

Feasibility Study to Connect All African Higher Education Institutions to High-Speed Internet

Report 2: Annex 4 Uganda Country Case Study Report



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Table of Contents

Abbreviations.....	vi
Acknowledgements.....	ix
Executive Summary.....	xi
1. Introduction.....	1
2. Country Overview.....	3
3. Demand Side—the Education Sector.....	6
3.1 Education Sector Policy and Governance.....	6
3.1.1 Key Policies and Regulations.....	6
3.1.2 Key Regulatory and Standards Institutions.....	7
3.2 Market Size.....	8
3.2.1 Target Institutions.....	8
3.2.2 Student Enrolment.....	9
3.2.3 Bandwidth for Higher Education.....	11
3.2.4 Quality and Sufficiency of Campus Networks.....	11
3.2.5 Sufficiency of Access Devices.....	12
3.3 Education Sector Challenges Impacting Leveraging ICT for Learning.....	13
4. Supply Side—the ICT Sector.....	15
4.1 ICT Sector Policy and Regulation.....	15
4.1.1 National Development Plans.....	15
4.1.2 Key Policies and Regulations.....	16
4.1.3 Key Policy and Regulatory Institutions.....	17
4.1.4 National ICT Indicators.....	17
4.2 Sector Operations.....	19
4.2.1 Licensing, Market Structure and Service Providers.....	19
4.2.2 Access to Broadband.....	19
4.2.3 IXPs and Data Centres.....	22
4.2.4 Cybersecurity.....	24
4.2.5 Electrification.....	25
4.2.6 COVID-19 Pandemic Implications for Connectivity.....	26
4.3 Sector Challenges Impacting Broadband Connectivity.....	26
5. Research and Education Network for Uganda.....	28
5.1 Critical Success Factors.....	29
5.2 NREN Maturity.....	34
5.3 Current Challenges.....	36
6. Cost Estimates for Connecting Higher Education in Uganda.....	40
6.1 Access to Computing Devices.....	40
6.2 Upgrading Campus Networks.....	42
6.3 Connecting Campuses Upstream.....	45
6.3.1 Estimating Bandwidth Requirements and Unit Cost.....	45
6.3.2 Aggregation Savings.....	46
6.3.3 Cost of Connecting Campuses Upstream.....	46

6.4 Support to RENU.....	47
6.5 Cost of Connecting HEIs in Uganda.....	48
7. Summary and Conclusion.....	49
Appendix A: Makerere University Profile.....	53
A.1 ICT Policies and Strategy.....	53
A.2 Student Enrolment.....	54
A.3 Access to, and Cost of Connectivity.....	54
A.4 ICT Infrastructure.....	55
A.5 Directorate for ICT Support.....	59
Appendix B: Tables.....	60

Table of Figures

Figure 1: Administrative map of Uganda.....	3
Figure 2: Trends in student enrolment in higher education.....	9
Figure 3: Net enrolment ratios for different levels of education.....	10
Figure 4: Organogram for DICTS at Makerere University.....	12
Figure 5: Comparison of households with access to computers and Internet.....	13
Figure 6: Type of network coverage by population and area.....	20
Figure 7: Distribution of fibre networks across Uganda.....	21
Figure 8: Trends in mobile and fixed subscriptions (per 100) 2010-2019.....	22
Figure 9: Schematic map of RENU network.....	28
Figure 10: Trends in RENU bandwidth amount and unit pricing, 2012-2019.....	31
Figure 11: Stages of NREN development.....	35
Figure 12: A schematic diagram to estimate costs for connecting higher education institutions in Africa.....	41
Figure 13: Matrix for determining bandwidth cost.....	46
Figure 14: Trends in Makerere bandwidth amount and cost.....	55
Figure 15: Schematic of Makerere University network.....	56
Figure 16: Organogram for DICTS.....	59

Index of Tables

Table 1: Student enrolment in lower education levels (000).....	10
Table 2: Forecast for student enrolment (rounded to 1000) and bandwidth requirements (2025 & 2030).....	11
Table 3: Stages of the Internet Exchange Ladder.....	18
Table 4: Costing for UIXP services, 2020.....	23
Table 5: Country performance in ITU Global Cybersecurity Index.....	25
Table 6: Comparison of electrification rate among case study countries.....	25
Table 7: RENU's tier pricing variation based on amount of bandwidth procured.....	32
Table 8: Comparison of bandwidth prices across NRENs.....	32
Table 9: Classification of Connectivity in African Higher Education.....	35
Table 10: Projected bandwidth gap at 12 top Ugandan universities by student enrolment.....	36
Table 11: Cost of equipping students and staff with access devices (2021 to 2025).....	42
Table 12: Assumptions for calculating campus network upgrade costs in Uganda.....	42
Table 13: Estimate for upgrading University and TVET campus networks in Uganda.....	43
Table 14: Distribution of Small, Medium and Large Campuses.....	44
Table 15: Distribution of HEI campus sizes in Uganda.....	44
Table 16: Recommended Progressive Bandwidth Targets for African Universities and TVETs..	45
Table 17: Projected bandwidth and cost based on Student Enrolment and Local Price (2021, 2025 & 2030).....	46
Table 18: Projected bandwidth and cost based on Student Enrolment and Regional Price (2021, 2025 & 2030).....	47
Table 19: Summary of total 5-year cost of connecting all higher education institutions in Uganda to high-speed Internet.....	48
Table 20: Trends in access to computers by college 2008/9 to 2018/19.....	57
Table 21: Number of accredited Universities and TVETs.....	61
Table 22: Current bandwidth and project gap for accredited Ugandan universities (based on 1 Gbps/1000 students).....	72
Table 23: Licensed ICT providers in Uganda.....	75

Abbreviations

Term	Description
ASN	Autonomous System Number
ATC	American Tower Company
AVU	African Virtual University
BCS	Bandwidth and Cloud Services
CapEx	Capital Expenditures
CENIC	Corporation for Education Network Initiatives in California
CERT	Computer Emergency Response Team
DE4A	Digital Economy for Africa initiative
DEA	Direct Engineering Assistance
DICTS	Directorate for ICT Support or Department of ICT Services
DNS	Domain Name System
DS4DE4A	Digital Skills for Digital Economy in Africa
ESSP	Education and Sports Sector Strategic Plan
EMIS	Education Management Information System
Gbps	Gigabits per second
HEI	Higher Education Institution
HESFB	High Education Student Financing Board
HESP	Higher Education Strategic Plan
ICT	Information and Communications Technology
IRU	Indefeasible Right of Use
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunication Union
IXP	Internet eXchange Point
KCL	Knowledge Consulting Ltd
LAN	Local Area Network
Mbps	Megabits per Second
MDAs	Ministries, Departments and Agencies of Government
MNO	Mobile Network Operator
MoES	Ministry of Education and Sports
MoFPED	Ministry of Finance, Planning and Economic Development

Term	Description
MoICTNG	Ministry of ICT and National Guidance
MoSIT	Ministry of Science, Technology and Innovation
NBI	National Backbone Infrastructure
NCDC	National Curriculum Development Centre
NCHE	National Council for Higher Education
NDP	National Development Plan
NISF	National Information Security Framework
NISS	National Information Security Strategy
NITA-U	National Information Technology Authority of Uganda
NOC	Network Operations Centre
NREN	National Research and Education Network
NSRC	Network Startup Resource Center
NTO	National Telecom Operator
ODAI	Other Degree Awarding Institution
OpEx	Operating Costs
OTI	Other Tertiary Institution
PIP	Public Infrastructure Provider
PNO	Private Network Operator
PoP	Point of Presence
PPP	Public–Private Partnership
PSP	Public Service Provider
PUJAB	Public Universities Joint Admission Board
RCIP	Regional Communications Infrastructure Program
RENU	Research and Education Network for Uganda
RREN	Regional Research and Education Network
RU	Rack Unit
SDG	Sustainable Development Goal
SETDA	State Educational Technology Directors Association
Tbps	Terabits per second
TVET	Technical and Vocational Education and Training
UBTEB	Uganda Business and Technical Examinations Board
UCC	Uganda Communications Commission
UETCL	Uganda Electricity Transmission Co. Ltd
UIS	UNESCO Institute of Statistics

Term	Description
UIXP	Uganda Internet Exchange Point
UNCST	Uganda National Council for Science & Technology
UNESCO	United Nations Education Scientific and Cultural Organization
UPE	Universal Primary Education
USE	Universal Secondary Education
VAT	Value Added Tax
VC	Vice Chancellor
WBG	World Bank Group

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Executive Summary

As part of the Digital Economy for Africa (DE4A¹) initiative, the World Bank commissioned a feasibility study to develop an operational roadmap to connect all African higher education institutions (HEIs) to high-speed Internet. The initiative, in support of the African Union Digital Transformation Strategy for Africa (2020-2030)², aims to digitally enable every African individual, business, and government by 2030. Connecting universities and research institutions is crucial for expanding the opportunities for teaching, learning and innovation to foster relevant digital skills on the continent. This study has received funding from the Digital Development Partnership (DDP)³.

This Case Study, one of four conducted to provide background information to the study, along with Burkina Faso, Côte d'Ivoire and Mozambique, explores the connectivity challenge from a higher education⁴ perspective (demand-side) as well as from the information and communication technology (ICT)-sector perspective (supply-side) in Uganda.

The connectivity target is to achieve at least 2 Gbps per 1,000 students by 2025 (to be provided for in the initial World Bank planning period ending 2023), and at least 20 Gbps per 1,000 students by 2030. These targets allow students and teachers of higher education access to global research and education resources and to participate actively in research collaboration at par with the rest of the world. Enrolment in higher education is forecast to reach 342,000 students in Uganda by 2025: higher education institutions will need at least 854 Gbps to serve institutions' bandwidth requirements across the country. This will rise to 402,000 students and 10.4 Tbps of bandwidth by 2030. To put these numbers into perspective, higher education enrolment in Uganda grew from 120,646 students in 2010 to a projected enrolment of 282,000 students in 2020. In 2020, higher education students across Universities and TVETs shared 6 Gbps resulting in a bandwidth ratio of 21.3 Mbps per 1,000 students.

As summarised in the table below, the overall total estimated cost of connecting higher education institutions in Uganda to high-speed Internet for a period of five years (2021 to 2025) is around USD 730 million. This includes the expense of providing devices to students and staff (USD 110 million), the cost of upgrading and maintaining campus networks (USD 574 million), core support to the Research and Education Network for Uganda (RENU) (USD 6 million) and bandwidth cost for upstream connectivity (USD 41 million). The potential savings on bandwidth cost in Uganda from demand aggregation, smart procurement strategies (e.g., benchmarking regional pricing) and procuring long-term leases are estimated at 73%.

1 See <https://www.worldbank.org/en/programs/all-africa-digital-transformation>.

2 <https://au.int/en/documents/20200518/digital-transformation-strategy-africa-2020-2030>.

3 <https://www.worldbank.org/en/programs/digital-development-partnership>.

4 We use the term Higher Education, also known as Tertiary Education in some countries, to refer to all post-secondary education, including both public and private universities, colleges, technical training institutes, and vocational schools <https://www.worldbank.org/en/topic/tertiaryeducation>

Category	Cost (USD, millions)	Potential Sources of Funding
End-user devices		
Students and Staff	110	Government, development partners, students, institutions
Sub Total	110	
Upgrading campus networks		
CapEx	213	Government, development partners
OpEx	361	Institutions, government, development partners
Sub Total	574	Using micro, mini, small, medium, large to very large campus sizes
Annual cost of connecting campuses upstream		
	With Aggregation Savings	
Using Student Enrolment & Regional Price	41	Development partners, institutions, students
NREN development and support costs		
RENU core support and NREN development related costs	6	Development partners, government
Total Cost Estimate (USD, millions)	730	Using cost of connecting campuses upstream based on student enrolment and regional price

Source: KCL calculations

Uganda expects the higher education sector to play an important role in developing the required human resource and skilled workforce to power the country's socioeconomic transformation enshrined in Vision 2040.

Digital technologies provide opportunities for addressing the challenges facing higher education—growing demand for higher education, falling quality, the mismatch between education and employability and disconnection between research and development challenges. The COVID-19 pandemic and its accompanying lock-downs have severely disrupted the education sector in Uganda, highlighting the critical gap in adoption of digital technologies and access to quality broadband, both of which support continued learning for students.

The Ministry of Education and Sports (MoES) oversees the education sector and works with other line ministries, district local governments, various semi-autonomous and affiliated

agencies as well as education institutions to deliver on the mandate expected of the sector in contributing towards the national Vision 2040. At the higher education level, there are currently 52 accredited Universities and 184 TVETs (classified into Other Degree Awarding Institutions and Other Tertiary Institutions). With about 259,000 students, universities have higher enrolment (72%) compared to TVETs (24%). Lower enrolment in TVETs is attributed to the negative image associated with TVETs, the general perception being that those pursuing TVET courses are failures that did not make it to University.

Based on the latest data from National Council for Higher Education (NCHE), Uganda's Gross Enrolment Ratio (GER) for higher education was only 6.9% in 2018.⁵ This is below the sub-Saharan Africa average of 9.4% and far below the world average of 38.8% in 2018.⁶ Some of the challenges that create this gap include insufficient public spending on education, low transition rates from primary to lower secondary education, disparities in levels of access to secondary education, an outdated and overloaded curriculum, and poorly qualified teachers who are often inefficiently deployed.

There are a number of factors that inhibit the use of ICTs as well as better connectivity in higher education in Uganda. The key ones include:

- i. Lack of an ICT policy for the sector to promote digital literacy and e-learning as an avenue to improve learning outcomes, particularly in higher education;
- ii. Generally low digital literacy among both lecturers/tutors and students on how to leverage ICT for teaching and learning;
- iii. Lack of knowledge and capacity on how to leverage ICT to improve teaching and learning;
- iv. Very limited investment in campus ICT resources and infrastructure, compounded by inadequate public funding for higher education that has not kept pace with growth in enrolment;
- v. Lack of mechanisms to evaluate and identify relevant and/or appropriate digital content and applications for different levels and programmes of education;
- vi. Lack of an adequate pool of high-level ICT champions within higher education that can promote the adoption and use of ICTs within their institutions.

The Ministry of ICT and National Guidance (MoICTNG) oversees the ICT sector, which is considered a “fulcrum of development” that will power other sectors through increasing efficiency and effectiveness (third National Development Plan [NDPIII, 2020/21-20204/25]). The Digital Transformation Program, one of 18 key programs of NDPIII, is designed to bridge the gap between what is available and what is needed to exploit the current development opportunities. Uganda would like to invest to increase national coverage of ICT infrastructure including in rural and remote areas, improve access to ICT services, reduce the cost of ICT devices and services and create more jobs within the ICT and other sectors.

There are 33 telecommunication service providers licensed by Uganda Communications Commission (UCC) to serve the market (Table 23 for full list). Despite the high number of

⁵ NCHE, 2019. *The State of Higher Education Report 2017/18*

⁶ World Bank data, <https://data.worldbank.org/indicator/SE.TER.ENRR?end=2020&locations=ZG-1W-UG&start=2010>

operators, the market remains highly concentrated, rendering competition suboptimal. In terms of ICT services, mobile voice is the predominant service while use of data services is still limited with access largely via mobile phones due to the wide coverage of the mobile networks. Recent data from UCC indicates that 85% of the population lives within coverage of a 3G mobile network and 61% within coverage of 4G. However, the proportion of individuals using the Internet is still low at only 24% compared to an African average of 28% or a World average of 54%.

Although ICT policy and regulation encourage infrastructure sharing, this is yet to be fully embraced. In terms of terrestrial fibre, Uganda now has about 21,472 km of fibre optic cable laid by both public and private licensed providers. This covers 49% of all districts and 24% of sub counties, but the duplication among licensed operators on certain routes means that effective coverage is limited and mainly covers major urban centres. Total International bandwidth has grown to 175 Gbps in 2020.

The Uganda Internet Exchange Point (UIXP) has 29 networks that peer at the exchange, and provides access to content caches from Google, Facebook and Akamai. Besides the National Data Centre built and operated by NITA-U, and largely used by government MDAs, First Brick Holdings is building Uganda's first Tier-III carrier-neutral data centre—Raxio Data Centre. Namanve Industrial Park, along Jinja road, the main fibre route between Kenya and Uganda hosts the new data centre. The country also has two major National Computer Emergency Response Teams (CERTs)—CERT-UG under NITA-U and a telecoms sector CERT under UCC. RENU also has a CERT that supports education and research member institutions. These are complimented by the Cybercrimes Unit under the Directorate of Forensic Services of the Uganda Police Force. However, cybersecurity awareness and investigative capacity for computer-related crimes are still low.

From a sector perspective, there are a number of factors that inhibit the use of ICTs in higher education and better connectivity. The key ones include:

- i. Inadequate development and deployment of ICT infrastructure to cover the whole country, particularly rural under/served areas, where access to electricity is limited;
- ii. Lack of coordination in building new infrastructure like roads or high-power lines to actually include ducts/fibre that encourage shared reuse and lower cost of building new ICT infrastructure;
- iii. Insufficient technically qualified staff and low levels of technical competence among ICT staff/technicians at higher education institutions to deploy and maintain capable ICT networks and applications;
- iv. Uncoordinated policies and other initiatives across different government ministries. For example, while the Ministry of ICT and National Guidance has been striving to lower the cost and increase access to laptops and computers for students and staff, the Ministry of Finance, Planning and Economic Development has been increasing the tax on connectivity, equipment, and services.

Universities in Uganda formed a National Research and Education Network (NREN), which is recognised by the government, in 2006—the Research and Education Network for Uganda

(RENU). RENU has validated the assertion that if higher education institutions work together and aggregate their connectivity demand, they can improve access to high-speed connectivity while driving down the cost. RENU has been successful as an NREN in part because of getting buy-in from members, especially the large universities; securing the collaboration of major network providers; assembling a good technical team to manage the network; and membership in the Regional REN—the UbuntuNet Alliance. RENU places high emphasis on sustainability. The RENU network consists of dark fibre and a managed bandwidth backbone at speeds of up to 20 Gbps in metro areas and 1 Gbps access links that connects 216 campuses across the country including 31 out of 52 Universities (61 campuses) and 15 out of 184 TVETs (16 campuses). Other connected institutions include 24 research institutions (58 campuses), 6 teaching hospitals, 61 secondary schools and 12 institutions affiliated with the education sector.

For most unconnected institutions, a one-time installation fee of USD 1,000 to 5,000 (depending on if it's a wireless or fibre connection) is the biggest obstacle. RENU charges member institutions the same unit rate for bandwidth (within the same capacity tier) irrespective of location, but there is a requirement to procure a minimum of 10 Mbps to justify the distribution costs. For connected institutions, current bandwidth amounts are inadequate for day-to-day teaching and learning purposes, but they lack resources to buy more bandwidth that supports advanced research and bandwidth intensive applications. It is a chicken-and-egg situation: institutions need to consume more bandwidth in order to lower the unit cost, but RENU and members institutions currently lack sufficient resources to commit to larger volumes of bandwidth that would help lower the unit cost of bandwidth (allowing institutions to get more bandwidth within their current budgets).

Our assessment shows that while connectivity of higher education has improved in Uganda, through the establishment of RENU, there is still need for more effort to improve digital technology integration in teaching, learning and research. This will require upgrading of the campus networks, improving access to devices for students and staff and access to more bandwidth at institutions. The Ministry of Education and Sports (MoES) together with other stakeholders needs to intensify efforts to accelerate digitalisation of higher education by identifying the necessary resources to implement the recommendations in this report. First, there is a need to support RENU to access more bandwidth at a cheaper cost through long-term leases and to be able to effectively distribute this bandwidth to higher education institutions across the country using a fibre backbone network. Currently, among the 236 universities and TVETs in the country, only 31 universities and 15 TVETs do receive some connectivity from RENU. Second, the MoES needs to explore various avenues to equip higher education students and staff with laptops. Universities and TVETs with support from RENU and other stakeholders will need to collaborate to improve the quality of campus networks in order to leverage the increasing amount of bandwidth and to support the increased number of devices on their networks.

1. Introduction

Uganda expects her higher education⁷ sector to play an important role in developing the required human resource and skilled workforce to power the country's socioeconomic transformation. The sector comprises public and private Universities, Other Degree Awarding Institutions (ODAI) and Other Tertiary Institutions (OTI) that also encompass Technical and Vocational Education Training (TVET) institutions.

Digital technologies provide opportunities for addressing the challenges facing higher education—growing demand for higher education, falling quality, the mismatch between education and employability and disconnection between research and development challenges. The COVID-19 pandemic has helped highlight the lack of digital preparedness among higher education institutions and their poor access to quality broadband. Higher education institutions in Uganda do not have access to adequate amounts of bandwidth to meet their research and education needs because the available broadband is expensive and insufficient to address their needs.

As part of the Digital Economy for Africa (DE4A⁸) initiative, the World Bank commissioned a feasibility study to develop an operational roadmap to connect all African HEIs to high-speed Internet. The initiative, in support of the African Union Digital Transformation Strategy for Africa (2020-2030)⁹, aims to digitally enable every African individual, business, and government by 2030. Connecting universities and research institutions is crucial for expanding the opportunities for teaching, learning and innovation to foster relevant digital skills on the continent. This study has received funding from the Digital Development Partnership (DDP)¹⁰.

As part of the feasibility study, this report provides a detailed country-level assessment to connect all HEIs in Uganda to high-speed internet.

Following the Introduction in Chapter 1, the report provides a country overview in Chapter 2 to provide the national context. The connectivity gap has both a supply-side and a demand-side: Chapter 3 explores the demand-side, focusing on ICT in the education sector and the challenges impacting the use of information and communication technologies for teaching, learning, and research—creating the pull factors; and Chapter 4 examines the supply-side, the ICT sector's key components and the challenges affecting high-speed connectivity. The National Research and Education Network (NREN), the Research and Education Network for Uganda (RENU) is the higher education response created to close the gap between the demand-side and the supply-side, and Chapter 5 presents a high-level summary of the status

⁷ We use the term *Higher Education*, also known as *Tertiary Education* in some countries, to refer to all post-secondary education, including both public and private universities, colleges, technical training institutes, and vocational schools
<https://www.worldbank.org/en/topic/tertiaryeducation>

⁸ See <https://www.worldbank.org/en/programs/all-africa-digital-transformation>.

⁹ <https://au.int/en/documents/20200518/digital-transformation-strategy-africa-2020-2030>.

¹⁰ <https://www.worldbank.org/en/programs/digital-development-partnership>.

of RENU as well as its achievements and limitation in delivering high-speed connectivity to HEIs. Drawing on findings from the earlier chapters, Chapter 6 discusses the cost of connecting all higher education institutions in Uganda to high-speed Internet. The conclusion is given in Chapter 7, followed by the Appendices.

Source: Office of Information and Communications Technology, United Nations



11 *Uganda Bureau of Statistics (UBOS) population projections, 2019*

as indicated in Figure 1. Each district is further subdivided into counties, Sub-counties, Parishes and Villages (the lowest administrative structure).

