			
If yes, has the government budget for school connectivity been utilized in this project?			

School budget

38. What is the school's budget in Kenya shillings? _____
39. Is there a subsidized budget line for connectivity?

- o Yes
- o No
- o I am not sure

40. Is there an unsubsidized budget line for connectivity?

- o Yes
- o No
- o I am not sure

Additional infrastructure and pricing

41. What types of new device will your school require to enhance broadband connectivity, online learning and tech-readiness?

Name	Number of devices	Approximate amount in KES
1.		
2.		
3.		
4.		

42. Is the school looking for other viable ways of financing ICT expenditure?

- o Yes
- o No

Section D: Governance

Communication to the school community of strategic importance of broadband

43. Is the school community aware of the strategic importance of broadband connectivity?

- o Yes
- o No

44. Does the school's vision include digital literacy and communication?

- o Yes
- o No

45. Does the school have an ICT policy?

- o Yes
- o No

46. If the answer to question 45 is yes, which internal stakeholders are familiar with the policy (tick all that apply)?

- o Principal/head teacher
- o Teachers
- o Students
- o Support staff
- o Other _____

47. If the answer to question 45 is no, why has such a policy not been adopted? _____

Responsibility for school connectivity

Security and privacy

48. What are some of the ways that the school has tried to make it secure for **students** to access the network and computers (tick all that apply)?

- o Firewalls
- o Antivirus software
- o Antispyware
- o Spam filters
- o Configuration of each of access point with MAC Addresses/Child online protection
- o A restricted number of accesses
- o Other (please specify) ____
- o None of the above

49. What are some of the ways that the school has tried to make it secure for **teachers** to access the network and computers (tick all that apply)?

- o Firewalls
- o Antivirus software
- o Antispyware
- o Spam filters
- o A restricted number of accesses
- o Other (please specify) _____
- o None of the above

50. Please answer Yes or No to the following questions on security and privacy.

	Yes	No
Does the school have a way of monitoring students' online activities?		
Does the school have clear rules about the information students can share when online or using a mobile device, laptop or computer at school?		
Can devices such as computers and other ICT equipment be tracked or traced?		
Is the school computer lab secure?		
Is the school physically secure?		

51. What data privacy and cybersecurity breaches have you experienced at school (tick all that apply)?

- o An unauthorized person gaining access to a laptop, e-mail account or computer network
- o Loss or theft of hard copy notes or USB drives containing personal data
- o Sending an e-mail with personal data to the wrong person
- o Other (please specify) _____
- o None

Number of training sessions held at the school and certification of teachers and students who use broadband

52. How often does the school offer formal training in broadband services to teachers or students?

	Never	Very rarely (once a year)	Rarely (three times a year)	Often (six times a year)	Very often (more than six times a year)
Teachers					
Students					
Others (please specify)					

53. Does the school offer certificates to those who complete broadband training?

	Yes	No
Teachers		
Student		
Others (please specify)		

Support

54. Who is the primary provider of maintenance and user support?

- o Dedicated school technician
- o Computer studies teacher
- o Other teachers
- o Internet service provider
- o Other (please specify) _____

55. Does the school have access to an ICT helpdesk or office staffed by technical personnel to assist with connectivity challenges?

- o Yes
- o No

Availability of access to an online platform for both teachers and learners; clear safety standards for learners and teachers at the school (procedures/rules and safety equipment)

56. Does your school have a portal to an academic management system or a virtual learning system providing school or learning materials?

- o Yes
- o No

57. How did COVID-19 affect the use of academic management and virtual learning systems?

_____

Number of learners and teachers who have developed new soft skills thanks to broadband access; form and type of soft skills developed

58. Please specify the number of teachers and students who have developed new soft skills since the introduction of broadband services.

Number of teachers and students who have benefited	Types of soft skills learned
Teachers:	
Students:	

Section E: Environmental effectiveness

59. What does the school do with its e-waste?

- o Sends it to the recycle centre
- o Dumps it in landfills
- o Returns damaged electronic devices to users
- o Keeps damaged electronic waste in stores
- o Sells it second-hand
- o Other (please specify) _____

60. How much plastic and electronic waste on average does the school dispose of per year (in kilograms)?

- o Less than 100 kg
- o 100–1 000 kg
- o More than 1 000 kg
- o None

- o I am not sure

Use of materials that can be reused/recycled or refurbished by the school in the broadband deployment.

61. Does the school use renewable energy to power communication?

    - o Yes
    - o No

62. If the answer to question 61 is yes, what kind of renewable energy? _____

End of survey: Thank you for participating in our survey, your feedback is very important.

Annex 4: Focus group discussion guidelines

ITU/Communications Authority of Kenya focus group discussion

Invitation

We would like to invite you to take part in an ITU connectivity focus group discussion. The discussion is championed by the Communications Authority of Kenya, which has partnered with ITU to provide broadband connectivity in secondary schools. You have been identified as a potential participant by the Communications Authority. Participation is entirely voluntary, but your responses would be valued and appreciated. The focus group discussions are open to principals or computer studies teachers. The person administering the discussion questions represents the expert employed to investigate the effectiveness of the school connectivity project.

Introduction

ITU, the United Nations specialized agency for ICTs, and the United Kingdom FCDO share a vision for digital inclusion and a keen desire to implement a range of programmes in the service of this vision. ITU is working with the FCDO Digital Access Programme to promote effective regulation, greater investment and innovative models for school connectivity in underserved communities and for broader digital inclusion in Kenya. To support the work under Activity area 1, on Regulatory Analysis, Framework and Tool Development to support digital inclusion objectives, ITU seeks to assess USF-funded school connectivity projects in Kenya. We have been informed that your school has been connected to the Internet as part of such a project. We would therefore ask you to spare 25 minutes to participate in this focus group discussion, the overall purpose of which is to evaluate the effectiveness of the school connectivity project. It is hoped that your answers to the questions asked will promote support for your use of the connectivity and help us to develop lessons for enhanced connectivity across the country. The focus group discussion has nine questions, some of which contain other, nested questions.

Benefits

The information obtained from this focus group discussion may be used by the ITU and the Communications Authority of Kenya for data analytics and to formulate policies to enable better connectivity in schools.

Reward

Your participation is voluntary and you may choose to participate or not to participate without any reward or penalty. It is within your right to answer or not to answer any question asked as part of the focus group discussion.

Confidentiality

This research and your responses will be considered strictly confidential. Your identity will be kept anonymous. Please note that the focus group discussion does not require you to give your name or any other identifying information. Data management principles encourage researchers to share the information that they collect and that information can be held for 10 years or more, but we will never share anything that names or identifies you in any way with any other person, without your explicit consent.

Contact information

For any queries or clarification, please contact the following persons: Dr Alfred Kitawi (akitawi@strathmore.edu) or Kagwiria R Nkonge (regina.nkonge@itu.int).

Questions

1. How does the Internet improve teaching and learning at your school (for teachers, students and administrators)? Do you think it was a good decision to include your school in the connectivity project and why?
2. What are the hurdles you have experienced in terms of the Internet connectivity provided (for teachers and students) and what future hurdles do you foresee?
3. How do you access materials that may sometimes be unavailable because of an unreliable broadband connection?
4. How do you think the issue of too few computers per student can be resolved (1 per around 30 students)? Are cheap tablets a possible solution and how can maintenance and durability be assured?
5. Given that there are too few computers per student, how do you determine who can access the computers in your school?
6. Which areas do you think should have a reliable and consistent Internet connection at school?
7. What do you foresee to be the negative and positive impact of reliable and consistent Internet connection at school, and what are the successes and failures experienced?
8. How regularly should teachers attend ICT training and certification programmes?
9. In what ways can your school participate in financing/funding ICT-related issues so that the connectivity project is sustainable?

Annex 5: Telephone interview guide for special needs education with responses on Internet connectivity

ITU-Communications Authority of Kenya Focus group discussion

Invitation

We would like to invite you to take part in the ITU connectivity telephone interview. The interview is championed by the Communications Authority of Kenya, which has partnered with ITU to provide broadband connectivity in secondary schools. You have been identified as a potential respondent by the Communications Authority. Participation is entirely voluntary, but your responses would be valued and appreciated. The interviews are open to principals or computer studies teachers. The person administering the questions represents the expert employed to investigate the effectiveness of the school connectivity project.

Introduction

ITU, the United Nations specialized agency for ICTs, and the United Kingdom FCDO share a vision for digital inclusion and a keen desire to implement a range of programmes in service of this vision. ITU is working with the FCDO Digital Access Programme to promote effective regulation, greater investment and innovative models for school connectivity in underserved communities and for broader digital inclusion in Kenya. To support the work under Activity area 1, on Regulatory Analysis, Framework and Tool Development to support digital inclusion objectives, ITU seeks to assess USF-funded school connectivity projects in Kenya. While your school has not benefited from such a project, your responses are critical to direct future policy and practical action in special needs education. We would therefore ask you to spare 15 minutes to answer the questions. The interview has ten questions.

Benefits

The information obtained from the interview may be used by the ITU and the Communications Authority of Kenya for data analytics and to formulate policies to enable better connectivity in schools. It will also benefit special need schools that need to be connected to the Internet.

Reward

Your participation is voluntary and you may choose to participate or not to participate without any reward or penalty. It is within your right to answer or not to answer any question asked during the interview.

Confidentiality

This research and your responses will be considered strictly confidential. Your identity will be kept anonymous. Please note that the interview does not require you to give your name or any other identifying information. Data management principles encourage researchers to share the information that they collect and that information can be held for 10 years or more, but we will never share anything that names or identifies you in any way with any other person, without your explicit consent.