Kampala, the country's capital was until 2019 the only urban agglomeration classified as a city. The government has announced the reclassification of 15 municipalities and towns in different regions of the country as regional cities that will be phased in over three years. This is expected to promote the transformation of surrounding rural economies and create new employment opportunities for the growing young population.¹²

Uganda Bureau of Statistics (UBOS) estimates the population growth rate stands at 3% per annum while the population density (number of people per square kilometre) is 173 persons. The youth within the age bracket for higher education (18-30 years) constitute 19.4% of the population and 71% of them live in rural areas.¹³ This growing population coupled with efforts to improve the performance of both Universal Primary Education (UPE) and Universal Secondary Education (USE) programs will put tremendous pressure on the capacity of the high education sector. The Gross Enrolment Ratio (GER) for primary education is 103% (2017) thanks to the UPE program. For secondary education, GER is 28% (2017), highlighting the low transition rate from primary to secondary education and the challenges facing USE. For higher education, GER is 6.9% (2018),¹⁴ below the sub-Saharan Africa average of 9.4% (2018), far below the world average of 38.8% (2018)¹⁵ and the target of 40% that Uganda needs to transform into a middle-income country.

Government expenditure on education has fallen from about 15% of total government spending in 2012/13 financial year to about 10% in 2018/19.¹⁶ This is in contrast to the recommended minimum level of 15% as specified in the agreement with the Global Partnership for Education (GPE) and the sub-Saharan African average at 17.8%.¹⁷

Uganda's economy grew by about 6.3% in 2019, largely driven by the expansion of the services sector. While agriculture is still one of the most important sectors of the economy, employing more than 70% of the work force, the economy is transitioning from an agriculture-based to a service-based economy. Other key economic drivers include retail, construction, and telecommunications were key economic drivers. Government expenditure has increased faster than domestic revenue generation, widening the fiscal deficit that is largely financed through external borrowing and domestic securities.¹⁸

Uganda faces a number of economic challenges. Conflicts in neighbouring countries have led to an increase in refugees, turning Uganda into the largest refugee hosting country in Africa. Besides increasing the number of refugees who compete with locals for resources and public service, the conflicts have disrupted trade with neighbouring countries, including with South Sudan, one of Uganda's main export destinations. Inadequate investments in the health,

12 List of cities and towns in Uganda, https://en.wikipedia.org/wiki/List_of_cities_and_towns_in_Uganda

13 UBOS, 2020. World Population Day Brochure 2020.

14 National Council for Higher Education (2019). The State of Higher Education Report 2017/18

15 World Bank data, <https://data.worldbank.org/indicator/SE.TER.ENRR?end=2020&locations=ZG-1W-UG&start=2010>

16 Uganda Education Sector Strategic Plan 2017-2020

17 <http://uis.unesco.org/en/country/ug>

18 African Development Bank: Uganda Economy Outlook 2019, <https://www.afdb.org/en/countries/east-africa/uganda/uganda-economic-outlook>

education, and economic opportunities are exacerbated by one of the fastest growing young populations, with a median age of 16.7, second lowest only after Niger.

This national context sets the stage for the discussion of the demand and supply side aspect relevant to access to broadband in Chapters 3 and 4.

3. Demand Side—the Education Sector

Within the context of the WBG initiative which is the subject of this feasibility study, the education sector is the consumer that must generate the pull factors that will make the outcomes sustainable. The potential size of this market, the ability to exploit broadband opportunities, and the ability to pay for the services are therefore key matters of consideration.

This Chapter examines the education sector in Uganda, and brings out the opportunities and the challenges, and also points to key areas of necessary intervention.

The education sector in Uganda falls under the purview of the Ministry of Education and Sports (MoES). MoES works with other line ministries, district local governments, various semi-autonomous and affiliated agencies as well as education institutions to deliver on the mandate expected of the sector in contributing towards the national Vision 2040.

3.1 Education Sector Policy and Governance

3.1.1 Key Policies and Regulations

The key education sector laws, policies and regulations that impact higher education include:

- i. The Universities and Other Tertiary Institutions (Amendment) Act, 2001, established a system to govern HEIs, regulates their establishment and management, defines the award of degrees, diplomas, certificates and other awards by different HEIs and equates the different professional qualifications.
- ii. The Business, Technical Vocational Education and Training Act, 2008 established an institutional framework for promotion and coordination of TVET, defines the scope and levels of TVET programmes and the roles of different stakeholders in TVET provision.
- iii. The Higher Education Students' Financing Board (HESFB) Act, 2014, established the Higher Education Students' Financing Board to provide loans and scholarships to Ugandan citizens intending to pursue Higher Education.
- iv. The Education and Sports Sector Strategic Plan (ESSP) 2017-2020, provides the policy framework to coordinate the work of different stakeholders across the education sector as they implement activities and guide investment programs to increase and improve equitable access to quality education.
- v. The BTVET Strategic Plan 2012-2022 "Skilling Uganda," is a guide to making TVET more relevant to the labour and production needs of Uganda and her economic development plans through improving equitable access, increasing the quality of skills provision and improving the effectiveness of TVET institutions.
- vi. The ICT in Education Sector Policy (still in draft since 2008), provides for creating

awareness about use of ICT in education and mechanisms to help improve digital literacy among both teachers and students.

- vii. The Technical Vocational Education and Training (TVET) Policy 2019 provides the framework to develop TVET through engaging the private sector, expanding the scope of the TVET Qualifications Framework and building an entity to manage skills development. The TVET policy is accompanied by a set of implementation standards and guidelines designed to guide stakeholders on mandatory practices and approaches across the sub-sector.

3.1.2 Key Regulatory and Standards Institutions

Sector policy, oversight, standards, content, assessment, and regulation are handled by MoES and various governmental agencies:

- Ministry of Education and Sports (MoES)¹⁹—sets the standards, provides technical guidance, monitors and evaluates education policy and regulates the education sector across the country. It is composed of three main directorates, one of these—the Directorate of Higher, Technical and Vocational Education and Training oversees higher education in Uganda.
- National Council for Higher Education (NCHE)²⁰—government agency responsible for the regulation of higher education in Uganda.
- National Curriculum Development Centre (NCDC)²¹—government agency responsible for development of curriculum and curricular materials. The BTVET department at NCDC develops competence-based curricula in line with the BTVET Act 2008 and Skilling Uganda Strategy.
- Uganda Business and Technical Examinations Board (UBTEB)²²—government agency mandated to streamline, regulate, coordinate and conduct credible national BTVET examinations and award Certificates and Diplomas.
- Directorate of Industrial Training (DIT)²³—agency responsible for quality assurance of the Business, Technical Vocational, Education Training (BTVET) sub-sector. They are mandated to develop occupational standards, regulate work-based training schemes, apply and expand the Uganda Vocational Qualifications Framework, accredit assessment centres, assess and award Uganda Vocational Qualifications as provided for in the BTVET Act 2008.
- The Industrial Training Council (ITC)—advisory body for MoES that advocates and lobbies for BTVET reforms and their implementation.

19 MOES website, <https://www.education.go.ug/>

20 UNCHE website, <https://www.unche.or.ug/>

21 NCDC website, <http://www.ncdc.go.ug/>

22 UBTEB website, <http://www.ubteb.go.ug/>

23 <https://dituganda.org/>

- High Education Student Financing Board (HESFB)²⁴—government agency responsible for providing loans to students pursuing studies in higher education institutions.
- Uganda National Council for Science & Technology (UNCST)²⁵—government agency under the Ministry of Science, Technology and Innovation (MoSIT) mandated to develop and implement strategies for integrating Science and Technology (S&T) in the national development process.

It is worth noting that accredited Universities are authorised to coordinate and run their own examinations for the different programmes that they offer, once these have been approved by the NCHE. The Ministry of Education and Sports' ICT Department is responsible for policymaking and standardisation in the education sector. The Department however, lacks the necessary resources and capability to assume this role.

3.2 Market Size

Higher education student enrolment in Uganda has grown from 120,646 students in 2010 to 282,000 students in 2020. Despite the tremendous growth in student enrolment, according to the National Council for Higher Education (NCHE), the Gross Enrolment Ratio for higher education was only 6.9% in 2018.²⁶ This is below the sub-Saharan Africa average of 9.4% and far below the world average of 38.8% in 2018.²⁷ Digital technologies present one of the avenues to increase access to higher education for the growing student number.

3.2.1 Target Institutions

Uganda's education system consists of three major levels of education that include:

- Primary education that consists of seven years of Primary (P1-P7). This has been free and compulsory since 1997 through the Universal Primary Education (UPE) program.
- Secondary education that consists of three to four years of Lower secondary (S1-S4) or Ordinary level and two years of Upper secondary (S5-S6) or Advanced level. Secondary education has been free and compulsory since 2007 through the Universal Secondary Education (USE) program.
- Higher education that consists of two to five years at a University or Business, Technical, Vocational Education and Training (BTVE).

It is important to note that BTVE institutions in Uganda can enrol both primary and secondary education graduates. In addition, Uganda makes a distinction between business and other technical and vocational studies, hence the term BTVE. In the context of this study, we use the term TVET to refer to BTVE institutions that enrol students that have completed secondary education.

²⁴ HESFB website, <https://www.hesfb.go.ug>

²⁵ UNCST website, <https://www.uncst.go.ug/>

²⁶ NCHE, 2019. *The State of Higher Education Report 2017/18*

²⁷ World Bank data, <https://data.worldbank.org/indicator/SE.TER.ENRR?end=2020&locations=ZG-1W-UG&start=2010>

The focus of this assignment is the higher education level (also sometimes referred to as tertiary) and institutions at this level provide the foundation for subsequent analysis. The Universities and Other Tertiary Institutions Act distinguishes among 3 categories of higher education institutions in Uganda:

- i. University—any Institution, School, Institute or centre of Higher Education, other than a Tertiary Institution, one of the objects of which is the provision of post-secondary education offering courses of study leading to the award of certificates, diplomas and degrees and conducting research and publish
- ii. Other Degree Awarding Institution (ODAI)—any institution that offers degrees and is duly registered with and has a licence from the NCHE
- iii. Other Tertiary Institution (OTI)—any public or private Institution, school or centre of Higher Education other than a University, one of the objects of which is to provide post-secondary education offering courses of study leading to the award of certificates or diplomas and conducting research.

TVETs are classified as ODAI when they offer degrees or OTI when they offer diplomas and certificates. All institutions are further categorised into public and private. There are currently 52 accredited Universities, 13 ODAs and 171 OTIs. The full list of accredited higher education institutions with their student enrolment is summarised in Appendix A:

3.2.2 Student Enrolment

Figure 2 shows trends in student enrolment (in higher education) based on available data, highlighting that more students (72%) were enrolled in universities compared to TVETs (24%). Lower enrolment in TVETs is primarily due to the negative image associated with TVETs, and the general perception that TVET courses are for failures that did not make it to University.²⁸

Source: Annual School Census, Ministry of Education and Sports, 2013-2017

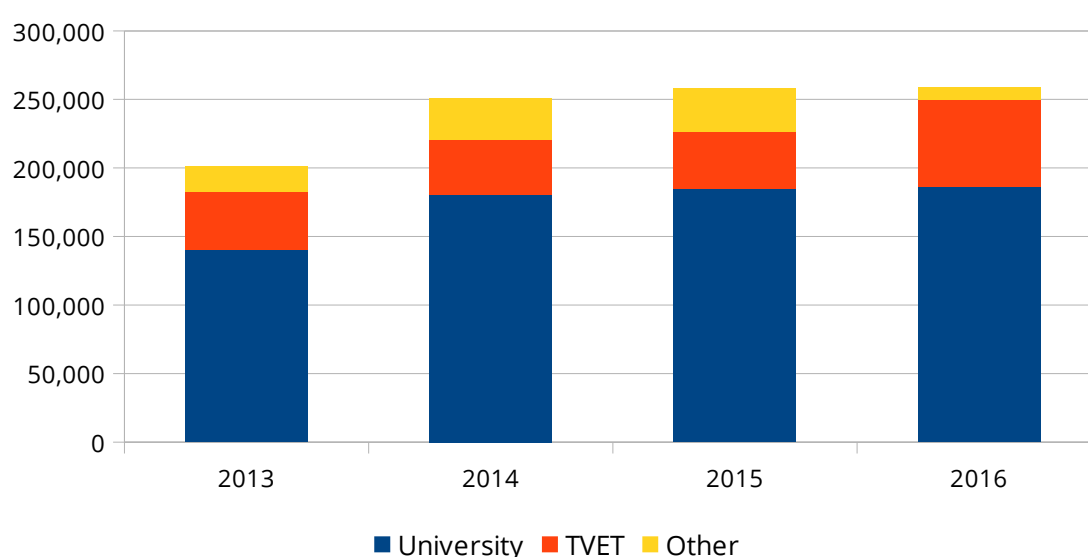


Figure 2: Trends in student enrolment in higher education

For this analysis, the lower levels of education are important from the perspective that they provide an indication of future enrolment for higher education. Based on the National Council for Higher Education (NCHE), Uganda's Gross Enrolment Ratio (GER) for higher education was only 6.9% in 2018.²⁹ This is below the sub-Saharan Africa average of 9.4% and far below the world average of 38.8% in 2018.³⁰ Table 1 shows that while Uganda has managed to expand access to primary education through UPE, it faces challenges in expanding access to secondary education, despite being the pioneer of USE in sub-Saharan Africa. The failure is attributed to different factors including insufficient public spending on education, low transition rates from primary to lower secondary education, disparities in levels of access to secondary education, an outdated and overloaded curriculum, and poorly qualified teachers who are often inefficiently deployed.³¹

Table 1: Student enrolment in lower education levels (000)

Level	2013	2014	2015	2016	2017	2020*
Pre-primary education	430	433	477	564	609	
Primary school education	8,460	8,773	8,264	8,656	8,841	9,236
Secondary school education	1,363	1,391	1,284	1,458	1,371	1,799

Source: Annual School Census, Ministry of Education and Sports, 2013-2017, 2020 figures are ESSP targets

Source: Annual School Census, Ministry of Education and Sports, 2013-2017

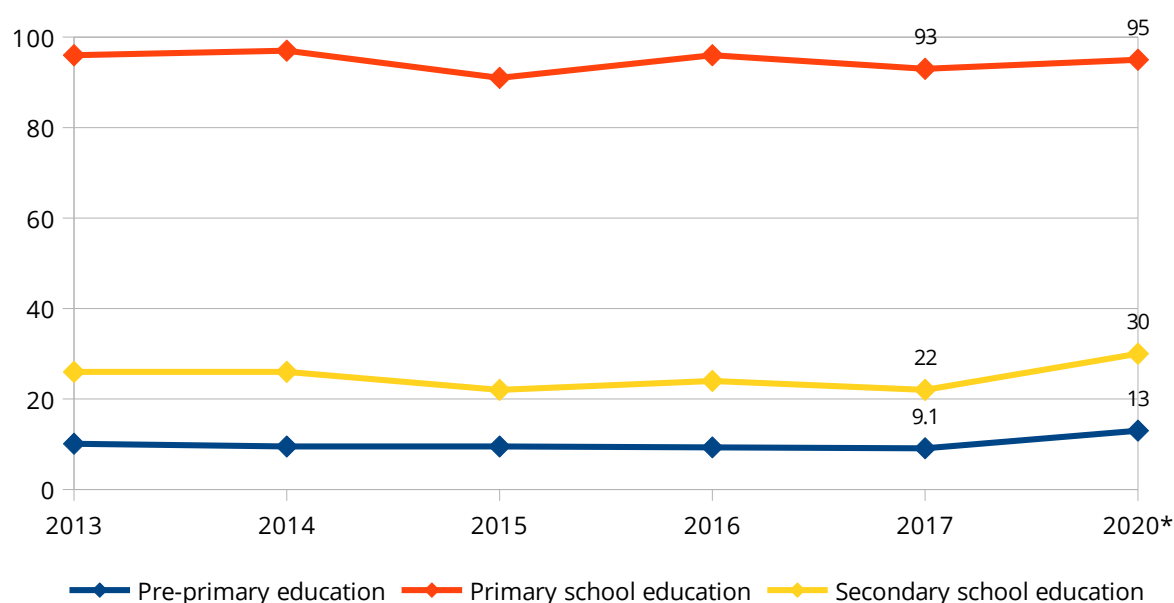


Figure 3: Net enrolment ratios for different levels of education

29 NCHE, 2019. *The State of Higher Education Report 2017/18*

30 World Bank data, <https://data.worldbank.org/indicator/SE.TER.ENRR?end=2020&locations=ZG-1W-UG&start=2010>

31 Bashir, Sajitha; Lockheed, Marlaine; Ninan, Elizabeth; Tan, Jee-Peng. 2018. *Facing Forward : Schooling for Learning in Africa*. Washington, DC: World Bank.

3.2.3 Bandwidth for Higher Education

Interviews with various stakeholders indicate that Universities in Uganda buy bandwidth based on available resources rather than what is sufficient for their student needs. Based on the connectivity requirements of students and staff, use of next generation technologies, as well as regional and global comparators, the Gap Analysis Report recommended that higher education institutions achieve connectivity of at least 200 Mbps per 1,000 students in 2021. The progressive bandwidth targets increase to at least 2 Gbps per 1,000 students by 2025 (to be provided for in the World Bank planning period ending 2023) and at least 20 Gbps per 1,000 students by 2030 (see Table 16).

Table 2 indicates that Universities and TVETs in Uganda will need about at least 684 Gbps by 2025 and 8 Tbps by 2030. Current total connectivity to Uganda for all national needs currently stands at 175 Gbps. These projections underscore the huge gap that has to be addressed by Uganda, not just by increasing external bandwidth, but by increasing the volume of local content, locally hosted content (like major caches) and traffic exchanged through IXPs.

Table 2: Forecast for student enrolment (rounded to 1000) and bandwidth requirements (2025 & 2030)

Year	Higher education students (rounded to nearest 1000)	Bandwidth requirement (Gbps)
2025 (2 Gbps per 1,000 students)	342,000	684
2030 (20 Gbps per 1,000 students)	402,000	8,043

Source: KCL calculations

3.2.4 Quality and Sufficiency of Campus Networks

From interviews with RENU and different universities in Uganda, it is apparent that universities and TVETs will need to invest in upgrading their campus networks in order to be able to effectively utilise the high-speed connectivity that they actually need based on current and projected student enrolment. For example, an institution like Makerere University has one of the best campus networks in the country with a fibre backbone that is already 10 Gbps enabled thanks using both internal resources and extensive support from the Government of Uganda and various development partners (see Appendix A:). But Makerere will also need to invest in some new infrastructure like aggregation switches at major campuses to be able to effectively distribute the increased capacity as well as new border routers capable of handling 100 Gbps and more.

Insufficient technically qualified staff and low levels of technical competence among ICT staff/technicians to deploy and maintain capable campus networks compound this challenge. To address the need for technical ICT expertise, most universities with more mature ICT infrastructure have created centralised units to maintain ICT infrastructure and services as well as provide guidance on ICT to other academic and administrative units. This is the

Directorate for ICT Support (DICTS) at Makerere (see Figure 4),³² the Directorate of ICT Services at Kyambogo University (DICTS),³³ University ICT Services at Uganda Christian University (UCU),³⁴ or the Directorate of ICT at Busitema University.³⁵ Despite this, the number of staff employed in such units is still low compared to the ICT services that need to be offered and supported. For example, at Makerere, DICTS has a staff establishment of 40 positions within the structure (see Figure 4), of which only 16 are currently filled with full-time staff, supported by 20 student interns. This team supports about 40,000 students and staff at the university.

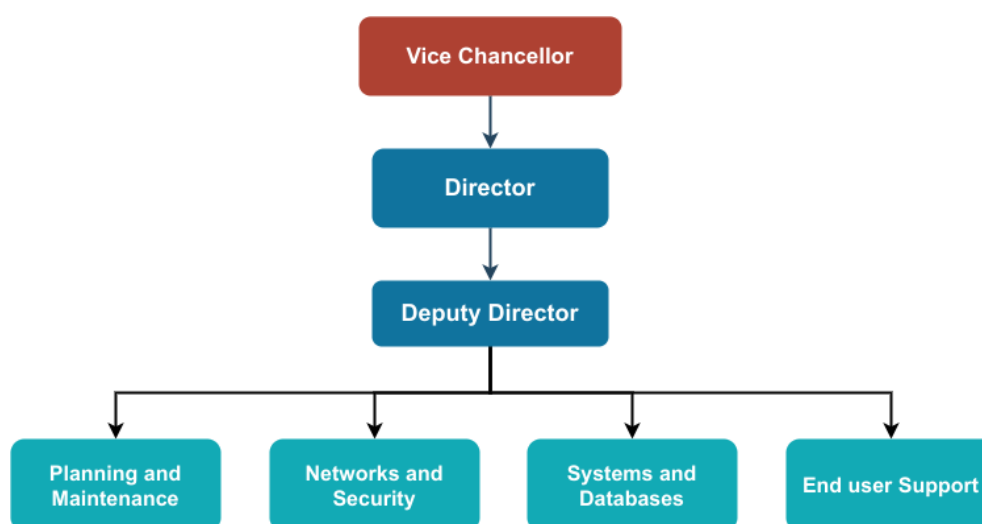


Figure 4: Organogram for DICTS at Makerere University

A limitation of such units is that they are predominantly focused on network and equipment maintenance, but not on supporting students and staff on how to use and integrate ICT into teaching and learning. While a few Universities have instituted cross-cutting foundational courses on ICT, none have units dedicated to addressing the wide gap that exists in terms of digital skills among students and staff.

Poor pay, lack of adequate numbers of staff as well as lack of training opportunities were cited by the ICT support staff that the consulting team interacted with.

3.2.5 Sufficiency of Access Devices

In Uganda, very few households have either Internet access or a computer at home as depicted in Figure 5. Like in other countries, more households have Internet access compared to computers because individuals can now connect to the Internet using other devices like smartphones.

Source: ITU, NITA-U and UCC

³² <https://dicts.mak.ac.ug/>

³³ <https://dicts.kyu.ac.ug/>

³⁴ <https://ucu.ac.ug/ucu-facilities/category1/university-ict-services>

³⁵ <https://busitema.ac.ug/services/directorate-ict/>

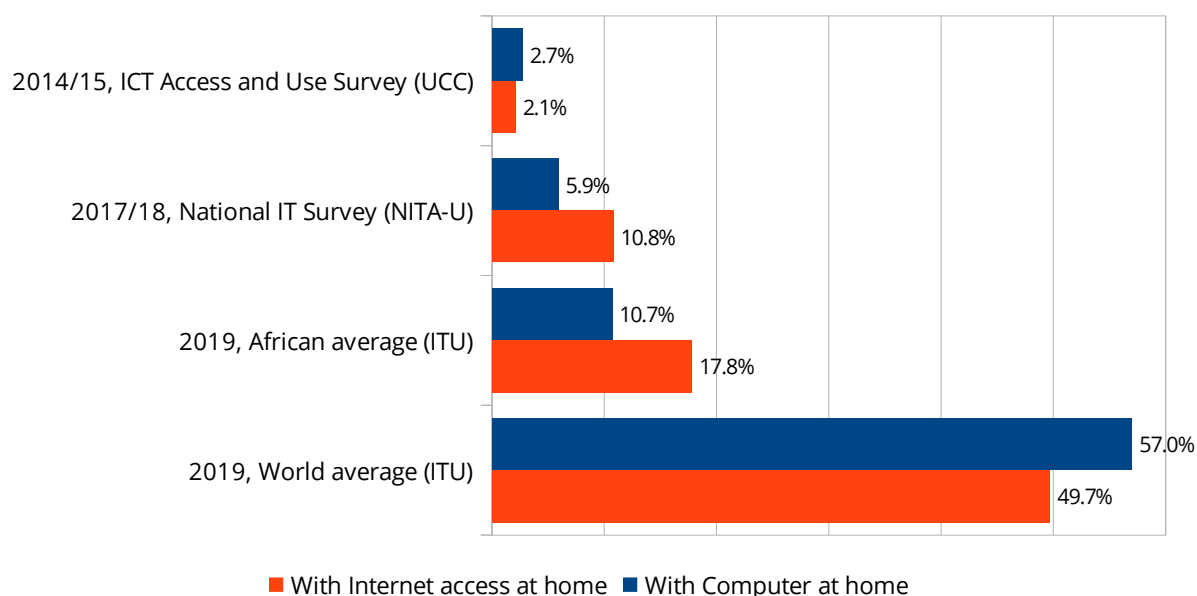


Figure 5: Comparison of households with access to computers and Internet

Shortage of computers for students on campus is still a big challenge. Although universities have tried to establish student computer laboratories, they are largely unsustainable. The Higher Education Strategic Plan (HESP) 2003–2015 stipulated that universities maintain an ICT equipment ratio of at least 1 computer to 10 students by 2010, and 1 to 5 by 2015. By 2012, when the African Development Bank (AfDB) appraised universities as part of the Support to Higher Technology (HEST) Project, only Makerere University had attained this requirement with a ratio of computers to students of 1:7. Mbarara University of Science and Technology (MUST) had a ratio of 1:23, Gulu University had a ratio of 1:34, while in Kyambogo University and Busitema University had far lower indicators.³⁶ While the HESP project set out to close this gap to an average ratio of 1:10 across target institutions, the situation at Makerere has only worsened. This reinforces findings that universities did not invest the resources required to maintain and replace desktops as they broke down or aged,³⁷ leading to the conclusion that student access needs to be addressed through individual ownership of devices.

3.3 Education Sector Challenges Impacting Leveraging ICT for Learning

From an education sector perspective, there are a number of challenges that inhibit the use of ICTs particularly in higher education. Some of these include:

- i. The ESSP highlights the lack of an ICT policy for the sector to promote digital literacy and e-learning in higher education and secondary education as an avenue to improve learning outcomes.³⁸ While the MoES has shown interest to develop a sectoral ICT policy, it did not have such capability, until recently where new policy initiative began in

³⁶ African Development Bank, 2012. *Project Appraisal Report, Project: Support to Higher Technology (HEST) Project, Uganda*.

³⁷ From assignments carried out for Sida by KCL

³⁸ MOES, 2017. *ESSP 2017/18 – 2019/20*

2020 in coordination with the Ministry of Information and Communication and National Guidance. A draft was developed in 2008 and updated in 2018 with the help of UNESCO, but is yet to be formalised in order to guide sector stakeholders. At the institutional level, most institutions still lack any kind of policy or strategy documents to guide prioritisation and the coherent integration of ICT within their functions.

- ii. Lack of an adequate pool of ICT champions within higher education that are positioned high enough within the hierarchy to promote the adoption and use of ICTs within their institutions. Integration of ICT is still treated as a technical challenge rather something that can be leveraged to improve operational efficiency.
- iii. Generally low digital literacy among both lecturers/tutors and students on how to leverage ICT for teaching and learning.^{39,40}
- iv. Lack of knowledge and capacity on how to leverage ICT to improve teaching and learning.
- v. Although there is digital content and applications that can be adopted to support teaching and learning, there is no formal mechanism to evaluate and determine what is relevant and/or appropriate for different levels and programmes of education.
- vi. The sector lacks a fully-functional Education Management Information System (EMIS), resulting in challenges with comprehensive and timely data to support effective planning as well as monitoring and evaluation. There is no comprehensive data on higher education institutions in Uganda. The little data available is siloed across multiple institutions including MoES, NCHE and the different higher education institutions.
- vii. Very limited investment in campus ICT infrastructure and resources, compounded by inadequate public funding for higher education that has not kept pace with growth in enrolment. In 2018, Uganda government expenditure on education was 2.1% of GDP compared to a sub-Saharan average of 4.3%. In addition, expenditure on higher education as a fraction of total government expenditure on education fell gradually from 28.3% in 1974 to 16.3% in 2014.⁴¹ All this is in contrast to a growing young population and implementation of UPE and USE. Both public and private institutions rely on funding from student tuition contributed by families that are largely poor. Consequently, higher education institutions have plenty of competing priorities, making it difficult to invest in ICT infrastructure and its exploitation for teaching and learning. Even when these are donated, institutions may find it difficult to maintain, replenish or replace such equipment, when the time comes.^{38,39}

39 NDPIII draft, 2020

40 MoICT, 2018. *National Broadband Policy*

41 World Bank data <https://data.worldbank.org/indicator/SE.XPD.TERT.ZS?end=2020&locations=ZG-1W-UG&start=2008>

4. Supply Side—the ICT Sector

The ease, or difficulty in connecting all HEIs to broadband will be influenced by the policy and regulatory environments. For clarity, the regulatory environment also extends to the tax laws, the investment code, and other laws, for example those which govern immigration, all these converge into the ease of doing business in the country.

This Chapter examines the supply side, looking at both the environment and the service providers as well as the opportunities and challenges in trying to deliver broadband to all the target institutions. While NREs are part of the supply side, the Research and Education Network of Uganda (RENU) is considered in a separate chapter because it has become a critical enabler for connecting to the target market.

4.1 ICT Sector Policy and Regulation

4.1.1 National Development Plans

As Uganda aspires to become a middle-income country as articulated in Uganda Vision 2040, the third National Development Plan (NDPIII, 2020/21-2024/25), which sets direction of the country, has identified 18 programs for continued investment to spur social and economic development. One of these programs, the Digital Transformation Program considers Information and Communication Technologies (ICT) as a “fulcrum of development” that can be used to power other sectors by increasing their efficiency and effectiveness. The NDPIII identifies a number of challenges holding back the ICT sector including:

- i. Limited coverage of ICT infrastructure and networks
- ii. High cost of ICT devices and services
- iii. Poor quality of ICT services
- iv. Inadequate ICT knowledge and skills among users and
- v. Limited ICT innovation capacity.

The Digital Transformation Program is designed to purposely increase national coverage of ICT infrastructure including in rural and remote areas, improve access to ICT services, reduce the cost of ICT devices and services and create more jobs within the ICT and other sectors.

Among the major lessons drawn from past NDPs is that the market alone will not successfully drive Uganda’s development. NDPIII therefore recommends a quasi-market approach that also calls for government intervention in selected key areas. Access to the internet is highlighted as one of the areas where market forces and power of competition have failed to improve the coverage and bring down the cost of services. ICT is earmarked as one of the key development opportunities that need increased investment in order to bridge the gap

between what is available and what is needed to exploit the current development opportunities. Investments are envisioned in ICT infrastructure, ICT incubation centres and more bandwidth.

4.1.2 Key Policies and Regulations

Key ICT sector laws, policies and regulations that have an impact on various components of connectivity include:

- i. Communications Act, 1997⁴² provided for the restructuring the ICT sector in Uganda, paving way for liberalisation and established Uganda Communications Commission (UCC) as a sector regulator. The Act was amended in 2013⁴³ to consolidate and harmonise the Uganda Communications Act and the Electronic Media Act and to dissolve UCC and the Broadcasting Council and reconstitute them as UCC to oversee both telecommunication and broadcasting. Under the Act, the Minister is empowered and has made a number of regulations to help operationalise the Act. Some of the regulations that are most pertinent for connectivity include:
 - a) Interconnection and Access Regulations, S.I No.88 of 2019 provides a framework for regulating interconnection and access agreements, infrastructure sharing, dispute resolution, conduct of operators with significant market power in interconnect and access markets, as well as consumer protection and data privacy. These regulations categorise licenses into national and regional, obligating national providers to carry other types of providers on their networks;
 - b) Licensing Regulations, S.I No. 95 of 2019 that aim to promote transparent licensing, fair competition and an inter-operable nation-wide ICT infrastructure;
 - c) Universal Service Regulations, S.I No.86 of 2019 to ensure measurable universal provision of and access to quality and affordable basic ICT services;
 - d) Quality of Service Regulations, S.I No.92 of 2019 that prescribes minimum standards of quality of service for operators, defines standard for measurement and stipulates penalties for non-compliance;
 - e) Computer Emergency Response Team (CERT) Regulations, S.I No. 81 of 2019 that help identify critical ICT infrastructure, provide for CERTs to manage Cybersecurity incidents and a framework for emergency response measures.
- ii. Electronic Signatures Act, 2011, which provides for the use of electronic signatures to ensure that transactions are carried out in a secure environment and establishes a public key infrastructure for authenticity and security of documents. The Electronic Signatures Regulations, 2013, help operationalise the Act;
- iii. Electronic Transactions Act, 2011, provides for the use, security, facilitation and regulation of electronic transactions to facilitate the development of e-commerce in Uganda. The Electronic Transactions Regulations, 2013, help operationalise the Act;
- iv. Computer Misuse Act, 2011, provides for the safety and security of electronic transactions and information systems by recognising computer crime and defining computer misuse offences. The Act has mechanisms to investigate and prosecute such crimes and offences. This is augmented by the National Information Security Strategy

42 Uganda Communications Act, 1997, Act No, 8 of 1997, <http://www.itu.int/ITU-D/ict/webs/ucc/uca1997.pdf>

43 Uganda Communications Act, 2013,, <https://www.ucc.co.ug/files/downloads/UCC%20Act%202013.pdf>

- (NISS) 2011 and the National Information Security Framework (NISF) 2014, which guide information security activities across various MDAs;
- v. Data Protection and Privacy Act 2019 is the latest regulation which provides a framework to protect the privacy of individuals and their personal data by regulating the collection and processing of personal information. It defines obligations of data collectors, processors and controllers and regulates disclosure of personal information. The Draft Data Protection and Privacy Regulations 2019 will help operationalise the Act. The Act is critical within the context of increasing connectivity of the education sector, especially in protecting learners' data;
 - vi. National ICT Policy, 2014 provides the framework to develop the ICT sector in support of the national development agenda by expanding and integrating ICT infrastructure across the country, building digitally-literate human capital, intensifying use of ICT services by both public and private sectors, improving research and innovation in ICT products and services as well as enhancing governance of the ICT sector;
 - vii. National Broadband Policy, 2018 provides a framework to review the licensing regime of ICT providers to ensure their operations are in line with sector strategic objectives, optimise and increase efficiency of broadband infrastructure by encouraging measures like infrastructure sharing and ensure broadband coverage across the country;
 - viii. Digital Uganda Vision, is a policy and strategic framework that consolidates all existing ICT policies and plans to respond to the national Vision 2040 and to provide a unified direction and ease implementation.

4.1.3 Key Policy and Regulatory Institutions

Some of the key institutions that oversee the ICT sector in the country include:

- Ministry of ICT and National Guidance (MoICTNG)—sets the standards, provides technical guidance, monitors and evaluates ICT policy and regulates the ICT sector across the country
- Uganda Communications Commission (UCC)—government agency responsible for regulating the communications sector encompassing telecoms, broadcasting, film, and postal services and infrastructure
- National Information Technology Authority of Uganda (NITA-U)—government agency responsible for integration and support of Information Technology (IT) systems across Government, harmonisation of IT standards across the public sector as well as the roll-out and operation of the National Backbone Infrastructure (NBI) across the country.

4.1.4 National ICT Indicators

National ICT indicators collected during the Gap Analysis phase also have a direct bearing on connectivity for higher education institutions at the country-level. The most pertinent integrated into the cost model include:

- i. Whether the country is landlocked or has access to the ocean allows direct access to

- submarine cables. Direct access to submarine cables reduces base bandwidth cost. Uganda is landlocked and has to rely on her neighbours to access submarine cables.
- ii. Number of submarine cable landing stations. Landlocked countries like Uganda have none, while Kenya, which provides Uganda's access to the sea has 6 cable landings and Egypt has the most with 15. More landings improve competition amongst cable providers resulting in competitive pricing. Uganda had licensed cable operators to offer IP transit through carrier Points of Presence (PoPs) or Virtual Landing Points (VLPs) for competitive global access.
 - iii. Internet eXchange Ladder Stage. Countries were categorised into 4 stages (see Table 3) depending on the number of IXPs and carrier neutral data centres they have as well as the interaction between these two important facilities.⁴⁴ Uganda is at Stage 2 of the ladder with one IXP—the Uganda Internet Exchange Point (UIXP), and a carrier-neutral data centre operated by Raxio.

Table 3: Stages of the Internet Exchange Ladder

Stage	Status	Countries
Stage 0	No IXP, internet traffic exchanged overseas	Algeria, Cabo Verde, Central African Republic, Chad, Comoros, Equatorial Guinea, Eritrea, Ethiopia, Guinea-Bissau, Lesotho, Libya, Mauritania, Niger, São Tomé and Príncipe, Seychelles, Sierra Leone, Somalia, South Sudan
Stage 1	Domestic internet traffic between ISPs exchanged at IXP	Benin, Botswana, Burkina Faso, Cameroon, Congo, Côte d'Ivoire, Egypt, Eswatini, Gabon, Gambia, Guinea, Liberia, Madagascar, Malawi, Mali, Namibia, Rwanda, Senegal, Sudan, Tanzania, Togo, Tunisia, Zambia, Zimbabwe
Stage 2	Diversity of participants at IXP, presence of global Content Distribution Networks (CDNs)	Angola, Burundi, Democratic Republic of Congo, Mauritius, Morocco, Mozambique, Uganda
Stage 3	IXP located alongside carrier neutral co-location data center	Djibouti, Ghana, Kenya, Nigeria, South Africa

Source: NREN Survey and Interviews with CEOs, 2020

- iv. % Population within 10-km fibre coverage (reflects fibre network coverage of the country). Only 28% of Uganda's population currently lives within 10-km of fibre coverage, mainly around the large urban areas. This has a direct bearing on the cost of connecting higher education institutions, especially rural campuses.
- v. Regulatory score, which reflects the maturity of the regulatory environment. It is based on individual country scores from ITU Global Regulatory Outlook 2020. While Uganda was the first country in Africa to attain fourth generation status, her score has been stagnant at 86 out of a possible 100 for the last three years. This maybe an indication of stagnation in terms of improving the ICT regulatory environment. A good regulatory environment leads to more competitive connectivity offerings.

44 World Bank Group, 2020. *National Data Infrastructure The Role of Internet Exchange Points, Content Delivery Networks, and Data Centres (was still in draft form)*

4.2 Sector Operations

4.2.1 Licensing, Market Structure and Service Providers

Uganda adopted a technology-neutral licensing framework in 2006 introducing a new range of licenses that distinguished between service provision and infrastructure service provision to encourage infrastructure sharing. The Public Infrastructure Provider (PIP) licence for commercial telecommunications infrastructure and the Public Service Provider (PSP) licence for telecommunication's services (voice, data, audio-visual content or other), have to co-exist with two National Telecom Operator (NTO) licences that had earlier been issued to vertically integrated providers operating in the market before the advent of the new licensing regime. The PSP licence has two sub-categories—one for providers to offer Voice and Data services and the other for Capacity Resale of leased services.

While the Ugandan market is considered dynamic on account of the number of operators, it remains highly concentrated, rendering competition suboptimal. Airtel and MTN, both vertically integrated Network Operators, together dominate the telecommunications market, with mobile voice services as the predominant service. Use of data services is still limited and access is still largely via mobile phones due to the wide coverage of the mobile networks. Uganda Telecom and Africell, the other MNOs, though also vertically integrated have limited reach in terms of infrastructure, making them marginal players. Africell's initial focus on the data services to attract customers to their network have since come under intense pricing pressure with operators undercutting each other in the shift from voice to data focussed business models.

The licensing regime attracted a number of providers primarily focussed on infrastructure and capacity resale to other licensed providers. Major players in this space include CSquared, Liquid Telecom, NITA-U (manages the National Backbone Infrastructure or NBI through Soliton Telmec), Bandwidth and Cloud Services group (BCS), and American Tower Company (ATC), the latter now the monopoly TowerCo after acquiring their only competitor, Eaton Towers. The distribution and services provided by current licensees is summarised in Table 23 in Appendix B:.

4.2.2 Access to Broadband

Broadband access in Uganda is still limited by the underlying network infrastructure. Currently, 85% of the population lives within coverage of a 3G mobile network and 61% within coverage of 4G as summarised in Figure 6 according to recent data from UCC.⁴⁵ Despite this, the proportion of individuals using the Internet is still low at only 24% compared to an African average of 28% or a World average of 54%.⁴⁶ By age group, individuals in the 15-24 age group, from whom higher education students are drawn, are the biggest proportion of individuals

⁴⁵ UCC 2020. *Market Performance Report 4th Quarter 2019*

⁴⁶ ITU 2019. *Measuring Digital Development: Facts and Figures*

that use the Internet or own smartphones.⁴⁷

Source: UCC data 2020

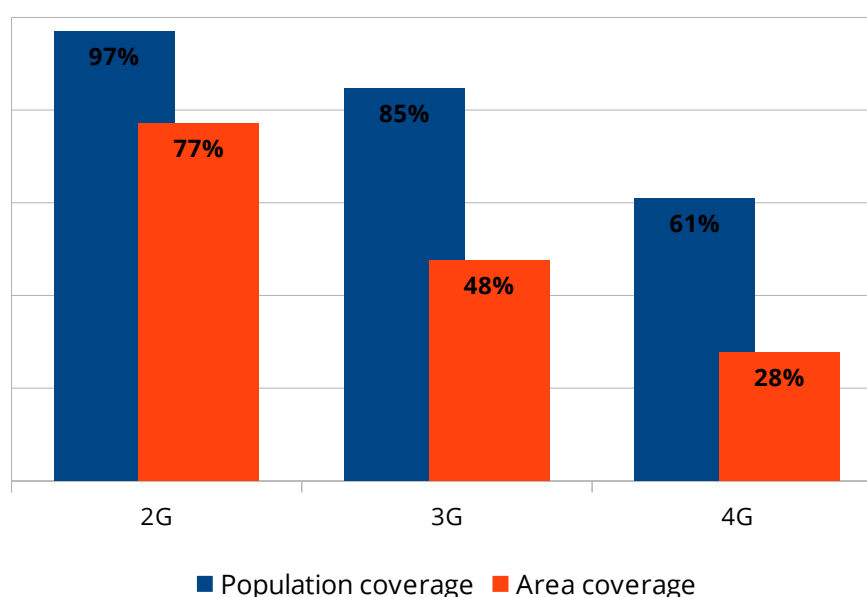


Figure 6: Type of network coverage by population and area

Although ICT policy and regulation encourages infrastructure sharing, this is yet to be fully embraced. In terms of terrestrial fibre, Uganda now has about 21,472 km of fibre optic cable⁴⁸ laid by both public and private licensed providers covering 49% of the districts and 24% of sub counties, but the duplication among licensed operators on certain routes as depicted in Figure 7 means that effective coverage is limited and mainly covers major urban centres.⁴⁹ This is one area that MoICTNG is trying to address through the National Broadband Policy by attempting to enforce infrastructure sharing among licensed operators. Fibre networks are particularly important because the high-speed broadband that WBG would like to provide higher education institutions can only be sustainably provided via such networks.

Being one of 16 countries on the continent that are landlocked, Uganda relies on overland routes through Malaba and Busia to Mombasa in Kenya, and through Mutukula to Dar es Salaam in Tanzania, to reach multiple submarine cables as shown in Figure 7. Total International bandwidth has grown to 175 Gbps while the number of internet subscriptions currently stands at about 19 million users according to recent UCC data.⁴⁸

⁴⁷ NITA-U, 2018. *National IT Survey 2017/18*

⁴⁸ UCC data, 2020

⁴⁹ NDPIII draft, 2020

Source: Africa Telecom Transmission Map, 2020. Hamilton Research Ltd, www.africabandwidthmaps.com

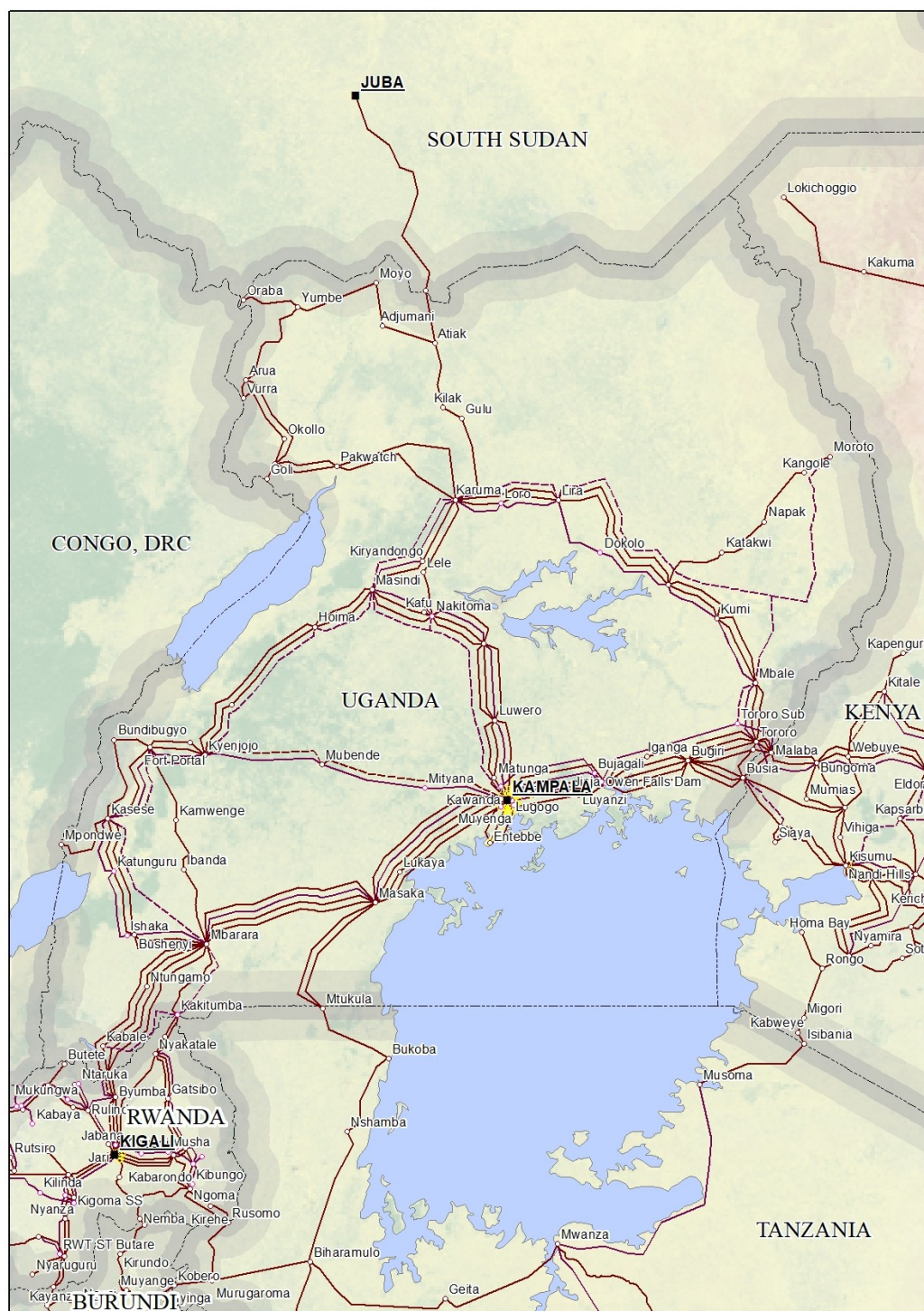


Figure 7: Distribution of fibre networks across Uganda

Mobile cellular subscriptions continue to grow while fixed-telephone subscriptions decline as shown in Figure 8. Mobile broadband subscriptions tally with the number of Internet users reflecting the fact that Internet users in Uganda predominantly use mobile devices to access the Internet.