Contact information

For any queries or clarifications, please contact the following persons: Dr Alfred Kitawi (akitawi@strathmore.edu) or Kagwiria R Nkonge (regina.nkonge@itu.int).

1. Does your school need Internet connectivity?
    - Yes, we need Internet connectivity.
2. What are the school's special hardware, software and connectivity needs, including furniture?
    - No special needs, but we request Internet connectivity.
    - Appropriate software will enable the deaf to learn online in classrooms, because the deaf learn well when they see. For this category of special learners, we need normal computers. Since our school caters also for the blind, we will need computers with text-to-speech services (and vice versa).
3. What is the average number of students?
    - Our school has 261 students
4. What is the percentage of boys and girls in your school?
    - Our school is a girls-only school
5. How can we make ICT more inclusive for special needs students?
    - Normally the blind have more requirements than the deaf.
6. Does your school need a subsidy? Do you get any funding for ICT equipment and connectivity?
    - Our school does need subsidies and support from the Government. We have no sponsor for ICT needs and equipment.
    - No sponsor for ICT needs or equipment. We need a special subsidy from the Government.
7. Wat challenges do you have and foresee in relation to Internet connectivity?
    - Our Internet service provider is Telekom. The connection is quite slow. It would help if we could get another provider.
    - Not all places are connected to the Internet. It is only an administration building, so we sometimes have problems downloading materials. The computer lab is also not connected to the Internet.
    - We have received very few donated computers (5–10), which is a challenge for the students.
    - In our school, the issue of misuse of computers does not arise.
8. What are the potential opportunities and benefits of Internet connectivity?
    - The Internet enables deep learning: the concepts can be understood easily because many human senses are involved.

9. Who could oversee ICT and Internet connectivity at your school?
    - The ICT teacher is in charge of ICT needs.
10. Do you use any online platforms to communicate and record students' marks and issues?
    - We do not have any special online platform or learning management system.

Annex 6: Focus group comments by survey theme

Name of school	County	Encoded as
Turkana Girls School	Turkana	School A
Ahero Girls	Kisumu	School B
Mwangea Boys School	Taita Taveta	School C
St Kevin Mixed School	Turkana	School D
Magui School	Vihiga	School E
Bura Girls	Taita Taveta	School F
Aloo Gumbi School	Kisumu	School G
Lodwar Boys	Turkana	School H
Chavakali School	Vihiga	School I
St Peter Claver Kithuki	Kitui	School J

Background attributes

- School information
- Teacher and student information
- Infrastructure
- ICT devices

School B: *It was a good decision to include our school in the project. It reduced expenditure on bundles for Internet access and allowed users to use the connectivity frequently.*

School C: *It was a good decision to include the school because connectivity is important to all parties in the school.*

School D: *It was a good decision to include our school because it has helped make learning more interesting by varying teaching and learning materials and administrative decisions and reporting has been made easier and faster.*

School E: *It was an appropriate decision to include our school because the school population is large and growing; it helps in research and academics; faster access to information than library; teachers can feed in marks and other data off-site.*

School G: *It was a good decision to include our school because the Internet is needed for practically everything these days and a connection reduces the need for infrastructure; now we only have to bring our own device.*

School H: *It was a good decision to include our school because connectivity is required for computer studies students, in addition to downloading, uploading students' projects and online communication.*

School I: *Yes, it was a good decision to include our school since it is a national school, and the ICT class is compulsory for Form 1s and Form 2s. It is easier to disseminate the basic skills, especially science research and robotics.*

School J: *Yes, it was a good decision since it will improve teaching and learning in our school.*

Social effectiveness

- **Access**

School B: *Since computers are few, we give priority to computer studies students. The group is limited so that no more than two students have access to one computer at each session.*

School A: *The students are taught in shifts so that at least each student can interact with the computer.*

School F: *No specific criteria used; however, we use the Internet based on concepts to be taught and per class timetable scheduling, eventually all students end up accessing the computers/ Internet at different times weekly within each term.*

School C: *To ensure equitable access when it comes to teachers, there can be a clocking-out system and handing back digital gadgets.*

School D: *Since the computers are few, we give priority to students who have selected Computer Science as an examinable subject. Also, teachers who are doing research.*

School E: *In ensuring equitable access, we group students and assign timeslots. Form 1s and Form 2s get grouped in larger lots. Computer studies students get priority access. Other students can register at the door and access the computer and record the time when they leave.*

School G: *Priority is given to computer studies students; they share computers, but the teachers ensure that each of them gets computer time in each session. Other students do not routinely have access; they can make a request to use a computer, however.*

School H: *I would ensure learners have basic introduction to computers and thereafter give access to those with more interest.*

School I: *Sharing of computers is done through a timetable and staggered access. It is also given to members of ICT club who want to access them outside of class time. Non-computer students must go through the ICT club captain.*