Source: ITU data 2019

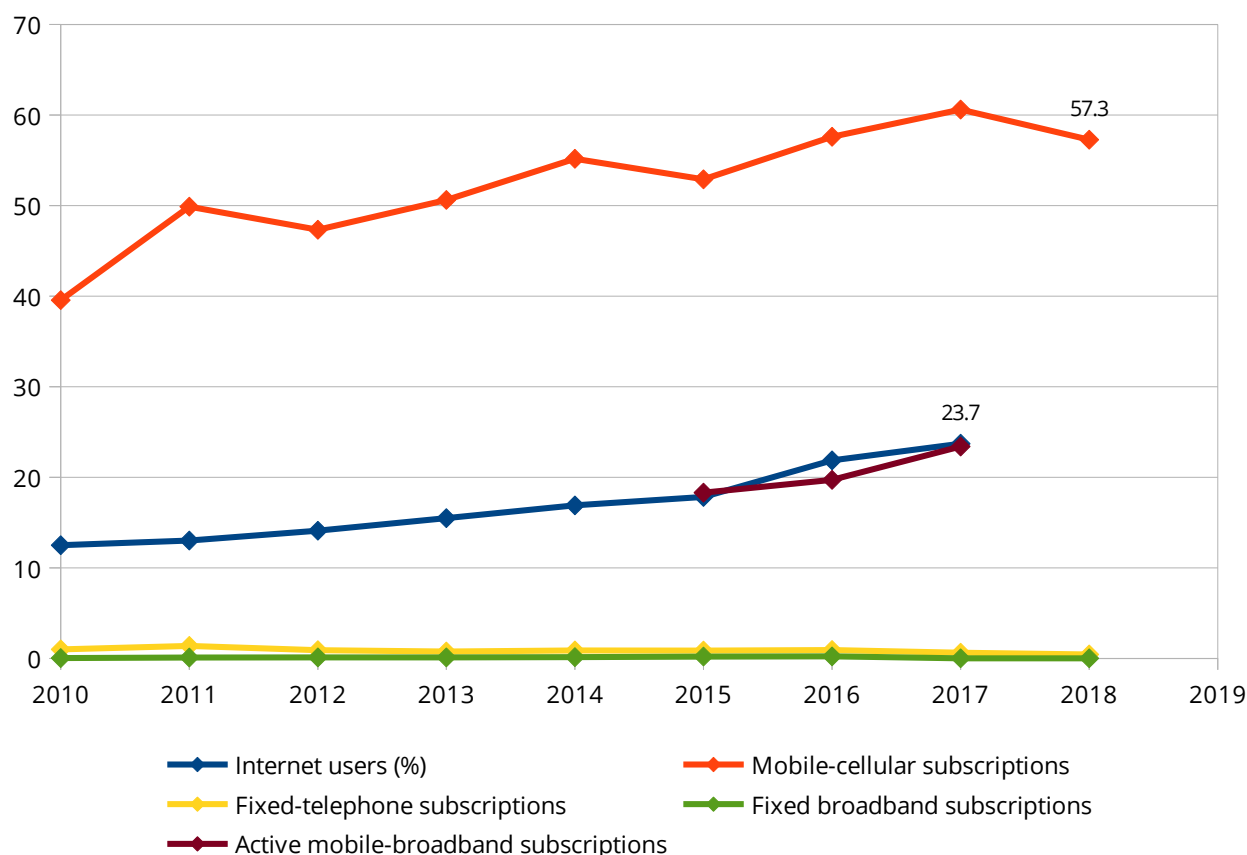


Figure 8: Trends in mobile and fixed subscriptions (per 100) 2010-2019

4.2.3 IXPs and Data Centres

Another mechanism for local Internet traffic aggregation and exchange is the Uganda Internet Exchange Point (UIXP).⁵⁰ This started off as a neutral initiative of the local Internet community to encourage the exchange of Internet traffic (IP traffic) between all interested parties in 2001. It started off with an equipment donation from the Network Startup Resource Centre (NSRC), a room donated by UCC and local ISPs providing technical setup and training on a voluntary basis. UIXP has since been formalised as non-profit organisation that provides reliable, high-speed network interconnection infrastructure complete with route servers, root DNS services and content delivery networks. The UIXP implemented service fees (setup and monthly recurring costs) with effect from January 2018. Currently, members pay a one-time setup fee which entitles them to power and 2 Rack Units (RU) free of charge and a monthly recurrent cost (MRC) that is reviewed annually for different services. RENU receives a 50% discount on peering charges at the UIXP for carrying research and education traffic, and indicated that on average they saved about 2 Gbps of international connectivity on a daily basis by exchanging traffic locally at the UIXP.⁵¹

Table 4 shows the costs for different services during 2020.

⁵⁰ Uganda Internet Exchange Point www.uixp.co.ug

⁵¹ Interview with Brian Masiga, who doubles as Head of Network Operations at RENU and an Exchange Engineer at UIXP

Table 4: Costing for UIXP services, 2020

Description	Non-Recurring Cost (NRC) US\$	Monthly Recurring Cost (MRC) US\$
Peering port 10 Mbps	200	Free
Peering port 100 Mbps	200	75
Peering port 1 Gbps	200	100
Peering port 10 Gbps	200	1000
Virtual Local Area Network (VLAN)	100	Free
Physical Private Network Interconnect (PNI)	100	150
Additional Rack Unit (RU)	100	250
Additional Peering IP Address	100	20

Source: UIXP, 2020

The IXP currently has 29 peering networks that also access content from Content Distribution Network (CDN) caches from Google, Facebook and Akamai. Regional carriers like Bandwidth & Cloud Services (BCS), Internet Solutions, Liquid Telecom and SEACOM also improve the quality of peers at the UIXP. Before the COVID-19 lock-down, peak traffic in 2020 reached 18 Gbps, saving the country expensive international bandwidth connectivity. This has since come down to about 8 Gbps as more users shift to mobile Internet usage, which has less impact on the IXP because mobile operators have on-network CDN cache nodes.^{52,53}

RENU, which receives a 50% discount on peering charges at the UIXP for carrying research and education traffic, indicated before the COVID-19 lock-down, on average saved about 2 Gbps of international connectivity on a daily basis by exchanging traffic locally at the UIXP.⁵⁴

Data Centres are another important component of a good digital ecosystem. NITA-U built and operates the National Data Centre in Kampala, which is largely used by government MDAs. First Brick Holdings is also building Uganda's first Tier-III carrier-neutral data centre, Raxio Data Centre, in Namanve Industrial Park, along Jinja road, the main fibre route between Kenya and Uganda.⁵⁵ It was initially slated for opening in early 2020, but COVID-19 lock-downs disrupted those plans. There is growing pressure for higher education institutions to provide a better online education and experience for students and staff within the constraints of growing numbers and diminishing space. While research is nascent, there is a lot of interest in big data and high process computing across different disciplines. All of this increases demand on campus ICT infrastructure at institutions with limited ICT budgets. Though universities have traditionally operated on-campus data centres and RENU offers basic data centre services, higher education institutions can benefit from increased availability of cloud services that reside in a Tier-III carrier-neutral data centre, especially if they are designed with a focus on higher education.

52 UIXP statistics <https://portal.uixp.co.ug/public-statistics/public>

53 UIXP blog, 2020 <http://blog.uixp.co.ug/2020/04/new-uptime-record-new-traffic-record.html>

54 Interview with Brian Masiga, who doubles as Head of Network Operations at RENU and an Exchange Engineer at UIXP

55 RAXIO Data Centre www.raxio.co.ug

Raxio has been courting international and national network providers, Internet Service providers (ISPs), Internet exchanges including the UIXP that has already signed on, mobile network operators, content distribution networks and cloud (storage and computing) service providers.^{56,57} Given that the bulk of the content exchanged at the IXP is from CDN caches at the IXP, if Raxio successfully attracts the Content Distribution Networks (CDNs) to directly setup shop and provide full content at the Data Centre, it is not yet clear what model the CDNs will adopt and how this will affect the traffic patterns at the IXP.

4.2.4 Cybersecurity

Cybersecurity policy and strategy are still evolving in Uganda. There are currently two major National Computer Emergency Response Teams (CERTs)—CERT-UG under NITA-U⁵⁸ and a telecoms sector CERT under UCC.⁵⁹ These are complimented by the Cybercrimes Unit under the Directorate of Forensic Services of the Uganda Police Force. The Global Cyber Security Capacity Centre facilitated a Cybersecurity capacity self-assessment with a wide range of stakeholders in 2016 who identified a number of areas for intervention that included developing a national Cybersecurity strategy, improving Cybersecurity awareness among various stakeholders, integrating information security training and education through all stages of education, strengthening investigative capacity for computer-related crimes and promoting the adoption of international standards within the public sector.⁶⁰

Higher education institutions possess large amounts of sensitive data including personal and academic information on their students and staff. As they seek to digitise their data and operations and to improve connectivity, higher education institutions will increasingly become a target for hackers and cyber criminals, even in Africa. The challenge is how to effectively manage cybersecurity while maintaining the openness associated with institutions of higher learning and necessary to spur cross-disciplinary collaboration and innovation.

Improved connectivity is necessary for teaching and learning as well as to exchange large amounts of research data. But improved connectivity also provides a good avenue for Cybercriminals to attack higher education institutions. Institutions will therefore need to invest in more highly skilled ICT staff, supported by better technical tools to monitor and respond to potential cybersecurity challenges. Institutions will also need to develop better usage policies and to educate their students and staff on how to effectively operate in this new environment. In addition, as the primary training, higher education institutions must produce a new breed of ICT professionals that will protect other sectors of the economy from similar challenges. To address cybersecurity issues within higher education and research, RENU set up a CERT to support member institutions in 2018.⁶¹

56 UIXP expansion plans <http://blog.uixp.co.ug/2020/04/new-uptime-record-new-traffic-record.html>

57 RAXIO unveils local fibre carriers <https://www.raxio.co.ug/raxio-data-centre-unveils-nine-local-fibre-carriers-ahead-of-launch/>

58 CERT-UG <https://www.cert.ug/>

59 UgCERT <https://www.ucc.co.ug/cert/>

60 <https://www.nita.go.ug/sites/default/files/publications/Uganda%20CMM.pdf>

61 RENU CERT <https://cert.renu.ac.ug/>

The ITU Global Cybersecurity Index (GCI)⁶² seeks to gauge how countries are dealing with Cyber threats. Using a range of indicators, the ITU compares countries in terms of knowledge for implementing Cybercrime legislation, national Cybersecurity strategies (NCS), computer emergency response teams (CERTs), capacity to spread awareness of developed strategies, and capabilities and programmes in the field of Cybersecurity.

Uganda's performance on the GCI has deteriorated, with the country sliding a number of positions from 50 to 65 out of 132 ITU member countries as indicated in Table 5. While Uganda has performed well in terms of putting the right policy and regulatory framework in place, the decline is on account of inadequate organisational and capacity building measures as well as cooperation both at international and national levels.

Table 5: Country performance in ITU Global Cybersecurity Index

Country	2017 GCI			2018 GCI		
	Score	Regional (out of 44)	World Rank (out of 193)	Score	Regional (out of 44)	World Rank (out of 193)
Burkina Faso	0.21	16	107	0.4	14	96
Cote d'Ivoire	0.42	8	73	0.46	9	86
Mozambique	0.21	17	108	0.16	26	132
Uganda	0.54	5	50	0.62	7	65

4.2.5 Electrification

Table 6 compares trends in electrification between Uganda and the other case study countries—Burkina Faso, Côte d'Ivoire and Mozambique. The country still has a low electrification rate, particularly in rural areas where most of the population lives, making improving the economy and connectivity that more challenging.

Table 6: Comparison of electrification rate among case study countries

	Proportion of the population with access to electricity					Population without access (million)
	National			Urban	Rural	2019
	2010	2015	2019	2019	2019	
Africa	44%	49%	56%	81%	37%	579
Sub-Saharan Africa	33%	40%	48%	76%	29%	578
Uganda	14%	19%	29%	66%	17%	32
Côte d'Ivoire	59%	63%	76%	>99%	51%	6
Burkina Faso	14%	19%	22%	69%	2%	16

62 ITU Cybersecurity Index <https://www.itu.int/en/ITU-D/Cybersecurity/Pages/global-cybersecurity-index.aspx>

Mozambique	16%	28%	35%	57%	22%	20
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Source: IEA, World Energy Outlook-2020

4.2.6 COVID-19 Pandemic Implications for Connectivity

The COVID-19 pandemic has resulted in the closure of all educational institutions in Uganda including higher education institutions as the country attempts to stem the spread of the virus. To provide continued learning, MoES encouraged higher education institutions to embrace e-learning. This has resulted in changes to network traffic patterns at higher education institutions as students demand for access to educational resources from home while institutional networks on campus lie idle.

The Research and Education Network for Uganda (RENU) has been talking to providers to find solutions to improve access for higher education students that are still stranded at home. RENU has collaborated with CSquared Ltd and Roke Telkom,⁶³ commercial providers to make eduroam accessible off-campus on their metro Wi-Fi network covering Kampala, Entebbe and Mukono, to help university students and staff to access learning and research resources remotely from their homes.⁶⁴ RENU has also worked with MTN Uganda and Airtel Uganda to implement zero-rated mobile data access to e-learning platforms for institutions that are connected to the RENU network, such that students and staff do not need to load data bundles to access their institutions' web-based e-learning platforms.

4.3 Sector Challenges Impacting Broadband Connectivity

From an ICT sector perspective, the desired environment for the digital take-off envisaged by the Digital Uganda Vision has yet to materialise. There are a number of challenges that inhibit the use of ICTs particularly in higher education. Some of these include:

- i. Inadequate development and deployment of ICT infrastructure to cover the whole country, particularly rural under/unserved areas and support the effective roll-out of broadband services and bring the unit cost of broadband access down. This is exacerbated by lack of coordination and true infrastructure sharing.⁶⁵
- ii. Low levels of technical competence among ICT staff/technicians at higher education institutions to be able to deploy, maintain capable ICT networks and applications that can support teaching and learning at an institutional scale.⁶⁶
- iii. Inadequate coordination and implementation of ICT initiatives across different government MDAs.⁶⁷

63 Roke Telkom, <https://www.roketelkom.co.ug>

64 <https://renu.ac.ug/assets/docs/eduroam-press-release.pdf>

65 MoICTNG, 2018. The National broadband Policy

66 Interviews with RENU, Makerere and UbuntuNet Alliance, who all alluded to the need for continuous professional training for university ICT staff and the need to set aside resources to adequately cover this

67 Draft National Development Plan III, 2020

- iv. Destruction and vandalism of ICT infrastructure. Even when government itself damages ICT infrastructure in the expansion of other infrastructure like roads, there are limited mechanisms to compensate affected infrastructure owners.⁶⁸
- v. Uncoordinated building of new infrastructure like roads or high-power lines that include ducts/poles/towers or other components like shelters, power and cooling installations that can lower the cost of building new ICT infrastructure and encourage infrastructure sharing (for both passive and active equipment) among licensed providers.^{65,69}
- vi. Uncoordinated policies and other initiatives across different government ministries. For example, while the Ministry of ICT and National Guidance has been striving to lower the cost and increase access to laptops and computers for students and staff, the Ministry of Finance, Planning and Economic Development has been increasing the tax on connectivity, equipment, and services.
- vii. Burdensome taxation regimes on ICT devices and services e.g., excise and VAT on data, OTT tax that are crippling the growth of the sector and the wider economy.⁷⁰

68 Interviews with Ben (Liquid Telecom)

69 Interviews with Michuki (ISOC), Ben (Liquid Telecom) Nicholas (RENU)

70 Research ICT Solutions, 2019. *ICT Sector Taxes In Uganda: Unleash, not squeeze, the ICT sector*

5. Research and Education Network for Uganda

The Research and Education Network for Uganda (RENU)⁷¹ is a not-for-profit organisation that manages the National Research and Education Network (NREN) in Uganda that was started in 2006 by 7 University Vice Chancellors and 2 heads of Research Institutions. It is recognised by the MoES (November 2009), received a Private Network Operator (PNO) licence from UCC in July 2010 and is the predominant avenue through which universities access broadband connectivity in the country.

Source: RENU, 2020

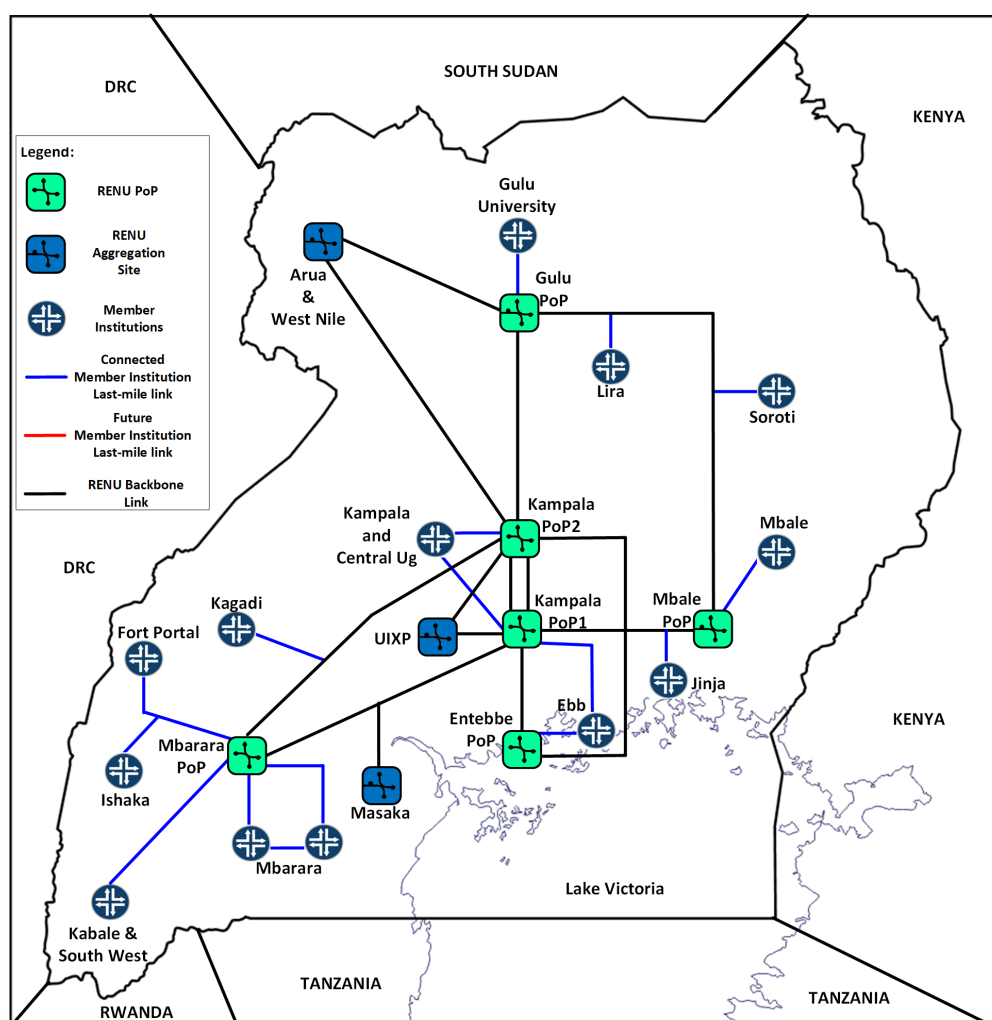


Figure 9: Schematic map of RENU network

⁷¹ <http://renu.ac.ug/>

RENU's operational processes and network infrastructure encompass a number of areas that include:

- A combination of own dark fibre and a managed bandwidth backbone at speeds of 10 and 20 Gbps in Metro Kampala and 1 Gbps for access links.
- 6 Points of Presence (PoPs) and 10 Mini PoPs or aggregation sites distributed across the country.
- RENU works with a wide range of Licensed Service Providers like C-Squared Ltd., BCS Group, MTN Uganda, Airtel Uganda, Roke Telkom, ATC Uganda and Liquid Telecom as well as with NITA-U to host network equipment upcountry and to back-haul traffic on the NBI.
- Peers locally at the Uganda Internet Exchange Point (UIXP) in Kampala and with the UbuntuNet Alliance at their Kampala PoP (4 Gbps).
- Traffic at the UIXP is primarily to Google Cache, Akamai Cache and Facebook Cache.
- Network backbone exceeded 1 Gbps of local traffic in July 2017, requiring an upgrade to deliver on promise of uncapped in-country traffic between members.
- Discussions with RENU indicate that 98% of the traffic from members is destined for the commodity Internet, indicating that local, regional and international collaboration among higher education institutions is still nascent. Access to the Internet provides a major revenue source for RENU and also allows the institutions to secure cheaper bandwidth with increased usage.
- The network currently connects 216 sites across 31 Universities and 15 TVETs. Other connected institutions include 24 research institutions, 6 teaching hospitals, 61 secondary schools and 12 institutions affiliated with the education sector.
- Of the 216 sites, 97% are connected via fibre, while 3% are connected via microwave fixed wireless technology.