School J: *The computers are accessible on need by an individual but based on computer literacy.*

- **Gender equality and social inclusion**

School D: *In ensuring all students are involved in learning, we pair students who are tech-savvy to students who are less familiar with Internet use (peer learning as a pedagogical technique).*

- **Pricing**
- **Connectivity usage**

School B: *The Internet has led to increased research and teachers can access auxiliary content online to integrate with available material. It also eases the storage and processing of grades and student information. It enables learners to receive content while away from school. It is also useful for entertainment and variety of content for students.*

School A: *The Internet has enabled access to learning materials and both teachers and students to carry out research, including explaining concepts that appear difficult.*

School F: *Students look at the visual content, thus they retain information easily, while the teacher is talking and displaying that information.*

School C: *We use the Internet to download question papers, project questions and posting marks. Teachers research on teaching materials, simulation videos to enhance learning.*

School D: *The Internet is used in enhancing research for students and teachers, makes learning be more student-centred and learners can learn at their own pace.*

School I: *The Internet provides an online system for storing and analysing data and provides reference materials, tutorials and videos, for instance YouTube. Learners use it for research purposes, for instance online books.*

- **Enablers**

School A: *The Internet connectivity has enabled the students to register for the Kenya Certificate of Secondary Examination (infrastructural).*

School F: *The Internet connectivity has enabled teachers to prepare well with the extra materials and thus allow for deep learning (people).*

School D: *An enabler when the Internet goes down is to have offline access for some materials e.g. turning on offline access for Google drive*.

School D: *An enabler to ensure connectivity is wider use of hotspot connections. At times when the Internet is not available, we connect the laptop to the mobile phone*.

School J: The Internet enables digital simulations and models. In traditional learning it is sometimes difficult for students to get a concept but thanks to the Internet, relevant models will easily be sourced as audiovisual aids and used for teaching and learning.

- **Tech literacy**

School C: *Administrators acquire skills to send e-mails, do video calls both internally and externally, for example parents, suppliers, clients.*

- **Quality of connectivity**

"The coastal region, which is Malindi, Mombasa, Voi – They had Wi-Fi that was fixed but never worked. This has brought so many problems to most schools e.g. Jilore High School, this has led to them forgoing some computer classes as they use self-sponsored bundles which is very expensive for them to afford and hotspot the whole school.

They would really wish help in Internet connectivity as this would offload a huge burden and facilitate the students in their computer studies. They would also need facilitation with the laptops and desktops, and they have few laptops and many students.

Marsabit and Narok North – They would need facilitation of laptops and desktops as they have very few as compared to the capacity of students in their school. The Internet coverage is also a problem due to the location and weather, but they are trying to find ways of how to manoeuvre through it. They however get no response from the wall that they were advised to write to whenever they are experiencing issues with the Internet. They kindly request the team to be checking often the wall to be able to assist them."

School B: *Premises where there should be a reliable and consistent Internet connection can be academic department, administration offices, quality and standards office, guidance and counselling, library, and computer lab.*

School A: *Premises where Internet connectivity should be stable are the school administration building, computer laboratory, academic department and science labs.*

School F: *Premises where the Internet connectivity should be prioritized include: administration; academics team; staffroom – teachers; computer room; learning and resource centre; library.*

School C: *Premises where Internet connectivity are needed include computer lab, academics department, science labs and administration block.*

School E: *Premises where there should be a reliable and consistent Internet connection are: computer labs, staffroom and library.*

School G: *Premises that need a reliable and stable Internet connection are computer lab and administration offices.*

School H: *Premises that should have Internet connectivity include the library, staffroom, administration block.*

School I: *The premises that should have a stable Internet connection include ICT rooms, science rooms, staffrooms and administration offices.*

School J: *The premises where Internet connectivity should be are the library section, the classrooms and the laboratory.*

School B: *The signal strength has reduced over time.*

School A: *At times the Internet is slow because of many devices connecting to the Internet (congestion).*

School C: *The Internet connection was working only from 2020 to November 2021.*

School D: *Internet connectivity should be in the ICT laboratory, the administration block, the finance and accounts office and the library.*

Economic effectiveness

- **Query about existing budget (USF)**

School F: *The school has 923 students, and currently it has 31 desktops, 20 laptops, so far, sponsored by the Government/US-based teams, thus an average of 18 students per computer. However, these facilities are underutilized for lack of Internet connectivity/access. The solution is installation of sufficient cables and the team of CAK/KUSF ensuring that the Internet access/ connection is put into effect and confirmed as working consistently.*

School F: *Currently the administration team is funded privately and connected to Safaricom broadband to ensure the school has an Internet connection. So far, the school has no government or sponsored funding to facilitate connectivity. The school is looking toward the assistance accorded by CAK/KUSF to ensure that they expand in the arena of ICT.*

School J: *Extra resources can be obtained from the local community through fundraising events (known as "harambees", a word in Kiswahili meaning "all pull together") to support the programme. The school, in consultation with other stakeholders, can charge a fee for ICT programmes in the school to be used for ICT support.*

- **School budget**

School B: *It reduced expenditure on bundles for Internet access and allowed users to use the connectivity frequently.*

School A: *The school can raise funds by allowing people from the community to access computers during holidays and sourcing for funds from well-wishers.*

School F: *Currently, because the Internet connection does not work, we spend on two Safaricom routers serving administration and academic offices @KES 11 598 a month and ICT-related costs approximately at KES 400 000 annually.*

School C: *Costs currently incurred by the school is KES 15 000 per month on Internet bundles and KES 500 000 on ICT-related costs.*

School G: *Recurring payments (KES 15 000) are a burden to the school; other packages have not been availed. When Internet connection is not available, we tether using personal mobile phones.*

- **Additional infrastructure and pricing**

School B: *We need more computers. Currently we have 1 computer for 66 students. The school can purchase more computers. We can also receive donations from the Government and other well-wishers. For instance, we can receive refurbished computers from government offices.*

School B: *School tablets can be a possible solution since it is better than nothing. Maintenance and durability can be assured through access control and security and annual maintenance.*

School B: *The school can participate in financing/funding ICT-related issues through purchase of more computers and exposing teachers to more ICT-related courses and trainings.*

School A: *Tablets can be a solution. They can be maintained and kept in school when students are on holiday.*

School F: *Since the Internet connection does not work, the teachers dig into their own personal pocket to buy their own Internet bundles and will be very grateful to be relieved of that burden, to better serve their students, without limits subject to what costs they are able to personally manage.*

School C: *We hope to get a sponsor/donor to purchase more computers because the school budget is overstretched. The school is already currently overstrained, what with the Internet connection through KUSF/CAK down. Currently using personally funded connection through Telkom and teachers using their own personal bundles.*

School C: *School tablets can be a solution, but they need to be locked securely and have a clear maintenance and support system for the tablets.*

School D: *Purchase of tablets can be a solution. Nevertheless, there is need to have rules on how the cheap tablets can be used/kept. The students should not be allowed to move with the tablets from the computer laboratory without clear plans. There is a need to employ a qualified ICT technician to service the tablets.*

School D: *The school can be involved in grant programmes, for instance Ministry of Education programmes, or even at the county level if available.*

School E: *We set up hotspots using personal mobile phones and modems; there are still no procedures for funding this arrangement, so it's mostly a personal cost. Acquiring cheap tablets is expensive in the long term, it is better to have more reliable equipment. There is a need to subsidize ICT training for teachers and staff.*

School G: *Yes, cheap tablets could be a possible solution; maintenance and durability assured through access control; and repair shops are accessible from here. School can supply part of the money for the connection.*

School H: *I think cheap tablets will not be a solution since they are not convenient for learning computer packages like Access, Desktop publisher due to incompatibility. Raising funds through parents' approval in AGMs can be a possible way, including requesting for funds from well-wishers. Participation in ICT challenges where winners are given funding is another means. We can also initiate ICT-related projects like publishing and selling magazines.*

School J: *Cheap tablets can be purchased to resolve the issue of few computers per student. They can be serviced by the computer teachers who will prescribe the period of check-ups and servicing. Tablets of lifespan of at least three years can be considered and they must be warrantied.*

School I: *Cheap tablets are a possible solution. Maintenance and durability can be ensured by sensitizing learners to be careful with the tablets and inculcating a sense of ownership in them. Currently we have 1 computer for 34 students, and we share computers among students.*

School I: *Additional financing can be through subsidizing Internet connection and getting services from market-based service providers.*

Governance

- **Strategic importance**

School A: *The Internet is important as it enabled the students to access online learning.*

School F: *It enables broad knowledge in their day-to-day activities, they can acquire more skills in the fields they are specializing in.*

School D: *Administrative decisions and reporting have been made easier and faster. Monitoring and supervision of the school have been enhanced through the installation of CCTV.*

School E: *Teachers can enter marks and other data off-site. It has also enabled the change from a manual system to a web-based system.*

School G: It has enabled circulars to be distributed online; online chat groups also help with communication. The Internet can assist teachers prepare for presentations to students; get experiences from other teachers; process exams and submit marks; and access e-learning for continuous professional development.