5.1 Critical Success Factors

RENU has validated the assertion that if higher education institutions work together and aggregate their connectivity demand, they can improve access to high-speed connectivity while driving down the cost. There are a number of critical success factors that emerge from a review of the history and operations of RENU. The key ones include:

i. **Getting buy-in from members, especially large universities**

RENU faltered a number of times during her initial days because of mistrust between potential members and lack of buy-in from a number of large universities. These are important because they are the largest consumers of bandwidth and can also provide resources like office space and technical staff to bootstrap the NREN. In RENU's case, once these issues were resolved, the inaugural members selected Makerere University, the largest public university, to host the nascent NREN by providing office space and technical staff. To this day, RENU offices are still located in Makerere (but they do pay rent) and RENU has hired a dedicated technical team to manage operations. The ability to create a feeling of ownership

among member institutions (especially the large public institutions in the case of Africa) and providing a mechanism that allows them to drive the operations of the NREN will determine whether the NREN can survive and thrive. RENU was able to build a solid foundation and has not looked back.

ii. Securing the collaboration of major network providers

RENU's fortunes changed dramatically with the entry of CSquared Ltd., an independent fibre infrastructure provider on the Ugandan market.⁷² Using a combination of self-provisioned dark fibre and leased metro fibre from CSquared Ltd., RENU has been able to build a network that is "scalable, easy to upgrade and resilient," according to former RENU CEO Eng. Isaac Kasana. In addition, RENU has partnered with NITA-U in order to leverage the national fibre backbone to interconnect PoPs around the country. As a result of having a network, traffic between members on the RENU network is uncapped, implying that members can use as much capacity as they need when exchanging traffic among themselves for research and educational purposes. The low traffic between members indicates that transactions between members are not a commercial issue. This will probably change as traffic grows and institutions begin to exchange learning content. An arrangement like this would be practically impossible on the network of a commercial Internet Service Provider (ISP).

iii. Building a good technical team to manage the network

In Uganda's case, RENU was formed at a time when high quality ICT expertise was on demand even from the private sector. By selecting Makerere University to host RENU, the members were able to tap into a good technical team at the Directorate for ICT Support (DICTS) unit that had been specifically assembled by Makerere using a pay structure different from the normal University system. From these humble beginnings, RENU was able to tap into this technical expertise to find its initial footing.

To-date, RENU continues to hire a highly competent technical core-team that is supported by a large and growing team of ICT interns, who eventually through nurturing and extensive training opportunities are transformed into a high calibre and highly-skilled ICT staff.

iv. Being part of the Regional REN

Membership in the UbuntuNet Alliance has also greatly helped RENU improve connectivity among her members. Through UA, RENU aggregates her bandwidth demand with other countries in the region, increasing bandwidth volumes, which in-turn makes it easier for member NRENs of UA to approach bigger regional carriers and submarine operators to buy bandwidth at cheaper rates. The UA has also built a regional network to distribute this bandwidth, exchange traffic among member NRENs and to connect them to other international RENs. This has also made it easier to engage different development partners like the European Union that have funded the AfricaConnect project now in its third phase.⁷³

For example, AfricaConnect1 was able to deliver subsidised bandwidth prices to RENU in early

⁷² <https://csquared.com/>

⁷³ <https://www.africaconnect3.net/>

2014 at a time when market rates were still much higher. In 2014, RENU obtained a price of USD 150 per Mbps/Month from UA and in-turn extended a unit price of USD 230 per Mbps/Month to RENU members compared to typical market rates of USD 600 per Mbps/Month and above. That helped RENU grow fast before the market rates eventually dropped. RENU has since dropped prices progressively as more institutions signed up for membership. Table 7 below shows current RENU pricing tiers for members.

v. Significantly Lower cost of bandwidth compared to prevailing market rates

A major factor that brings together institutions to form an NREN is the need to lower the high cost of their bandwidth bill. In Uganda's case, high costs were exacerbated by the poor quality of service prior to the establishment of RENU. The high cost of bandwidth provided a rallying call that pushed executives at major universities to learn more about NRENs and explore how these could help them in furthering their research and learning objectives.

In early days before it had a network, RENU organised a bandwidth consortium through which members collectively bought bandwidth from suppliers and had it delivered individually to each member institution. This validated the notion that if they worked together and aggregated their connectivity demand, they could drive down their connectivity costs. Figure 10 summarises the trends in aggregate bandwidth amount and unit bandwidth pricing from RENU from the early consortium arrangements in 2012 to 2013 when RENU managed to establish a network and UbuntuNet first delivered bandwidth in-country (2014) with the support of the AfricaConnect project.

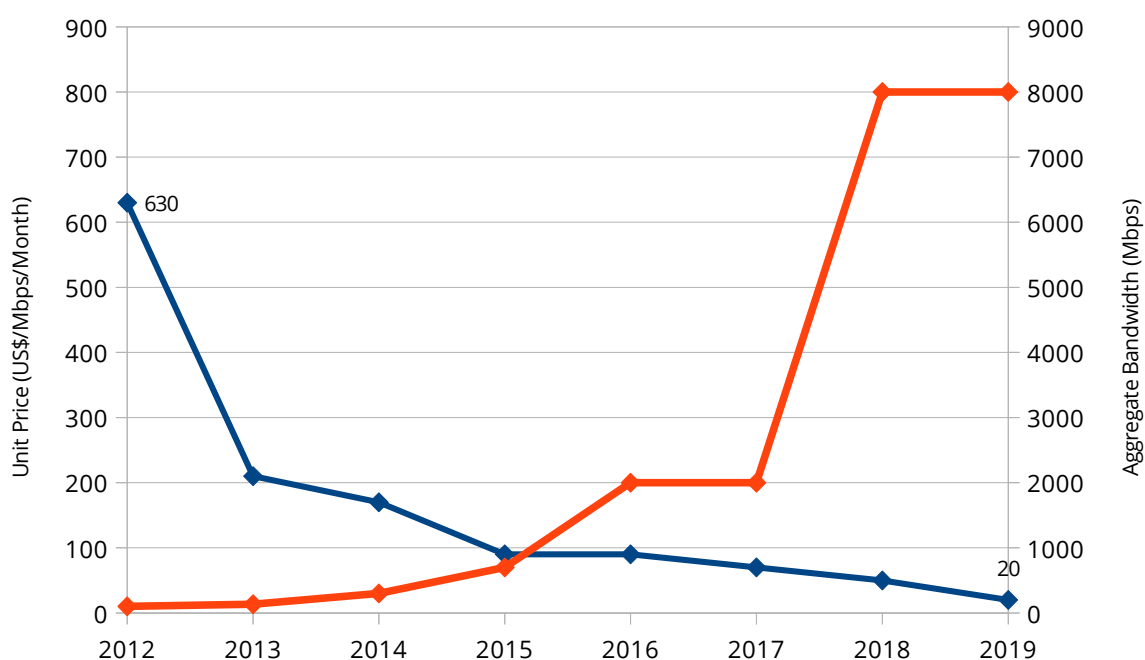


Figure 10: Trends in RENU bandwidth amount and unit pricing, 2012-2019

RENU's history indicates that once the NREN is in place, the pricing for bandwidth offered to members must be competitive compared to the local market. If this is not achieved, commercial ISPs will try to undercut NREN pricing to lure away the larger institutions that

consume most bandwidth and disrupt the NREN, particularly during infancy, when most members have not yet fully understood the full benefits of an NREN.

RENU currently procures total connectivity of 6 Gbps from the UbuntuNet Alliance at a cost of \$8 per Mbps/month and delivers this bandwidth to campus sites of member institutions at a cost that varies between \$10-\$50 per Mbps/month depending on the volume of bandwidth that a member procures (see Table 7 for pricing tiers). The more bandwidth procured the lower the unit price per Mbps/Month.

As a comparison, the average price charged by commercial providers for dedicated bandwidth is \$84 per Mbps/month in Kampala while NITA-U charges government MDAs and Local Governments \$70 per Mbps/month.⁷⁴ Table 8 gives a continental comparative of bandwidth pricing from selected African NRENs.

Table 7: RENU's tier pricing variation based on amount of bandwidth procured

Capacity (Mbps)	US\$/Mbps/month
1 – 99	50
100 – 399	40
400 – 999	30
1,000 – 4,999	20
5,000+	10
Shared Capacity (Minimum 2 – Maximum 10)	108 (total per month)

Source: RENU, 2020

Table 8: Comparison of bandwidth prices across NRENs

NREN/Country	Cheapest (USD)	Bandwidth (Mbps)	Most Expensive (USD)	Bandwidth (Mbps)
KENET (Kenya)	5	≥ 4,000	80	≤ 5
MAREN (Malawi)			85	Does not vary with amount of bandwidth ordered
MoRENet (Mozambique)			60	Heading 3 -ditto
MARWAN (Morocco)	3	≥ 5,000	21	≤ 100
NgREN (Nigeria)			25.5	Does not vary with amount of bandwidth ordered

RENU (Uganda)	10	$\geq 5,000$	50	≤ 99
SomaliREN (Somalia)	92	≥ 50	115	≤ 10
TERNET (Tanzania)	15 (in capital) 35 (outside capital)	$\geq 1,000$	85 (in capital) 100 (outside capital)	≤ 5

Source: NREN Survey, 2020

vi. High emphasis on sustainability

RENU has benefited from a number of grants from the early Fostering Research and Education Networking in Africa (FRENIA) program managed by the South African NREN—TENET (funded by the Mellon Foundation) that brought together the Vice Chancellors (VCs) and CEOs of potential RENU members for the inaugural workshop (December 2006) and provided start-up core funding, to more recent UCC contributions for the AfricaConnect project. Despite all this support, RENU has always prioritised financial sustainability of her activities.

While local and international development partners can and do contribute, members need to learn from the onset that they need to prioritise NREN payments or contributions, helping to create a more sustainable NREN. For example, RENU was able to collect contributions (against future bandwidth deliveries) from a few members that were complimented by a grant from UCC to make her subscription towards the first phase of the AfricaConnect program in 2013.

vii. Differentiating from commercial service providers

RENU like many other growing NRENs derives 99% of its income from providing connectivity services to members, just like a commercial ISP would. In addition, 98% of the traffic on the RENU network is destined for the commodity internet with only 2% destined for other REN networks. It is therefore important for the NREN to develop other services and diversify the portfolio while reducing reliance on connectivity.

Although connectivity is still the dominant service, RENU provides member institutions with a range of other services that include:

- Trust and Identity or rather Federated Identity services
- eduroam
- Data Center services (e.g., Virtual Machines and Co-location of servers)
- Web hosting
- Learning Management Systems
- Zero-rated mobile data access
- Content caches (Google and Facebook)
- Cybersecurity services
- Web conferencing (Zoom and Big Blue Button)
- Research enabling tools (e.g., anti-plagiarism, simulation platforms, repositories)
- DNS services (e.g., domain name translations and pointer records)
- Network Operations Centre (NOC) services (e.g., Traffic analysis and monitoring)

- tools)
- Capacity Building services (e.g., Workshops and Direct Engineering Assistance)

RENU also collaborates with consortia or communities of practice that have emerged to support different research themes or academic functions. A good example of such an organisation is the Consortium of Uganda University Libraries (CUUL), an umbrella organisation for university librarians/libraries with which RENU has an MoU.

5.2 NREN Maturity

Survey results show that African countries are at different levels of NREN development or maturity based on a number of indicators relevant to higher education connectivity. The most pertinent ones integrated into the cost model include:

- Presence of NREN (1 point). Uganda has a formal REN.
- NREN governance structure (1 point). RENU is a not-for-profit organisation owned by member institutions with a clear governance structure.
- Government recognition of NREN/NREN relationships (1 point). RENU is recognised by UCC, the sector regulator as well as by the Ministries in charge of the ICT and Education sectors.
- Variety of funding sources for NREN (1 point each for membership fees, government grants and sale of bandwidth), (scored 2 out of 3 points). RENU derives most of its funding from selling bandwidth to members. It has also received occasional grants from government through UCC to participate in the AfricaConnect project.
- Whether has a network (network [virtual or physical] 1 point, national POPs 2 points). RENU currently has a network with 6 PoPs spread across the country (see Figure 9)
- Whether NREN has an Autonomous System Number (ASN) (1 point).^{75,76} This facilitates routing within NREN network, exchange of routing information with other network operators and ability to directly peer with an IXP. RENU has an ASN.
- Whether at least one University or more has an ASN that facilitates multi-homing (1 point). Both Makerere University and Uganda Christian University (UCU) have ASNs.
- Whether any ASN has networks that they peer with (1 point).⁷⁷ RENU, Makerere and UCU ASNs do peer with other networks both within and outside the country.
- NREN regional/global connectivity (transit in Africa 1 point, transit in Europe 2 points), (scored 2 out of 2 points). RENU has access to regional and global transit through its partnership with the UbuntuNet Alliance.
- Middle-ware services offered by NREN (1 point each for ICT training, DNS, NOC services), (scored 3 out of 3 points). RENU offers a wide range of middle-ware services to members.
- Advanced services offered by NREN (1 point each for identity and access management, data centre services, video conferencing, research management tools), (scored 4 out of 4 points). RENU offers advanced services to members.

⁷⁵ AfriNIC is the regional Internet registry that allocates these for the African region, <https://afrinic.net/asn>

⁷⁶ AfriNIC ASN Statistics <https://stats.afrinic.net/asn/>

⁷⁷ AfriNIC ASN Statistics <https://stats.afrinic.net/asn/>

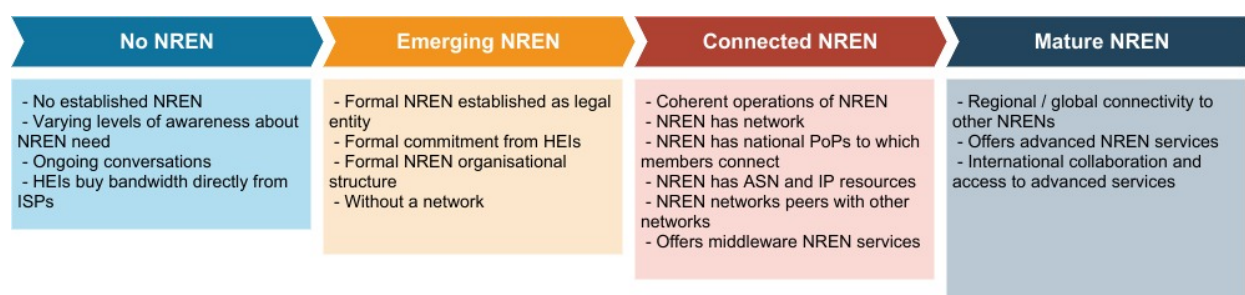


Figure 11: Stages of NREN development

Using a combination of Duncan Greaves' NREN Capability Maturity Model⁷⁸ and Mike Foley's levels of NREN development,⁷⁹ different African countries can be scored and organised into levels of NREN maturity. There are four broad groups summarized in Figure 11, that include:

- No-NREN: no NREN, but varying levels of awareness about need and ongoing conversations.
- Emerging NREN: legal entity established, with formal organisational structure, but without a network.
- Connected NREN: has network of varying coverage, may have national PoPs to connect members, has ASN and IP resources that facilitate peering with other networks and offering middle-ware services, and
- Mature NREN: has high-speed regional (transit in Africa)/global (transit in Europe) connectivity to other NRENs and offering advanced services.

Table 9 depicts how the NRENs in different African countries can be categorised around these stages. It also shows the potential savings derived from demand aggregation of bandwidth requirements among higher education institutions and smart procurement strategies (e.g., benchmarking regional pricing), and procuring long-term leases. RENU is categorised as a Mature NREN.

Table 9: Classification of Connectivity in African Higher Education

State of NREN development	Countries	Actions	Contribution to Saving via aggregation
No NREN	Angola, Cape Verde, Central African Republic, Comoros, Republic of Congo, Eritrea, Equatorial Guinea, Eswatini, Gambia, Guinea-Bissau, Lesotho, Mauritius, São Tomé and Príncipe, Seychelles, South Sudan	<ul style="list-style-type: none"> • Ensure access to bandwidth to all higher education institutions (2 years) • NREN development (3 years) • Transition to full NREN model (5 years) 	0% saving
Emerging NREN	Botswana, Burkina Faso,	<ul style="list-style-type: none"> • Strengthening NREN 	30% saving

⁷⁸ Greaves, D. (2009). An NREN Capability Maturity Model. [https://www.casefornrens.org/Resources_and_Tools/Document_Library/Documents/NREN%20Capability%20Maturity%20Model%20\(CMM\).pdf](https://www.casefornrens.org/Resources_and_Tools/Document_Library/Documents/NREN%20Capability%20Maturity%20Model%20(CMM).pdf)

⁷⁹ Foley, M. (2016). *The Role and Status of National Research and Education Networks in Africa*. World Bank.

	Burundi, Cameroon, Chad, Djibouti, Guinea, Liberia, Libya, Mali, Mauritania, Namibia, Niger, Sierra Leone, Sudan, Zimbabwe	<ul style="list-style-type: none"> Ensuring that higher education institutions are connected to adequate Internet bandwidth 	
Connected NREN	Algeria, Benin, Cote d'Ivoire, DRC, Egypt, Ethiopia, Gabon, Ghana, Madagascar, Malawi, Morocco, Mozambique, Nigeria, Rwanda, Senegal, Somalia, Tanzania, Togo, Tunisia, Zambia	<ul style="list-style-type: none"> Ensuring that higher education institutions are connected to adequate Internet bandwidth Provision of advanced services Transition to full-fledged NREN in three years 	60% saving
Mature NREN	Kenya, South Africa, and Uganda	<ul style="list-style-type: none"> Provision of advanced connectivity and services 	90% saving

Source: KCL

5.3 Current Challenges

Like NRENs in other parts of Africa, RENU faces a number of challenges that hinder better performance and delivery of high-speed connectivity to higher education similar to those unearthed via the NREN survey. RENU has attempted to address some, but does certainly need support from other partners to resolve many of them.

i. Inadequate bandwidth to serve research and learning needs

Among the 236 universities and TVETs in the country, only 31 universities and 15 TVETs do currently receive some connectivity from RENU. Given that universities account for the largest proportion of students in higher education, they would consume over 70% of any projected bandwidth. Table 22 shows current bandwidth at the top 12 universities (by student enrolment in 2019/20) and their projected bandwidth requirement based on a threshold of 2 Gbps per 1,000 students by 2025 to facilitate blended learning and research. On average, the current bandwidth deficit among these higher education institutions is 91.7% with Makerere having the smallest deficit at 72.3% and Kampala International University having the highest deficit at 97.8%.

Table 10: Projected bandwidth gap at 12 top Ugandan universities by student enrolment

Institution Name	Student enrolment 2019/20	Bandwidth Need 2025 (Mbps)	Current Bandwidth (Mbps)	Ratio of Bandwidth Gap / Need
Makerere University	36,477	7,295	2,020	72.3%
Kyambogo University	23,790	4,758	400	91.6%
Makerere University Business School	18,156	3,631	90	97.5%

Kampala International University	13,938	2,788	62	97.8%
Uganda Christian University	8,150	1,630	300	81.6%
Islamic University in Uganda	8,031	1,606	30	98.1%
Bishop Stuart University	6,833	1,367	42	96.9%
Ndejje University	6,483	1,297	30	97.7%
Uganda Martyrs University	5,758	1,152	135	88.3%
Nkumba University	5,076	1,015	58	94.3%
Bugema University	4,607	921	100	89.1%
Gulu University	4,572	914	40	95.6%

Sources: NCHE and RENU, 2020

At lower levels of education, the connectivity situation is even much worse. RENU concluded work on a pilot project with UCC in 2020 to connect 54 government-funded secondary schools onto the RENU network using funding from UCC's Rural Communications Development Fund (RCDF) Project. Each secondary school received international bandwidth of 5 Mbps

ii. High cost of bandwidth

For connected higher education institutions, the current bandwidth they procure from RENU is inadequate for teaching and research purposes. In addition, current institutional budgets are inadequate to buy more bandwidth because of the many competing priorities. This creates a kind of chicken-and-egg problem—higher education institutions do need to consume more bandwidth in order to bring the unit cost down, but RENU and her members currently lack sufficient resources to commit to the larger volumes of bandwidth through long term leases that can significantly drive down the unit cost of bandwidth down, which would in-turn allow higher education institutions to get more bandwidth, even within their current budgets.

iii. Inadequacy of distribution and last mile links

Fibre networks are currently the only feasible and future-proof way to connect universities and TVETs to high-speed connectivity. While 97% of RENU members are currently connected via fibre, fibre networks in Uganda cover only 49% of the districts and 24% of sub counties (smaller administrative sub-divisions of a district) and often the major urban towns. Most institutions have so far failed join the network because they cannot afford a one-time installation fee (Non-Recurring Cost or NRC) that varies from USD 1,000 to 5,000 depending on the whether the distribution or last mile link is wireless or fibre. Our assessment indicates that this is one of the reasons for low RENU membership. RENU has made a strategic decision that the location of a member, whether urban or rural, near a RENU POP or remote, should not influence the price that members have to pay for connectivity. The only requirement is that a member has to procure a minimum of 10 Mbps for RENU to be able to absorb the distribution costs. This has enabled RENU to even the playing field between urban and rural-

based higher education institutions. But it comes at high cost because RENU has to find a licensed operator willing to provide the last mile fibre link from the institutional campus to the nearest fibre node/PoP or invest in laying own fibre.

iv. Perception by Commercial Service Providers as a competitor

Many licensed providers still consider RENU as a competitor and many times seek to undermine RENU's relationship by seeking to poach some of the largest member institutions in terms of connectivity. RENU had adopted a subcontracting model, where they evaluate and choose to work with the best Licensed Service provider for a given service. This has created an efficient operating environment that has resulted in competitive pricing and improved quality of service to RENU. In addition, this has helped to reduce animosity between RENU and some Licensed Service providers while allowing RENU to maintain a lean team and minimise operating costs. Currently, RENU employs 24 full-time staff in various roles that include network operations (8), systems and software (6), finance operations and administration (5), internal audit and risk (1), communications and logistics (3), all under the Chief Executive Officer (CEO).

v. Low awareness about the benefits of an NREN

Awareness among members and other stakeholders about the potential benefits of an NREN is still very low. Building awareness among members, decision makers in both government and academia, and the broader public about the benefits of an NREN dedicated to supporting the needs of research and education in the country is a tall order for NRENs in Africa.⁸⁰ RENU participates in various fora (both in ICT and education) and has set up a dedicated communications department that continually works to raise the profile of research and education networking.

vi. Inadequate public funding for ICT infrastructure

RENU lacks sufficient public funding to invest in upgrading the network and to harness cheaper prices that come with procuring bigger volumes of bandwidth. This is compounded by the fact that members have got very small budgets for bandwidth and often fail to pay well in advance.