- **Responsibility for school connectivity**

School F: *The Administration block is currently incurring costs, having hired Internet services from Safaricom, broadband fibre network (2018-CA WIFI). The project being handled by KUSF/ CAK, once effective, will ensure there's no limitation in exploring ICT at deeper levels.*

School D: *The responsibility for school connectivity can be at school level with the school making sure that the router and modem for the Wi-Fi is connected to the UPS to assist whenever there is power failure.*

School H: *Maintenance and durability can be assured by strict supervision by personnel in charge and educating learners on the responsibility to maintain the devices in good condition.*

School I: *It is important for the school to ensure the maintenance of computers and Internet infrastructure.*

- **Security and privacy**

School F: *Some students may access harmful information, eroding moral values, example pornographic materials that are socially detrimental, with psychological impacts, and spiritually degrading.*

School B: *Negative impact of the Internet includes Internet addiction.*

School A: *At times, students access sites that are not educative when not supervised.*

School C: *There is a need to restrict sites to prevent negative exposure to students. There should also be control measures in school.*

School C: *There should be controls also for teachers to avoid hoarding and to ensure no other teacher is inconvenienced after work, especially for shared resources. A suitable solution can be to have a clocking-out system and handing back the digital gadgets.*

School D: *There is Internet addiction and peer influence can be acquired easily.*

School G: *Controlling students' access to the Internet, and filtering the information that they get, is a challenge. Students can access unwanted websites/material and overreliance on the Internet by teachers (they get lazy). Access management is difficult; passwords can be disseminated to outsiders, throttling access.*

- **ICT training**

School J: *In relation to digital literacy: To successfully use the Internet in teaching and learning, a certain degree of technological proficiency is required – including the ability to successfully log in, participate in classes, submit work, and communicate with teachers and learners. Some teachers and learners have not been able to fully adopt and practice Internet usage in learning due lack of digital skills.*

School B: *Teachers should go for ICT training annually.*

School A: *Teachers of ICT should go for ICT certification programmes at least once a year.*

School F: *According to our set-up/planning programme, training and certification programmes should be done yearly because of the short terms in between. We recommend that the trainers be extremely well prepared, for sometimes they offer the same information yearly, so the teachers see no value added, and their time that could have been used constructively has been taken up by a non-value-adding programme. A possible suggestion is for a review team to be sent over once a year above the training, to see if what was learnt was implemented and identify any learning gaps and fill them up.*

School C: *Teachers should go for training once a year. In case of changes, a once-a-term update is allowed, due to short terms and tight schedules. Reviews for after training are also recommended, at least once a year.*

School E: *Teachers should go for ICT training every two months because things change fast.*

School G: *Teachers should go for training once a year and that will help them use ICT and keep up to date with new developments.*

School H: *Teachers should go for training annually.*

School I: *There should yearly training because things change fast.*

School J: *Teachers can be trained annually on ICT and certification programmes updated with technological advancements.*

- **Support**

School B: *When we have the challenge of signal strength, we must wait until the service provider resumes the issue before using any other means.*

School F: *The KUSF installed an Internet router within the school grounds, but it just shows the digital signal, however, on the ground, there's no actual connection within the course of year 2021. Several visits so far done by CAK/KUSF team members sent to the school, however no changes seen. For both teachers and students, once you open, you discover it's not responsive, it is not useful now as there's no actual help.*

- **Availability of an online platform for teachers and learners and clear safety standards**

School B: *Other students are allowed when expedient to use computers, under the supervision of the teacher or a computer studies student.*

School E: *The Internet connectivity enables storing, analysing data and generating report cards.*

School G: *Processing exams has been improved and access to NEMIS (National Education Management Information System) to assign students UPI (Unique Personal Identifier) numbers.*

- **Soft skills acquired**

School A: *It has enabled students develop information search skills.*

School F: *Once the students use it and retain more academic concepts, they can perform well. Knowledge received on varied views helps them grow academically, socially, mentally and [into] all-rounded individuals, in a nutshell.*

School C: *The Internet connectivity helps with innovating ideas.*

School D: *The Internet has brought about sharing of information with other schools and access of unlimited first-hand information.*

School H: *It improves creativity of teachers in delivering content to students and makes learning interesting for students.*

School I: *It is easier to disseminate the basic skills, especially science research and robotics.*

(Main twenty-first-century skill is communication, collaboration and in some cases creativity, robotics and artificial intelligence)

Environmental effectiveness

- Amount of plastic waste
- Reuse and recycling of materials

School B: *We can also receive donations from the Government and other well-wishers. For instance, we can receive refurbished computers from government offices (KEBS-ITLET standards).*

Conclusion section IV

- **Challenges**

School B: *The signal strength has decreased over time.*

School C: *The Internet breaks down often, there is a weak signal and at times it is slow. Access points do not reach the whole school.*

School C: *Overreliance on the Internet for research, rather than personal reading from books, hence, need to control their accessibility – we have a control mechanism. The Internet was only effective from 2020–2021 November, since then it's not working.*

School F: *The KUSF installed an Internet router within the school grounds, but it just shows the digital signal, however, on the ground, there's no actual connection within the course of year 2021. Several visits so far done by CAK/KUSF team members sent to the school, however no changes seen. Students are limited to the teachers' hotspot connection for each lesson, so they can't do further research on the Internet after class.*