RENU has been able to participate in the AfricaConnect project since its conception with support funding from UCC and some contributions from members (against future bandwidth supplies). For RENU to successfully deliver the high-speed connectivity envisioned by the WBG team, RENU will need to find resources to significantly upgrade their network.

vii. Over reliance on the sale of bandwidth to members

RENU receives 99% of its funding from the sale of bandwidth to member institutions. While RENU does not need to worry about turning a profit, the need to invest in upgrading the network, the goal to keep uniform pricing for members irrespective of location and the need to develop new income generating services all require financing. All of this hinders the desire

⁸⁰ Foley, Michael. *The Role and Status of National Research and Education Networks in Africa*. World Bank, 2016.

to continuously drive down bandwidth pricing, which would in turn and spur more bandwidth consumption among members.

viii. Unfriendly taxation policy

RENU is required by the Uganda Revenue Authority, the local tax authority, to charge Value Added Tax (VAT, 18%) on all services offered to members, including bandwidth. In addition, they are subject to Withholding Tax (WHT). In addition, RENU is subject to income tax at a rate of 30% on gross income after deducting allowable expenses under the income Tax Act (ITA).

Being not-for-profit, RENU strives to make savings, which are then reinvested in the network to increase coverage and subsidise services to members, particularly the rural and remote institutions. Taxing these savings or surpluses is not progressive and may deter NREN investments that can help increase connectivity for higher education institutions.

ix. Poor campus networks and low skilled ICT staff

Member institutions have made very limited investments in campus ICT infrastructure and resources. This is often compounded by the networks being poorly designed and managed by ICT staff with low levels of technical expertise. Some institutions have such poor networks that even when they acquire more bandwidth it does not result in visible changes in speed or user experience. To address these challenges, RENU organises regular training workshops for ICT staff drawn from members. The trainings are rotated around the country to make it easier for staff from different parts of the country to attend. This is augmented by regular Direct Engineering Assistance (DEA) to institutions to help redesign and improve their campus networks. RENU also sources for network equipment from different international partners around the World (including NSRC and NRENs in Europe) that it then distributes to members to help improve their networks.

6. Cost Estimates for Connecting Higher Education in Uganda

Connectivity, recognized as a foundation for learning and innovation, has four major components, all of which need to be addressed to complete the value chain: end-user access devices; high quality campus networks to deliver a good broadband experience to the end-users; high quality national networks to interconnect campuses; and regional and global networks to join national networks to the global environment.

A schematic diagram for arriving at the cost of connecting African higher education institutions is shown in Figure 12. The pricing used to determine the cost estimates in this report is specific to Uganda, and therefore provides more accurate projections compared to the general continental averaging.

6.1 Access to Computing Devices

From discussions with local suppliers and staff involved with ICT procurement at Universities, the factors that affect the cost of laptops include the quantity to be procured, the specifications of devices, the operating system (Windows has a cost while Linux is free) and the warranty period desired for the devices (from one year upwards with increasing cost).

To compute the cost of access to computing devices for students and staff that are necessary to facilitate use of high-speed broadband delivered to higher education institutions, these assumptions have been borrowed from the cost model:

- i. Used forecast of student enrolment and staff numbers in Uganda for 2021 to 2025;
- ii. 80% of students are undergraduate students who spend on average three years at the university, 20% are graduate students who spend two years at the university;
- iii. One third of undergraduates in a given year are assumed to be freshers, while one half of graduate students are assumed to be freshers at the start of any given academic year. This results in a weighted average of 36.7% that need to acquire devices at the start of any academic year;
- iv. Predetermined scaling down of support from different partners for student devices. Support starts at 80% of the first-year students in 2021 and reduces by 20% year-on-year: 60% in 2022, 40% in 2023, ending with 20% in 2024;
- v. All staff will get devices between 2021 and 2025. Staff devices are supported up to 100%, and new staff are given new devices after recruitment;
- vi. Used an average of USD 400 per user laptop including volume licence for the operating system and productivity suite of applications based on discussions with local providers and economies of scale.

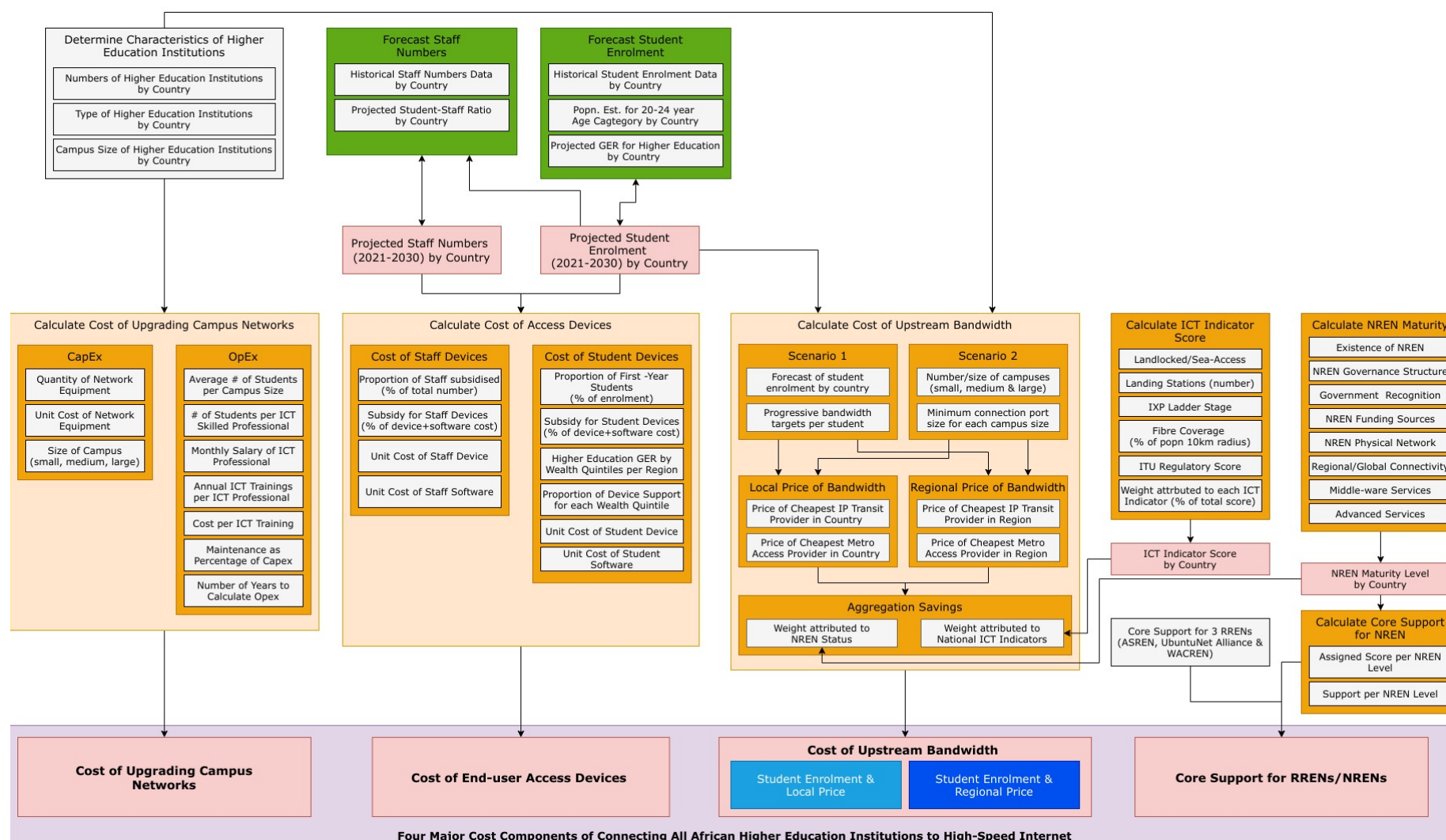


Figure 12: A schematic diagram to estimate costs for connecting higher education institutions in Africa

Uganda needs USD 110 million to provide access devices for all first-year students and staff in higher education institutions between 2021 and 2025, as summarised in Table 11.

Table 11: Cost of equipping students and staff with access devices (2021 to 2025)

Year	Forecast student enrolment	Forecast staff numbers	Estimated Average cost of devices (USD, million)
2021	294,000	11,300	42.5
2022	306,000	11,700	29.6
2023	318,000	12,100	20.7
2024	330,000	12,500	16.2
2025	342,000	12,900	0.6
Total	1,590,000	60,500	110

Source: KCL calculations

6.2 Upgrading Campus Networks

Table 12 summarises the assumptions used for calculating the cost of upgrading campus networks across Ugandan higher education institutions.

Table 12: Assumptions for calculating campus network upgrade costs in Uganda

Area	Assumptions
Number of buildings	A micro campus has 1 large building, a mini campus has 1 medium and 1 building, a small campus has 2 medium and 3 large buildings, a medium campus has 4 medium and 6 large buildings, a large campus has 8 medium and 12 large buildings while a very large campus has 12 medium and 18 large buildings.
Length of fibre	A micro campus needs 1 km of fibre network, a micro campus needs 2 km, a small campus needs a 5 km fibre network backbone, a medium campus needs 10 km, while large and very large campuses need 20 km and 30 km, respectively. Assumed a unit cost of \$20 per metre of laying fibre, including civil works.
Switching centres	A micro campus has 1 switching centre (with 1 core switch and 1 layer 3 switch) while mini and small campuses have 1 switching centre (with 1 border router and 1 core switch). Medium campuses have 1 switching centre (with 1 layer 3 switch and 1 core switch). Large and Very Large campuses have 2 switching centres (each with a core router) and one border router for large and 2 for very large campuses. Very large campuses have two border routers, giving the network ability to support 2 independent connections. Given the poor reliability of power in many African countries, each switching centre has a standby generator.
Data centre	A campus needs a small data centre (Tier I) with racks, centralised UPS and

	some servers. We budgeted 3 servers for the micro, mini and small campuses, 9 servers for medium, 12 servers for the large and 18 for very large campuses. The data centre, switching centre, and Network Operations Centre (NOC) should be co-located in the same location to save on costs.
Multimedia classroom	Micro, mini and small campuses have 1 fully integrated smart classroom with different technologies, including smartboards, projectors, cameras, speakers, audio equipment, lighting etc. A medium campus has 3 of these; a large campus has 5, while a very large campus has 7 smart classrooms.
Support to institutional library	A Local Area Network and PCs in the main library that is connected to an online public access catalogue (OPAC).
Skilled staff	At least 1 ICT skilled professional for every 450 students earns at least 1.5K per month to compete with the private sector. The staff should have access to one training opportunity per year in line with the needs of their institution.
Consulting and design support	Institutions should be able to access technical support to help the technical team implement various solutions that address their institution's needs. This can start with campus network design and span other areas, including installing and maintaining various systems and equipment.
Equipment supplies and maintenance	Institutions should be able to undertake corrective and preventive maintenance to extend the campus network's life and operation.

Table 13 summarises the CapEx and OpEx for upgrading all university and TVET campus networks in Uganda.

Table 13: Estimate for upgrading University and TVET campus networks in Uganda

Size of HEIs	Number of HEIs	CapEx (US\$, millions)	OpEx (US\$, millions) for 5 years	Total (US\$, millions)
Institutions with less than 5000 students (small campus)	225	330	410	740
Institutions with between 5000-15000 students (medium campus)	7	19	29	48
Institutions with more than 15,000 students (large campus)	4	20	38	58
Total	236	368	478	846

Source: KCL calculations

The OpEx cost covers five years (default period that can be modified in the model) and includes a maintenance component for the campus networks (15% for hardware and software costs). The OpEx excludes bandwidth costs that are handled in the next section.

Table 13 shows that OpEx (excluding bandwidth) and the CapEx are comparable, indicating that OpEx can be high on a long-term basis. Given the need for sustainability, this highlights the need for both higher education institutions and the government to budget these costs

appropriately.

Table 14 indicates that small campuses account for 95.3% of all campuses and 87.5% of the total cost of upgrading campus networks. Given that the average enrolment for small campuses was only 608 students per campus, the small campus category has been refined into three categories—mini campus (500 students or less), micro campus (500 to 1,500 students) and small campus (1,500 to 5,000 students) as shown in Table 15. Similarly, large campuses have also been refined into two categories—large campus (15,000 to 25,000 students) and very large campus (25,000 or more students).

Table 14: Distribution of Small, Medium and Large Campuses

	No. of HEIs	Average enrolment	% of HEIs	% of CapEx + OpEx
Small (<=5000)	225	608	95.3%	87.5%
Medium (5001-15000)	7	7,753	3.0%	5.7%
Large (>=15000)	4	26,141	1.7%	6.9%
Total	236		100.0%	100.0%

Source: KCL

Table 15: Distribution of HEI campus sizes in Uganda

	Min enrolment	Max enrolment	No. of HEIs	Average enrolment	% of HEIs
Micro campus	0	500	150	163	63.6%
Mini campus	500	1500	56	872	23.7%
Small campus	1,500	5,000	19	2,824	8.1%
Medium campus	5,000	15,000	7	7,753	3.0%
Large campus	15,000	25,000	2	20,973	0.8%
Very large campus	25,000		2	32,000	0.8%
Total			236		100.0%

Source: KCL

Refining the categories shown in Table 14 as shown in Table 15 reduces the cost of upgrading campus networks from the USD 846 million derived from the continental (that has only Small, Large, and Medium categorisations) to 574 million, a saving 32.2%. This highlights that countries with a larger proportion of small campuses can save on the cost of upgrading campuses' networks by refining the categories to account for much smaller campuses and dimensioning their networks appropriately. More savings can be derived from the use of shared infrastructure like switching and data centres among micro and mini campuses that are geographically very close to each other.

6.3 Connecting Campuses Upstream

Based on the Vision and Progressive targets as provided in the Gap Analysis Report⁸¹ and drawing on global bandwidth use, it is recommended that higher education institutions achieve connectivity of at least 1 Gbps for campuses that host 5000 students and staff in 2021, as indicated in Table 16. The connectivity target is to achieve at least 2 Gbps per 1000 students by 2025 (to be provided for in the World Bank planning period ending 2023) and at least 20 Gbps per 1,000 students by 2030.

Table 16: Recommended Progressive Bandwidth Targets for African Universities and TVETs

Year	Minimum Bandwidth	Remarks
2021 (targeted minimum)	0.2 Gbps @1,000	This translates to 1Gbps for a campus of 5,000; and 10 Gbps for a campus of 50,000
2021-2025	2 Gbps @1,000	This translates to 10 Gbps for a campus of 5,000; and 100 Gbps for a campus of 50,000. <i>This should be the minimum entry level for the WBG intervention.</i> It should be noted that the general aspirational target of most African NRENs by 2025 or earlier is 1Gbps per 1000 students, but this is heavily influenced by current challenges and limitations.
2025-2030	20 Gbps @1,000	This translates to 100 Gbps for a campus of 5,000. Actual size for any campus to be based on the TENET approach: <i>"sufficient bandwidth to be able to use the prevailing applications of the day" with port sizes twice the normal usage.</i>

Source: KCL

6.3.1 Estimating Bandwidth Requirements and Unit Cost

Figure 13 shows two ways to determine the Unit Price (USD/Mbps/month). The unit price of bandwidth varies widely depending on distance from fibre network, local access and transit costs, the maturity of NREN, national ICT situation and regulatory score. The Local Price comprises the cheapest cost of IP transit and the cheapest cost of local access to deliver the bandwidth in a metro area within Uganda. IP transit is calculated based on 10 GigE volume or more from the cheapest provider in the country. Local metro access costs to deliver bandwidth to HEIs are calculated based on Gigabit Ethernet (GigE) circuits where available and smaller circuits in locations without big capacities, assuming that higher education institutions are located at most 15 km from a provider's PoP in a metro/urban area.

The **Local Price (USD 11.2)** is derived by adding the cost of IP transit and local access to deliver the bandwidth in a metro area for the cheapest provider in Uganda. The cheapest IP transit price from a local provider is currently USD 6 per Mbps/month from NITA-U for a volume of 500 Mbps. The cheapest distribution cost is currently from CSquared Ltd., which charges USD

81 See parallel Report under the same study: "A Connectivity Gap Analysis and a Review of Existing Programs"

1 per Mbps/month for leased fibre capacity to deliver 1 Gbps irrespective of distance in areas of the central region (Kampala, Wakiso and Mukono). Major providers charge about USD 8 per Mbps/month for upcountry locations for leased capacity to deliver 1 Gbps. This results in a total cost between USD 7 – 14 per Mbps/month depending on whether the institution is located in the central region or beyond. RENU estimates that about 50% of higher education institutions are located in the central region. On this basis, we have assumed an average **Local Price of USD 11.2 per Mbps/month** to deliver a minimum of 1 Gbps connection to any higher education institution in 2021.

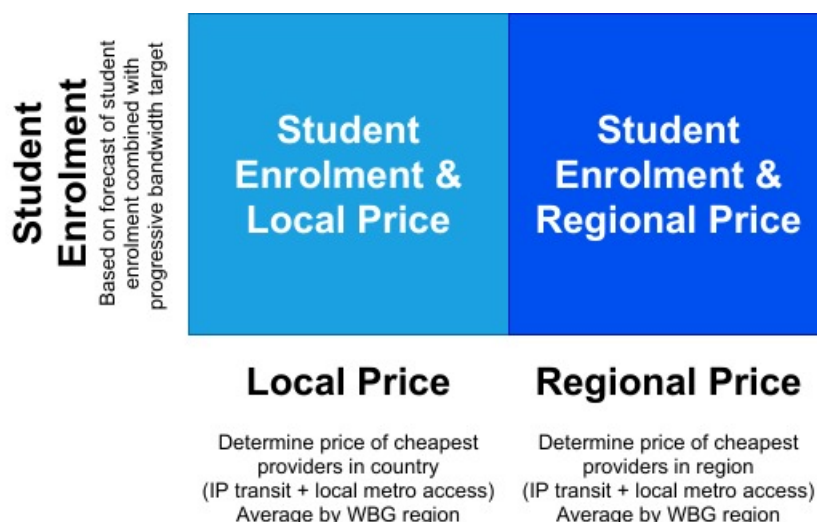


Figure 13: Matrix for determining bandwidth cost

The **Regional Price (USD 7.2)** is derived by adding the cost of IP transit and local access to deliver the bandwidth in a metro area for the cheapest provider in the East African region. At the regional level, Hurricane Electric offers a flat rate of USD 20,000 for 10 Gbps/month IP transit port at their PoPs in Nairobi and Mombasa. This works out at USD 2 per Mbps/month. Assuming a similar distribution cost for both institutions in the central and other areas implies an average **Regional Price of USD 7.2 per Mbps/month**.

6.3.2 Aggregation Savings

The Aggregation Savings calculated from Uganda's NREN maturity (see section 5.2), and its performance on various national ICT indicators (see Section 4.1.4) pertinent to connectivity is 73%. This reflects the potential savings from demand aggregation of bandwidth requirements among higher education institutions, use of smart procurement strategies (e.g., benchmarking regional pricing) and procuring long-term leases.

6.3.3 Cost of Connecting Campuses Upstream

Based on this, Table 17 shows the projected bandwidth requirements for Ugandan higher education institutions using Local Price, while Table 18 is based on Regional Price.

Table 17: Projected bandwidth and cost based on Student Enrolment and Local Price

(2021, 2025 & 2030)

Year	Student enrolment	Projected bandwidth (Gbps)	Projected cost (USD millions) no aggregation Savings	Projected cost (USD millions) with aggregation Savings
2021	294,000	294	40	11
2025	342,000	684	46	13
2030	402,000	8,043	135	37

Source: KCL calculations

Table 18: Projected bandwidth and cost based on Student Enrolment and Regional Price (2021, 2025 & 2030)

Year	Student enrolment	Projected bandwidth (Gbps)	Projected cost (USD millions) no aggregation Savings	Projected cost (USD millions) with aggregation Savings
2021	294,000	294	25	7
2025	342,000	684	30	8
2030	402,000	8,043	87	24

Source: KCL calculations

6.4 Support to RENU

Discussions with NREN officials in Africa indicate that they spend about 60% of their OpEx on connectivity-related expenses and the remaining 40% on human resources and related costs. Given that member institutions cover connectivity-related expenses through payments for bandwidth, NRENs often struggle to cover core costs as well as costs related to ongoing capacity building for both internal staff and especially member institutions where the value of connectivity is realised. Shortage of funding also means NRENs fail to retain competent staff who are attracted by the much higher pay within the ICT private sector: this is especially a challenge in the development and growth stage of five to ten years. It is especially important to provide for such support in order to reap the resulting value of the NREN to the delivery of broadband.

Based on interviews with the CEO, RENU needs an OpEx budget of about USD 3 million per year. Of this about 40% (or USD 1.2 million) is spent on core costs (mostly human resource), technical capacity building and NREN development and outreach related costs. The final price for bandwidth offered to members will take into account the costs necessary to upgrade and maintain the RENU network in order to be able to distribute the increased volumes of bandwidth. As bandwidth cost goes down, RENU will need support for core and NREN development related costs. This gives a requirement of USD 6 million over five years.

6.5 Cost of Connecting HEIs in Uganda

Table 19 summarises the cost elements for different components that make up the total cost of connecting all higher education institutions in Uganda for five years (2021-2025), including equipping students and staff with access devices, and designing and upgrading campus networks. The overall cost is based on aggregation savings that in turn assume demand aggregation, use of smart procurement strategies (e.g., benchmarking regional pricing) and procuring long-term leases.

Table 19: Summary of total 5-year cost of connecting all higher education institutions in Uganda to high-speed Internet

Category	Cost (USD, millions)	Potential Sources of Funding
End-user devices		
Students and Staff	110	Government, development partners, students, institutions
Sub Total	110	
Upgrading campus networks		
CapEx	213	Government, development partners
OpEx	361	Institutions, government, development partners
Sub Total	574	Using micro, mini, small, medium, large to very large campus sizes
5-year cost of connecting campuses upstream		
	With Aggregation Savings	
Using Student Enrolment & Regional Price	41	Development partners, institutions, students
NREN development and support costs		
RENU core support and NREN development related costs	6	Development partners, government
Total Cost Estimate (USD, millions)	730	Using cost of connecting campuses upstream based on student enrolment and regional price

Source: KCL calculations

7. Summary and Conclusion

This Case Study explores the connectivity challenge from an education-sector perspective (demand-side) as well as from the information and communications technology (ICT)-sector perspective (supply-side). This Chapter, presents a summary of the key findings and recommendations.

- i. The connectivity target is to achieve at least 2 Gbps per 1000 students by 2025 (to be provided for in the World Bank planning period ending 2023) and at least 20 Gbps per 1,000 students by 2030. Given a forecast enrolment of 342,000 higher education students in 2025 implies that higher education institutions in Uganda will need at least 684 Gbps to serve the bandwidth requirements of higher education institutions across the country. This will raise to 402,000 students and 8 Tbps in 2030.
- ii. Uganda currently has 52 accredited Universities and 184 TVETs (classified into Other Degree Awarding Institutions and Other Tertiary Institutions), some of which have multiple campuses. With about 259,000 students, enrolment in higher education is biased towards universities with more students (72%) enrolled in universities compared to TVETs (24%). Lower enrolment in TVETs is attributed to the negative image associated with TVETs, the general perception being that those pursuing TVET courses are failures that did not make it to University.
 - a) Based on data from National Council for Higher Education (NCHE), Uganda's Gross Enrolment Ratio (GER) for higher education was only 6.9% in 2018. This is below the sub-Saharan Africa average of 9.4% and far below the world average of 38.8% in 2018. Uganda would like to achieve a GER of 40% as part of efforts to transform into a middle-income country. But based on the forecast of student enrolment and population in the age category 20-24, GER will not significantly change in 2025 (6.6%) and 2030 (6.7%).
 - b) Uganda faces many challenges in expanding access to higher education including insufficient public spending on education, low transition rates from primary to lower secondary education, disparities in levels of access to secondary education, an outdated and overloaded curriculum, and poorly qualified teachers who are often inefficiently deployed.
- iii. From an education sector perspective, some of the challenges that inhibit the use of ICTs in higher education and better connectivity include:
 - a) Lack of an ICT policy for the sector to promote digital literacy and e-learning particularly in higher education as an avenue to improve learning outcomes;
 - b) Generally low digital literacy among both lecturers/tutors and students on how to leverage ICT for teaching and learning;

-
- c) Lack of knowledge and capacity on how to leverage ICT to improve teaching and learning;
 - d) Very limited investment in campus ICT infrastructure and resources, compounded by inadequate public funding for higher education that has not kept pace with growth in enrolment;
 - e) Lack of mechanisms to evaluate and identify relevant and/or appropriate digital content and applications for different levels and programmes of education;
 - f) Lack of an adequate pool of high-level ICT champions within higher education that can promote the adoption and use of ICTs within their institutions.
- iv. Uganda's licensing regime for ICT providers has helped to create competition among providers but is still struggling to advance other important aspects like infrastructure sharing that can improve access to broadband and lower the price of services
- a) The Uganda Internet Exchange Point (UIXP) facilitates exchange of local traffic between 29 networks that peer at the exchange and provides access to content caches from Google, Facebook and Akamai. Before the COVID-19 lock-down, peak traffic at the UIXP reached 18 Gbps in early 2020 saving the country expensive international bandwidth connectivity;
 - b) Besides the National Data Centre built and operated by NITA-U, and largely used by government MDAs, First Brick Holdings is building Uganda's first Tier-III carrier-neutral data centre, Raxio Data Centre, in Namanve Industrial Park, along Jinja road, the main fibre route between Kenya and Uganda;
 - c) Uganda has two major National Computer Emergency Response Teams (CERTs)—CERT-UG under NITA-U and a telecoms sector CERT under UCC. RENU also has a CERT that supports education and research member institutions. But Cybersecurity awareness and investigative capacity for computer-related crimes are still low.
- v. From an ICT sector perspective, some of the challenges that inhibit the use of ICTs in higher education and better connectivity include:
- a) Inadequate development and deployment of ICT infrastructure to cover the whole country, particularly rural under/served areas
 - b) Lack of coordination in building new infrastructure like roads or high-power lines to actually include ducts/fibre that encourage shared reuse and lower cost of building new ICT infrastructure
 - c) Low levels of technical competence among ICT staff/technicians at higher education institutions to deploy and maintain capable ICT networks and applications
 - d) Uncoordinated implementation of ICT and other initiatives across different government MDAs that can help improve connectivity. Uncoordinated policies and
-

other initiatives across different government ministries. For example, while the Ministry of ICT and National Guidance has been striving to lower the cost and increase access to laptops and computers for students and staff, the Ministry of Finance, Planning and Economic Development has been increasing the tax on connectivity, equipment, and services.

- vi. Universities in Uganda formed an NREN—the Research and Education Network of Uganda (RENU) in 2006, which is recognised by the government. RENU has validated the assertion that if higher education institutions work together and aggregate their connectivity demand, they can improve access to high-speed connectivity while driving down the cost.
 - a) RENU has been successful as an NREN in part because of getting buy-in from members, especially the large universities, securing the collaboration of major network providers, assembling a good technical team to manage the network, membership in the Regional REN—the UbuntuNet Alliance as well as placing high emphasis on sustainability;
 - b) The RENU network consists of dark fibre and a managed bandwidth backbone at speeds of up to 20 Gbps in metro areas and 1 Gbps access links that interconnect 216 sites across the country. These include 31 out of 52 Universities (61 campuses) and 15 out of 184 TVETs (16 campuses). Other connected institutions include 24 research institutions (58 campuses), 6 teaching hospitals, 61 schools and 12 institutions affiliated with the education sector;
 - c) Like NRENs in other parts of Africa, RENU faces challenges including inadequate bandwidth to serve research and learning needs (6 Gbps against a demand of 48.5 Gbps in 2020), poor of back haul, distribution, and last mile connectivity, low awareness about the benefits of an NREN, over reliance on the sale of bandwidth to members as well as poor campus networks and low skilled ICT staff;
 - d) Following COVID-19 lock-downs of educational institutions, RENU started working with commercial providers to make eduroam accessible off-campus to help university students and staff access learning and research resources remotely from their homes. In addition, RENU has implemented zero-rated mobile data access to e-learning platforms for institutions connected to the RENU network, such that students and staff do not need to load data bundles to access their institutions' web-based e-learning platforms when using mobile networks.

Our assessment shows that while connectivity of higher education has improved in Uganda, through the establishment of RENU, there is still need for more effort to improve digital technology integration in teaching, learning and research. This will require upgrading of the campus networks, improving access to devices for students and staff and access to more bandwidth at institutions. The Ministry of Education and Sports (MoES) together with other stakeholders needs to intensify efforts to accelerate digitalisation of higher education by identifying the necessary resources to implement the recommendations in this report. First, there is a need to support RENU to access more bandwidth at a cheaper cost through long-

term leases and to be able to effectively distribute this bandwidth to higher education institutions across the country using a fibre backbone network. Currently, among the 236 universities and TVETs in the country, only 31 universities and 15 TVETs do receive some connectivity from RENU. Second, the MoES needs to explore various avenues to equip higher education students and staff with laptops. Universities and TVETs with support from RENU and other stakeholders will need to collaborate to improve the quality of campus networks in order to leverage the increasing amount of bandwidth and to support the increased number of devices on their networks.

Appendix A: Makerere University Profile

In this section we profile Makerere University to investigate her performance on various aspects that impact student connectivity within the institution. Makerere University is the largest in terms of student enrolment as well as the most advanced in terms of ICT infrastructure and expertise.

The history of the Internet in Uganda dates back to October 1992 with reference to a Fidonet node at Makerere University.⁸² In 1999/2000, Makerere started to explore avenues of using ICT to support its various functions. Several development partners expressed interest in supporting the university, and agreed with the university that a well-planned effort was cardinal. The Swedish International Development Cooperation Agency (Sida) funded this initial consultative process in early 2000 and Makerere came up with an ICT Policy and Master Plan, which would later guide subsequent activities in this arena. Since then, Makerere has prioritised ICT services and systems as drivers in achieving its Vision and Mission. Consequently, the University has invested in a wide range of ICT infrastructure using both internal resources and extensive support from the Government of Uganda and various development partners.

A.1 ICT Policies and Strategy

Current ICT developments within Makerere are guided by the ICT Policy and Master Plan 2016-2020. This is complimented by a number of other ICT policies that have been approved by the University Council and these include:

- Acceptable Use of ICT Resources
- Physical ICT Security Policy
- Data Security
- Web Content Publishing
- Disposal of ICT Equipment and Electronic Waste Management

The University has also developed a number of Information Management Policies to guide the use of ICT in various business processes to control who can access different kinds of information and what they can do with such information. These include:

- Communications Policy
- Open Distance and E-Learning Policy
- Records Management Procedures (Pending Approval)
- Record Keeping Policy (Pending Approval)
- Mass Mail Policy (Pending Approval)

82 Fidonet history project <http://ambrosia60.dd-dns.de/fidonet/nlarchive2.php>

- Disaster Recovery Policy (Pending Approval)
- Accessible Information Policy and Procedures (Pending Approval).

A.2 Student Enrolment

Total student enrolment in Makerere University has been fluctuating over the years. It went from 33,100 students in 2009/10 to a peak of 42,500 in 2013/14, and then down to 34,600 in 2018/19. The latter reduction in numbers was probably due to fluctuating enrolment at the secondary level (see Table 1) and increasing competition from private universities.

A.3 Access to, and Cost of Connectivity

Makerere currently procures most bandwidth among universities and TVETs in Uganda, but at 2 Gbps, this translates to a meagre 0.06 Mbps per student based on current student enrolment. Recall that based on progressive recommendations in the Gap Analysis Report, higher education institutions should be at 1 Gbps per 1,000 students in 2021. Makerere has spent about \$40,000 on average per month on broadband for the last 20 years. This provided 10 Mbps in the early 2000s, which increased to about 70 Mbps during the initial RENU Bandwidth Consortium a few years later. It is now at 2 Gbps through the Research and Education Network of Uganda (RENU), and the UbuntuNet Alliance. Were the price to go down to the \$0.01 per Mbps/month envisaged by the African Union – and indeed common around the world – Makerere University, would afford 4 Tbps. Figure 14 summarises the trend in amount and cost of bandwidth since RENU started to provide connectivity to universities.

At the 1 Gbps per 1000 students and an average student enrolment of 35,000 students, Makerere needs a minimum of 35 Gbps of connectivity or has a deficit of 33 Gbps. At 2 Gbps per 1000 students, a minimum of 70 Gbps would be required and so on. It is apparent that Makerere needs more bandwidth to support teaching and research activities given the student and staff population.

Sources: DICTS, Makerere University, 2020

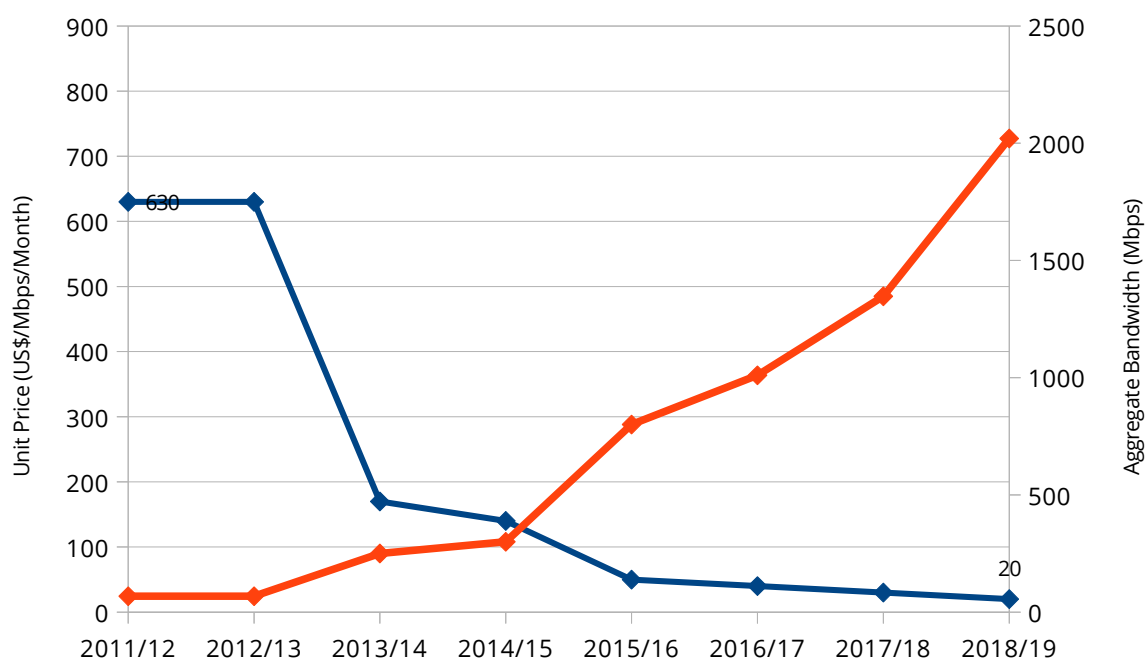


Figure 14: Trends in Makerere bandwidth amount and cost

On a side note, In 2020, Makerere University reduced their bandwidth budget to about USD 28,800 per month as a result of Covid-19 effects. Given the large amount of bandwidth that Makerere consumes, the budget reduction was a big disruption to the finances of RENU.

A.4 ICT Infrastructure

Makerere ICT infrastructure provides both wired and wireless network access for end-users. The university has about 33 km of fibre covering about 95% of all academic and administrative buildings spread out on the Main campus and 4 remote campuses—College of Health Sciences on Mulago Campus, Agricultural Research Institute at Kabanyolo (MUARIK), Jinja Campus and Lira Campus as depicted in Figure 15.

On each campus, a Gigabit Ethernet fibre backbone interconnects buildings having a Local Area Network (LAN). On the Main campus are two switching centres interconnected redundantly at 40 Gbps via fibre, with the primary hosting the University data centre and acting as the Network Operations Centre (NOC) and the secondary acting as the Disaster Recovery Center (DRC). Each of the remote campuses is connected to the Main campus via fibre at 1 Gbps. Each switching centre has air conditioning, an automated fire suppression system, a standby backup generator that is supported by UPSs to cater for the time lapse between mains power failure and automatic switching to generator power. Each switching centre has Layer 2 and Layer 3 switches for routing and switching backbone traffic, redundant servers for information systems and storage systems to back up the large amounts of data generated by the different systems.

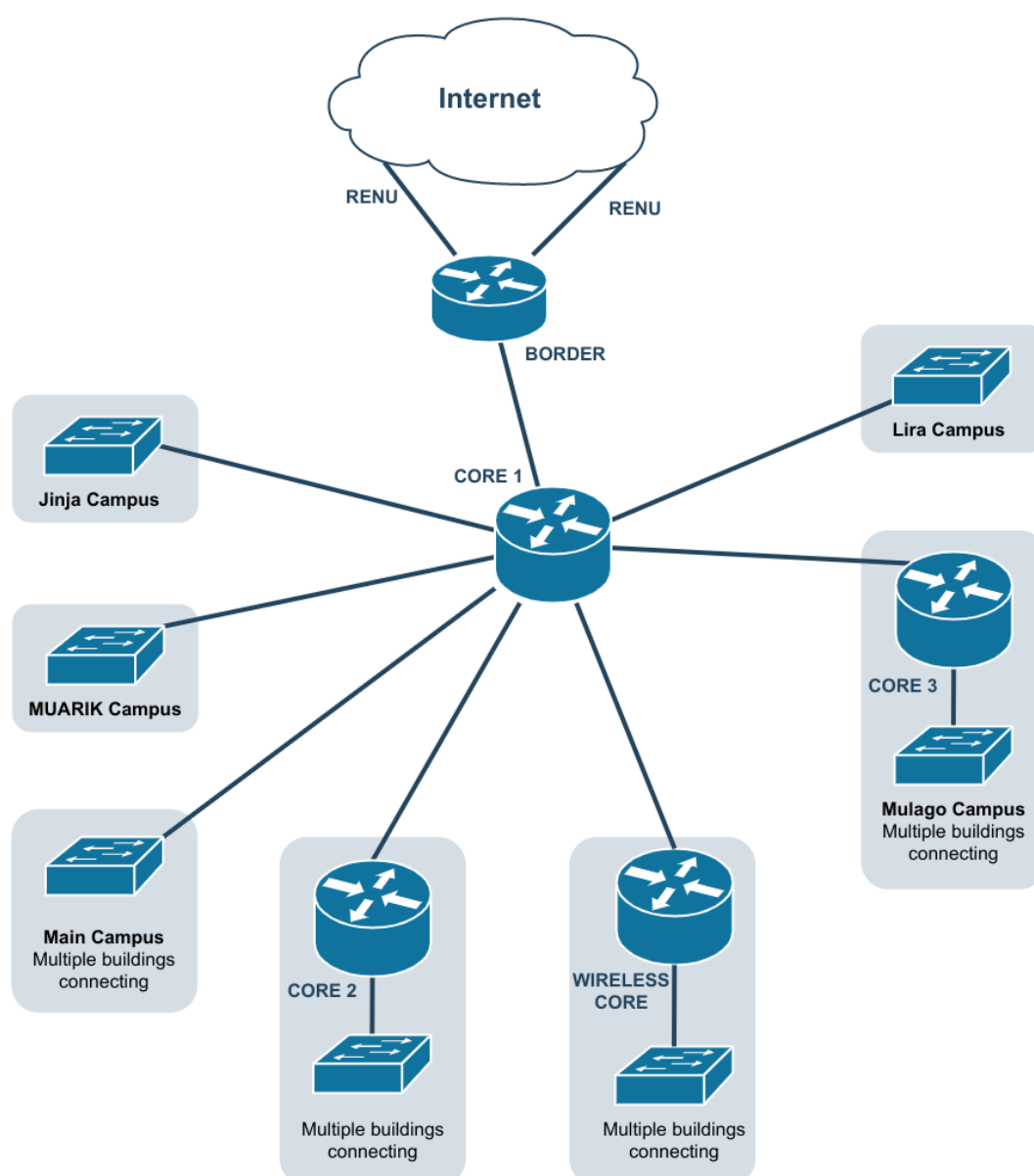


Figure 15: Schematic of Makerere University network

The university network has over 10,000 wired LAN nodes that are complimented by a WiFi network (MAKAIR), first setup in 2010 and extended over time to cover different student learning spaces. The WiFi network that blends both old and new technologies is composed of Cisco, Ubiquiti and TPlink and Dlink access points that cover about 60% of Makerere. This includes most academic buildings, all nine undergraduate and one graduate halls of residence on the Main campus and two hostels on Mulago and Kabanyolo campuses. But it does not extend to the private student hostels around the Main campus that accommodate the largest proportion of students.

Student access to computers has greatly improved from about 7 students to 1 computer in 2008/9 as indicated in Table 20, but is still not universal. From the onset, this was recognised as a unique challenge. Besides providing access to computers within computer laboratories at each college, the University also created Internet kiosks modelled after the famous Internet

cybercafes that were a predominant mode of Internet access in the early days of the Internet in Uganda. Open for 24 hours to any student with a University ID, these helped bridge the divide between students from academic units that owned computers (often science-based) and those that lacked computers (often humanities). Now more students do own individual laptop computers allowing them to freely access the Internet from a wide range of spaces from the classroom to their halls of residence, if they stay on campus.

Table 20: Trends in access to computers by college 2008/9 to 2018/19

College	2008/09			2014/15		
	Students	Computers	Ratio	Students	Computers	Ratio
Agricultural & Environmental Sciences	1,566	501	3:1	2,496	199	13:1
Business and Management Sciences	4,974	228	22:1	5,528	123	45:1
Computing & Information Sciences	4,132	2,035	2:1	4,656	805	6:1
Education & External Studies	8,792	205	43:1	6,725	137	49:1
Engineering, Design, Art & Technology	2,490	367	7:1	3,295	175	19:1
Health Sciences	1,370	100	14:1	1,739	116	15:1
Humanities & Social Sciences	8,023	481	17:1	8,829	275	32:1
Natural Sciences	1,127	270	4:1	1,280	116	11:1
Veterinary Medicine, Animal Resources & Bio Security	641	150	4:1	781	63	12:1
School of Law	1,248	90	14:1	1,406	6	234:1
Library		140			504	
Student Kiosks		393			82	
Total	34,363	4,960	7:1	36,735	2,601	14:1

Sources: Makerere Annual reports and Fact books 2011-2019

At an institutional level, Makerere has put in place or uses a number of information systems to support daily operations. Some of these include:

- Academic Information Management Information System (AIMS)—an Enterprise Resource Planning System (ERP) for Public Universities and higher education institutions that was provided by the Government of Uganda and managed by the Ministry of Finance, Planning and Economic Development (MoFPED)
- Public Universities Joint Admission Board (PUJAB) system—handles admission government sponsored students, functionality that is not yet implemented in AIMS
- Integrated Tertiary Software (ITS) is a legacy system that encompasses academic, human resource and financial data for students that have not yet been moved to AIMS
- Library Information System (VTLS Virtua) for cataloguing of University library resources. This is in the process of being replaced by Koha, an open source system
- Makerere University E-Learning Environment (MUELE) is a local customisation of Moodle
- Dspace repository for scholarly work and publications that is managed by the

University library

- Open Courseware (OCW) mirror that provides a wide range of learning materials that covers different subjects from MIT
- University-wide email system serving both students and staff built on top of open source components.

For Makerere to get to this position, it has leveraged a lot of resources from a wide range of partners. Government and a number of development partners have invested heavily in ICT infrastructure at Makerere University. Some of these include:

- The United States Agency for International Development (USAID) funded Leland Initiative provided Makerere's first direct International Internet connectivity via satellite (128Kbps up/1Mbps down) and built a wireless network linking key buildings on the Main campus and the Mulago campus (US\$ 800,000)
- Makerere was one of the campuses of the World Bank led African Virtual University (AVU) project, which provided video-conferencing facilities for students to attend online classes delivered from a remote studio
- The Government of Uganda through a loan from the African Development Bank (AfDB) worth US\$1 million built the first fibre optic network backbone, connecting key buildings on the main campus
- Sida invested about US\$2.1 million (2000-2001) to facilitate the consultation and planning processes that resulted in the first ICT Policy and Master Plan. Sida then invested another US\$14.8 million (2001-2005) to extend the fibre network to some academic buildings on the main campus, setup research Local Area Networks (LANs) in some buildings, procure servers for university-wide email/intranet services, setup a library information system and create an electronic catalogue, provide access to electronic journals (meant for all universities) as well as end-user training
- Carnegie corporation invested US\$1.4 million (2002-2011) to support digitisation of Main University Library and LANs in 5 faculties process
- NUFFIC from Netherlands invested US\$120,000 to support ICT skills and e-learning training for staff and students across the university
- Norwegian Agency for Development Cooperation (NORAD) invested US\$23.6 million (2000-2009) for an institutional development programme. A portion of these resources funded three administrative Information Systems for Finance, Academic Records and Human Resources, a building for the Faculty of Computing and Information Systems that also houses Makerere's primary Data Centre managed by DICTS and supported building digital literacy skills among students and staff in the early days
- Sida has invested over US\$84.4 million (2006-2020) to build research capacity at the university and a conducive environment for research. Some of these resources have been invest in ICT infrastructure and systems in order to better support researchers
- Makerere University has also invested a lot of its own internally generated resources, primarily from a student technology fee of about \$30 per student per year.

A.5 Directorate for ICT Support

The University has created a central service unit—the Directorate for ICT Support (DICTS), which maintains institutional ICT infrastructure and services as well as providing guidance on ICT to all academic and administrative units across the university.