School D: *There are electricity interruptions or cut-out and at times the speed is too slow and there is congested connectivity. The computers are also inadequate for use of the Internet.*

School E: *The challenges we have faced include low Internet connections, sporadic network and the contract elapsed on 31 December 2021, and since then there has been no connection; there was a short notice, only on 29 December 2021.*

School G: *At first, the satellite connection was very slow and there were a lot of outages (e.g. connections were sometimes available only at midnight); the installation of a router rectified the connection.*

School H: *There is misuse of the Internet by students accessing non-academic sites and slow Internet connectivity by Telkom providers.*

School I: *The Internet connectivity never works. Though connected, we cannot upload anything. We therefore use another service provider, Safaricom.*

School I: *Internet connection may make the students lazy when they focus only on entertaining videos.*

School J: *Overuse of the Internet can greatly reduce the usage of textbooks and physical materials for teaching and learning by both students and learners; teachers may extremely rely on Internet-downloaded materials rather than considering making notes for teaching. Some of the notes downloaded may not be standard and in rhyme with the syllabus. Consistent use of the Internet may encourage laziness or relaxation in both teachers and learners since the Internet readily provides solutions to assignments and teaching and learning resources. It may expose learners to harmful information and sites such pornography.*

School J: *Technical problems (quality of Internet): A strong Internet connection is required in the whole school for quick connection and use of the Internet in teaching by teachers and for students in learning. Low bandwidth and weak Internet in some points of school has affected the connectivity and limited the use of the Internet.*

- **Positive points**

School B (located near a town): *The Internet has made it able to access quality information, getting the latest content and teaching methodologies in various subjects; reduction in spending by school on bundles; information access to more people. It has also enabled access to a better exam management system and more efficient data management.*

School A: *The connectivity enables video conferencing with neighbouring schools.*

School F: *Students look at the visual content, thus they retain information easily, while the teacher is talking and displaying that information.*

School C: *The Internet has led to effective learning through online materials, further research and exposure to higher learning, referencing to projects.*

School D: *The Internet has brought about sharing of information with other schools and access to unlimited firsthand information.*

School E: *Internet connectivity leads to varied access to digitized teaching and learning resources.*

School G: *Processing exams has been improved; teachers in higher education have been able to graduate faster; secretaries find it easier to do their administrative jobs, like converting files between different formats online; access to NEMIS (National Education Management Information System) to assign students UPI (Unique Personal Identifier) numbers and manipulate data there is easier.*

School H: *The Internet has enabled both students and teachers to get the latest updates in the education sector. It improves creativity of teachers in delivering content to students and makes learning interesting for students.*

School I: *The Internet has enabled referencing to be easy, asynchronous learning and eases demonstration of concepts.*

School J: *Consistent usage of the Internet will promote digital literacy in school. It will enhance the use of ICT integration in teaching and learning. It will lead to improvement in performance due to the wide range of information and learning materials accessible on the Internet. Students will be able to learn and manage themselves in the absence of teachers using Internet sources.*

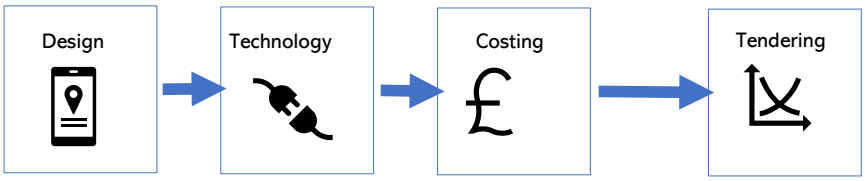
School J: *The Internet provides a wide range of information, knowledge and educational resources, increasing opportunities for learning in and beyond the classroom. Teachers will be able to use online materials to prepare lessons. Students can use the Internet for searching for their study-relevant materials, assignments, quizzes, presentations, all study relevant materials available on the Internet.*

- **Innovation when the Internet is down**

School C: When the Internet is down, we use an alternative school Wi-Fi telecommunication connection. Also, teachers purchase bundles at their own cost.

Annex 7: Design considerations

Pre-project design



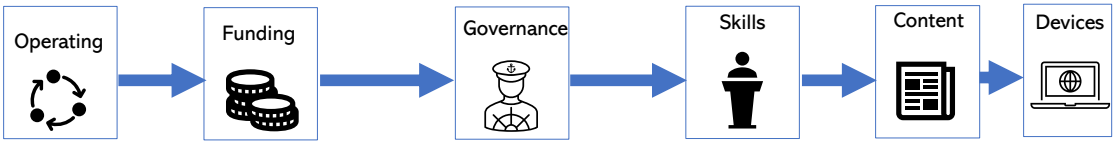
- According to geographic region.
- Focus on urban and peri-urban areas because of more school coverage through a mix of State/government, contracts and turnkey.
- Remote areas (according to priority: a) energy + b) connection + c) security).

- Fibre (capacity of 20 Mbit/s) urban and peri-urban schools.
- WiMAX (capacity of 20 Mbit/s) urban and peri-urban schools.
- Electricity +connectivity as a business model (KPLC and KETRACO).
- VSAT to remote schools).

- In the case of larger schools (>300 students), 1 Mbit/s/20 students is the target. This implies an average speed of 15 Mbit/s for a school of 300 students. The monthly minimum on data is 100GB. Giga advises a target of 200 GB per month. Cost per student in the former case is USD 12 per year (subsidized). Giga's meaningful download speed for meaningful connection is 10 Mbit/s with an upload speed of 2.5 Mbit/s.
- Remote areas without energy and connectivity need last-mile funding and PPP involvement; insecure areas need community consultations + set-up of administrative posts.

- Peri-urban and urban schools (open tendering process).
- Remote schools may need additional funding, depending on distance and security issues.
- Remote schools connected should provide other additional advantages e.g. business case to support other community needs for instance community hot spots and dedicated access points.
- Community involvement in the tendering process of schools in insecure areas.

Implementation



- Build, operate and transfer (CAPEX needs government and donor support).
- Mixed operation model of CAPEX equipment (PPP and government).
- Phased OPEX cost transfer process with schools (mainly urban and peri-urban schools).

- Government and PPP for CAPEX.
- Tax considerations for companies to support neighbouring schools.
- Staggered transfer of connectivity costs at 25% each year over a four-year period.
- Continued Government and donor support for remote schools.

- Regional and national polling statistics that collect statistics.
- Clarity of responsibilities for Internet connectivity + ICT.
- Expanded school ICT policies.
- Weekly connectivity reports school level.
- Enhanced KICD portal with links to content providers.
- Clear report mechanisms.

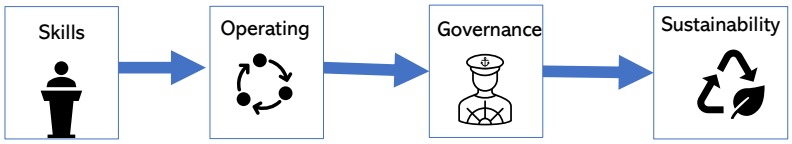
- Embed ICT and 21st century skills on TPAD training sessions (TSC and KEMI)
- Train school technicians on connectivity, 21st century skills and cyber-security
- Ensure 5 other staff members have adequate ICT skills before site transfer

- KICD portal as a gateway to materials (LMS and AMS).
- Tertiary institutions to provide educational content (OER).
- Formation of community of education practitioners connected through LMS and AMS.

- Desktop ratio of computer to student of 1:10.
- Wi-Fi connection in 5 main school areas.
- Allocate computer donor funding according to school level.

LMS-learning management systems; AMS-Academic Management systems.

Post-implementation



- Annual sessions for teachers.
- Embed values-based education and 21st century skills on use of Internet connectivity for students.
- Bi-annual post implementation review.

- Bi-annual post-implementation review on quality of connectivity; support; complaints; connectivity and procedural audits; cost-benefit analysis; and skill assessment.

- Individual within school tasked to do post-implementation reviews.
- Post-implementation reviews of Internet connectivity as part of annual school reporting plan.

- Initial funding through government and USF sources, especially CAPEX costs (additional budget from MoE and MoICT.
- Link connectivity to other business opportunities outside school.
- Ensure clear annual budgetary item for Internet connectivity and ICT costs.
- Where Internet connectivity is provided outside school, staggered increment of Internet connectivity according to business case beyond 20 Mbit/s
- Cross-subsidization.

Annex 8: Average ICT devices by county

	Average ICT devices by county			
	Desktops	Laptops	Tablets	Phones
Vihiga	50	13		2
Turkana	38	14		1
Homa Bay	34	17		
Nairobi City	33	13		
West Pokot	30			
Kitui	26	1		
Taita-Taveta	26	13		
Nakuru	26	14		
Mombasa	25	12	3	
Baringo	25			
Machakos	24	10		
Nyamira	24	13		
Kwale	23	6		
Laikipia	23	3		21
Nyandarua	23	12		
Busia	22	15		
Narok	21	12		
Kisii	21	11		
Trans Nzoia	21	6		
Makweni	21	15		
Kericho	20	3		
Kisumu	20			
Mandera	20	8		
Kiambu	19	8		
Embu	18	5		
Marsabit	18	6		12
Murang'a	17	6		
Elegeyo-Marakwet	16	10	4	3
Kilifi	16	3		3

(continued)

	Average ICT devices by county			
	Desktops	Laptops	Tablets	Phones
Kajiado	15	4		
Migori	15			
Lamu	15	5		
Bomet	13	7		
Nandi	12	7	4	3
Bungoma	10	4		3
Wajir	8	3		
Kakamega	7	3		
Uasin Gishu	5	1		2

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