The unit has a staff establishment of 40 positions under a structure presented in Figure 16. Of these, only 16 are currently filled with full-time staff, who are supported by 20 student interns.

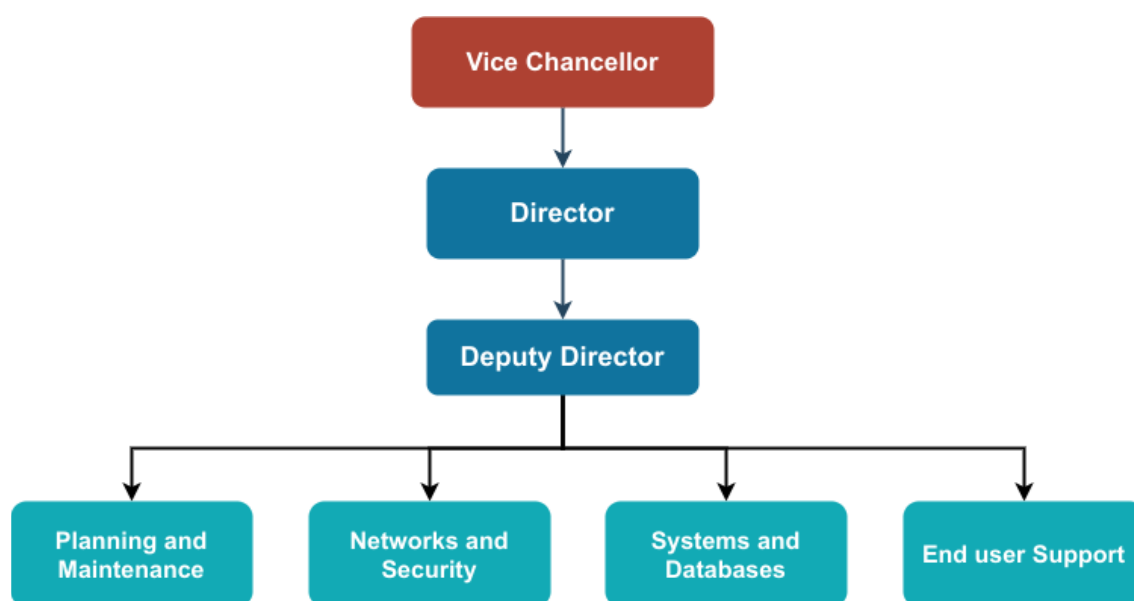


Figure 16: Organogram for DICTS

Appendix B: Tables

Table 21: Number of accredited Universities and TVETs

Name	Type	Sector	Institution type	Enrolment
Makerere University	University	Multiple	Public	36,477
Mbarara University of Science and Technology	University	Multiple	Public	3,264
Kyambogo University	University	Multiple	Public	23,790
Gulu University	University	Multiple	Public	4,572
Busitema University	University	Multiple	Public	3,049
Lira University	University	Multiple	Public	814
Muni University	University	Multiple	Public	371
Kabale University	University	Multiple	Public	2,651
Soroti University	University	Multiple	Public	93
Islamic University in Uganda	University	Multiple	Private	8,031
Uganda Christian University	University	Multiple	Private	8,150
Uganda Martyrs University	University	Multiple	Private	5,758
Ndejje University	University	Multiple	Private	6,483
Bugema University	University	Multiple	Private	4,607
Nkumba University	University	Multiple	Private	5,076
Kampala International University	University	Multiple	Private	13,938
Aga Khan University	University	Multiple	Private	200
All Saints University Lango	University	Multiple	Private	260
Clarke International University	University	Multiple	Private	762

Name	Type	Sector	Institution type	Enrolment
Cavendish University	University	Multiple	Private	2,830
Bishop Stuart University	University	Multiple	Private	6,833
Kumi University	University	Multiple	Private	1,219
Uganda Pentecostal University	University	Multiple	Private	1,774
St. Lawrence University	University	Multiple	Private	3,100
Kampala University	University	Multiple	Private	2,823
Mountains of the Moon University	University	Multiple	Private	1,910
Muteesa I Royal University	University	Multiple	Private	2,226
African Bible University	University	Multiple	Private	107
International University of East Africa	University	Multiple	Private	1,777
Victoria University	University	Multiple	Private	179
Uganda Technology and Management University	University	Multiple	Private	787
Africa Renewal University	University	Multiple	Private	430
Ibanda University	University	Multiple	Private	1,268
African Rural University	University	Multiple	Private	43
Livingstone International University	University	Multiple	Private	312
Islamic Call University College	University	Multiple	Private	58
Virtual University of Uganda	University	Multiple	Private	87
St. Augustine International University	University	Multiple	Private	216
University of Kisubi	University	Multiple	Private	877
Team University	University	Multiple	Private	1,203

Name	Type	Sector	Institution type	Enrolment
Ankole Western University	University	Multiple	Private	990
University of the Sacred Heart Gulu	University	Multiple	Private	36
Metropolitan International University	University	Multiple	Private	2,062
Valley University of Science & Technology	University	Multiple	Private	106
Avance International University	University	Multiple	Private	132
ISBAT University	University	Multiple	Private	831
University of St. Joseph Mbarara	University	Multiple	Private	0
Nile University	University	Multiple	Private	0
Fins University	University	Multiple	Private	0
Limkokwing University of Creative Technology	University	Multiple	Private	0
Great Lakes Regional University	University	Multiple	Private	0
Uganda Management Institute	ODAI	Multiple	Public	3,510
Multitech Business School	ODAI	Multiple	Private	1,052
Ernest Cook Ultra Sound Research Education Institute	ODAI	Multiple	Private	244
YMCA Comprehensive Institute	ODAI	Multiple	Private	4,798
ESLSCA International Business School	ODAI	Multiple	Private	314
Westminster Christian Institute Uganda	ODAI	Multiple	Private	91
Institute of Hospice and Palliative Care in Africa	ODAI	Multiple	Private	68
Indian Institute of Hardware	ODAI	Multiple	Private	0
Uganda Baptist Seminary	ODAI	Multiple	Private	287
Bukalasa Agricultural College	OTI	Agriculture	Public	1,310

Name	Type	Sector	Institution type	Enrolment
Fisheries Training Institute	OTI	Agriculture	Public	216
Nyabyeya Forestry College Masindi	OTI	Agriculture	Public	574
Kyera Agricultural Training College	OTI	Agriculture	Private	134
Uganda Institute of Allied Health and Management Science	OTI	Health	Private	1,419
Public Health Nurses College	OTI	Health	Private	99
Health Tutors College Mulago	OTI	Health	Public	221
Butabika School of Psychiatric Nursing*	OTI	Health	Public	425
Butabika School of Psychiatric Clinical Officers	OTI	Health	Public	594
Chemiquip Laboratory School	OTI	Health	Private	178
Jinja School of Nursing and Midwifery	OTI	Health	Public	870
Kabale School of Comprehensive Nursing	OTI	Health	Public	569
Kabale Institute of Health sciences	OTI	Health	Private	71
Medicare Health Professionals	OTI	Health	Private	306
School of Clinical Officers-Gulu	OTI	Health	Public	325
School of Clinical Officers Fortportal	OTI	Health	Public	372
School of Hygiene Mbale	OTI	Health	Public	456
Machsu School of Clinical	OTI	Health	Private	158
Masaka School of Comprehensive Nursing	OTI	Health	Public	192
Medical Laboratory Technician's School, Jinja	OTI	Health	Private	372
Ophthalmic Clinical Officers Training School	OTI	Health	Public	30
Soroti School of Comprehensive Nursing	OTI	Health	Public	492

Name	Type	Sector	Institution type	Enrolment
School of Clinical Officers-Mbale	OTI	Health	Public	427
International Institute of Health science	OTI	Health	Private	272
Institute of Hospice and Palliative Care in Africa (IHPCA)	OTI	Health	Private	83
Mildmay Centre	OTI	Health	Private	538
Gulu Institute of Health Science	OTI	Health	Private	261
School of Health Sciences Kabale	OTI	Health	Private	513
Gulu School of Nursing and Midwifery	OTI	Health	Private	455
Uganda Technical College Bushenyi	OTI	Technical	Public	661
Uganda Technical College Elgon	OTI	Technical	Public	1,077
Uganda Technical College Kichwamba	OTI	Technical	Public	566
Uganda Technical College Lira	OTI	Technical	Public	875
Uganda Technical College Kyema	OTI	Technical	Public	381
Nile Vocational Institute - Njeru	OTI	Technical	Private	1,311
Vision for Africa International Christian College	OTI	Technical	Private	65
AICM College of Science & Technology	OTI	Technical	Private	874
Kabalega College Masindi	OTI	Teacher Training	Private	1,244
National Teachers College Unyama	OTI	Teacher Training	Public	807
National Teachers College Mubende	OTI	Teacher Training	Public	437
National Teachers College Kabale	OTI	Teacher Training	Public	1,121
National Teachers College-Kaliro	OTI	Teacher Training	Public	431
National Teachers College Muni	OTI	Teacher Training	Public	776

Name	Type	Sector	Institution type	Enrolment
Word of Life Africa Bible Institute	OTI	Theology	Private	29
Covenant Bible Institute of Theology & Seminary	OTI	Theology	Private	49
All Nations Theological College	OTI	Theology	Private	66
Africa Theological Seminary	OTI	Theology	Private	183
Glad Tidings Bible College	OTI	Theology	Private	84
Institute of Advanced Leadership	OTI	Theology	Private	137
Katigondo National Major Seminary	OTI	Theology	Private	275
Kampala Evangelical School of Theology	OTI	Theology	Private	28
Reformed Theological College	OTI	Theology	Private	110
Uganda Bible Institute	OTI	Theology	Private	109
St. Paul National Seminary Kinyamasika	OTI	Theology	Private	98
Pentecostal Theological College (PTC)	OTI	Theology	Private	68
Uganda Martyrs Seminary Namugongo	OTI	Theology	Private	264
Global Theological Seminary	OTI	Theology	Private	68
Makerere University Business School	ODAI	Business & Commerce	Public	18,156
Uganda College of Commerce Aduku	OTI	Business & Commerce	Public	1,099
Uganda College of Commerce Kabale	OTI	Business & Commerce	Public	983
Uganda College of Commerce Pakwach	OTI	Business & Commerce	Public	622
Uganda College of Commerce Soroti	OTI	Business & Commerce	Public	909
Uganda College of Commerce Tororo	OTI	Business & Commerce	Public	1,236
Rwenzori College of Commerce	OTI	Business & Commerce	Private	212

Name	Type	Sector	Institution type	Enrolment
Royal Institute of Business and Technical Education	OTI	Business & Commerce	Private	229
Rosa Mystica Inst of Business & Voc Training Fortportal	OTI	Business & Commerce	Private	184
Uganda Institute of Banking and Financial Services	OTI	Business & Commerce	Private	334
United College of Business Studies	OTI	Business & Commerce	Private	89
Institute of Accountancy and Commerce	OTI	Business & Commerce	Private	131
International College of Business and Computer Science	OTI	Business & Commerce	Private	66
Mbarara Business Institute	OTI	Business & Commerce	Private	180
Kampala College of Business	OTI	Business & Commerce	Private	118
Kabarole College of Commerce	OTI	Business & Commerce	Private	21
Kampala College of Commerce and Advanced Studies	OTI	Business & Commerce	Private	84
Kyotera College of Business Studies	OTI	Business & Commerce	Private	176
Makerere Business Institute	OTI	Business & Commerce	Private	909
Makerere College of Business and Computer Studies	OTI	Business & Commerce	Private	344
Maganjo Institute of Career Education	OTI	Business & Commerce	Private	120
Nyamitanga College of Business Studies	OTI	Business & Commerce	Private	188
Nakawa Institute of Business Studies	OTI	Business & Commerce	Private	189
Namasuba College of Commerce	OTI	Business & Commerce	Private	509
YMCA College of Business Studies Jinja	OTI	Business & Commerce	Private	963
YWCA Training Institute	OTI	Business & Commerce	Private	1,060
Zenith Business College	OTI	Business & Commerce	Private	580
The College of Business Studies	OTI	Business & Commerce	Private	25

Name	Type	Sector	Institution type	Enrolment
The College for Professional Development	OTI	Business & Commerce	Private	65
Tropical College of Commerce and Computer Studies	OTI	Business & Commerce	Private	76
Bridge Tutorial College	OTI	Business & Commerce	Private	114
Bethel Training Institute	OTI	Business & Commerce	Private	657
College of Business and Management Studies	OTI	Business & Commerce	Private	53
College of Business Studies Uganda	OTI	Business & Commerce	Private	67
Fortportal Institute of Commerce	OTI	Business & Commerce	Private	122
Great Lakes Regional College	OTI	Business & Commerce	Private	479
Higher Learning Institute of Business Masaka	OTI	Business & Commerce	Private	88
African College of Commerce & Technology	OTI	Business & Commerce	Private	420
Aptech Computer Education Centre	OTI	Business & Commerce	Private	115
Ankole West Institute of Science and Technology	OTI	Business & Commerce	Private	1,195
Buganda Royal Institute of Business & Technical Education*	OTI	Business & Commerce	Private	1,451
College of Professional Development	OTI	Business & Commerce	Private	583
Centre for Procurement Management	OTI	Business & Commerce	Private	547
Datamine Technical Business School	OTI	Business & Commerce	Private	745
Institute of Management Science and Technology	OTI	Business & Commerce	Private	81
Management and Accountancy Training Company Limited	OTI	Business & Commerce	Private	2,361
Liberty College of Management	OTI	Business & Commerce	Private	498
Africa Population Institute	OTI	Business & Commerce	Private	87
East African School of Taxation	OTI	Business & Commerce	Private	126

Name	Type	Sector	Institution type	Enrolment
Meritorious Biz Technical College	OTI	Business & Commerce	Private	163
African Institute of Music	OTI	Business & Commerce	Private	76
Kampala International College	OTI	Business & Commerce	Private	35
Uganda Christian Institute for Professional Development	OTI	Business & Commerce	Private	741
Global Professional Solutions	OTI	Business & Commerce	Private	910
East African Institute of Management Science	OTI	Business & Commerce	Private	544
Institute of Accountants and Vocational School Kyotera*	OTI	Business & Commerce	Private	132
Al – Mustafa Islamic College	OTI	Business & Commerce	Private	50
Mityana Business Institute	OTI	Business & Commerce	Private	84
Victoria Business Secretarial College	OTI	Business & Commerce	Private	123
Axial International College	OTI	Business & Commerce	Private	30
Institute of Petroleum Studies, Kampala	OTI	Business & Commerce	Private	287
Uganda Institute of Business and Management Studies	OTI	Business & Commerce	Private	159
African Ark College of Management Sciences	OTI	Business & Commerce	Private	260
Alliance Vocational School Ibanda	OTI	Business & Commerce	Private	700
Non Commissioned Officers Academy	OTI	Business & Commerce	Public	1,200
Fountainhead Institute of Management and Technology	OTI	Business & Commerce	Private	566
Uganda Catholic Management and Training Institute	OTI	Business & Commerce	Private	295
Institute of Accountants & Commerce	OTI	Business & Commerce	Private	144
Kigumba Business and Vocational Institute	OTI	Business & Commerce	Private	36
Management Institute of Science & Technology (MIST)	OTI	Business & Commerce	Private	88

Name	Type	Sector	Institution type	Enrolment
St. Benedict Technical College Kisubi	OTI	Business & Commerce	Private	175
Institute of Social Work & Community Development	OTI	Business & Commerce	Private	334
Uganda Institute of Business and Media Studies	OTI	Media	Private	143
Uganda Institute of Information and Communications Tech	OTI	Media	Private	951
UMCAT School of Journalism and Mass Communication	OTI	Media	Private	518
International Institute of Business and Media Studies	OTI	Media	Private	43
Nsamizi Training Institute of Social Development	OTI	Media	Public	1,791
Management Training and Advisory Centre	OTI	Media	Public	2,901
Bishop Magambo Counsellor Training Institute	OTI	Media	Private	60
Caritas Counselling and Training Institute	OTI	Media	Private	141
Makerere Institute of Administrative Management	OTI	Media	Private	49
Mbarara Institute for Social Development	OTI	Media	Private	573
Makerere Institute of Management	OTI	Media	Private	1,651
Makerere Institute for Social Development	OTI	Media	Private	715
Nile Institute of Management Studies Arua	OTI	Media	Private	466
Visions Institute of Public Relations and Management	OTI	Media	Private	150
Rukungiri Institute of Management	OTI	Media	Private	285
Development Studies Centre	OTI	Media	Private	54
Rubindi Vocational Institute	OTI	Media	Private	220
Labour College of east Africa	OTI	Media	Private	78
Luigi Guissani Institute of Higher Education	OTI	Media	Private	79

Name	Type	Sector	Institution type	Enrolment
Uganda Wildlife Training Institute Kasese	OTI	Hospitality	Public	234
Hotel and Tourism Training Institute	OTI	Hospitality	Public	393
Pearl Crest Hospitality Training Institute	OTI	Hospitality	Private	20
Jimmy Sekasi Institute of Catering	OTI	Hospitality	Private	208
Law Development Centre	OTI	Legal	Public	1,327
National Meteorological Training Institute	OTI	Metrology	Public	96
Institute of Survey and Land Management	OTI	Survey and Land Management	Public	532
East African School of Aviation, Soroti	OTI	Aviation	Public	120
Uganda Petroleum Institute Kigumba	OTI	Petroleum	Public	70
Tororo Co-operative College	OTI	Cooperatives	Public	71
Uganda Cooperative College Kigumba	OTI	Cooperatives	Public	205
Nagenda International Academy of Art and Design	OTI	Art & Design	Private	56
Artfield Institute of Design	OTI	Art & Design	Private	166
Michelangelo College of Creative Arts, Kisubi	OTI	Art & Design	Private	141

Table 22: Current bandwidth and project gap for accredited Ugandan universities (based on 1 Gbps/1000 students)

Name	Location	Status	Students No.	Current Bandwidth (Mbps)	Connection Type	RENU member	Bandwidth Gap (Gbps)
Makerere University	Kampala	Public	36,477	2,000	Fibre	Yes	34.5
Uganda Christian University	Mukono	Private	8,150	300	Fibre	Yes	7.9
Makerere University Business School	Kampala	Public	18,000	90	Fibre	Yes	17.9
Mbarara University of Science and Technology	Mbarara	Public	3,264	113	Fibre	Yes	3.2
Kampala International University	Kampala	Private	13,938	62	Fibre	Yes	13.9
Kyambogo University	Kampala	Public	23,790	400	Fibre	Yes	23.4
Uganda Martyrs University	Kampala	Private	5,758	135	Fibre	Yes	5.6
Uganda Technology and Management University	Kampala	Private	787	28	Fibre	Yes	0.8
Busitema University	Busitema	Public	3,049	48	Fibre	Yes	3.0
Gulu University	Gulu	Public	4,572	40	Fibre	Yes	4.5
Bugema University	Kampala	Private	4,607	100	Fibre	Yes	4.5
Cavendish University	Kampala	Private	2,830	10	Fibre	Yes	2.8
Muni University	Arua	Public	371	13	Fibre	Yes	0.4
Victoria University	Kampala	Private	179			No	0.2
Islamic University in Uganda	Mbale	Private	8,031	30	Fibre	Yes	8.0
Mountains of the Moon University	Fort Portal	Private	1,910	30	Fibre	Yes	1.9
ISBAT University	Kampala	Private	831			No	0.8
Clarke International University	Kampala	Private	762			No	0.8

Nkumba University	Entebbe	Private	5,076	58	Fibre	Yes	5.0
Kabale University	Kabale	Public	2,651	72	Fibre	Yes	2.6
Muteesa I Royal University	Kampala	Private	2,226	25	Fibre	Yes	2.2
Kampala University	Kampala	Private	2,823	19	Fibre	Yes	2.8
Bishop Stuart University	Mbarara	Private	6,833	42	Fibre	Yes	6.8
International University of East Africa	Kampala	Private	1,777			No	1.8
Ndejje University	Ndejje	Private	6,483	30	Fibre	Yes	6.5
Lira University	Lira	Public	814	24	Fibre	Yes	0.8
African Rural University	Kagadi	Private	43	12	Fibre	Yes	0.0
St. Lawrence University	Kampala	Private	3,100			No	3.1
Soroti University	Soroti	Public	93			No	0.1
LivingStone International University	Mbale	Private	312	18	Fibre	Yes	0.3
Kumi University	Kumi	Private	1,219			No	1.2
African Bible University	Wakiso	Private	107			No	0.1
Africa Renewal University	Kampala	Private	430			No	0.4
Uganda Pentecostal University	Fort Portal	Private	1,774			No	1.8
Ankole Western University	Kabwohe	Private	990			No	1.0
Ibanda University	Ibanda	Private	1,268			No	1.3
All Saints University Lango	Lira	Private	260			No	0.3
Aga Khan University	Kampala	Private	200	12	Fibre	Yes	0.2
University of Kisubi	Kisubi	Private	877	16	Fibre	Yes	0.9
University of the Sacred Heart	Gulu	Private	36			No	0.0

Uganda Country Case Study

Metropolitan International University	Kisoro	Private	2,062	0	Fibre	Yes	2.1
Team University	Kampala	Private	1,203			No	1.2
University of St. Joseph Mbarara	Mbarara	Private		10	Fibre	Yes	0.0
Valley University of Science & Technology	Bushenyi	Private	106			No	0.1
Avance International University	Kampala	Private	132			No	0.1
Kayiwa International University	Kampala	Private				No	0.0
Nsaka University	Jinja	Private				No	0.0
Virtual University of Uganda	Kampala	Private	87	10	Fibre	Yes	0.1
							176.541

Table 23: Licensed ICT providers in Uganda

No.	Operator Name	Current License	Services
1	MTN Uganda Ltd	NTO	Mobile Network Operator (MNO) with extensive fibre footprint across the country, provides wholesale and retail services for both infrastructure as well as voice and data services
2	Uganda Telecom Limited	NTO	Former incumbent with extensive fibre and copper infrastructure across the country, provides wholesale and retail services for both voice and data services
3	American Tower Company (ATC) Ltd	PIP	Only mobile TowerCo in Uganda after acquiring competitor Eaton Holdings in 2019
4	C-Squared Ltd	PIP	Google project offshoot that provides wholesale open access dark fibre and leased services
5	Uganda Electricity Transmission Co. Ltd (UETCL)	PIP	Electricity distributor who provides wholesale open access dark fibre that runs along its distribution grid across the country
6	Africell Uganda Ltd	PIP & PSP	Mobile Network Operator (MNO),
7	AIRTEL Uganda Ltd	PIP & PSP	Mobile Network Operator (MNO) with extensive fibre footprint across the country, provides wholesale and retail services for both infrastructure as well as voice and data services
8	Bandwidth & Cloud Service (BCS) Group Ltd	PIP & PSP	Regional fibreCo that provides wholesale and retail for dark fibre, leased fibre and bandwidth services
9	i-way Africa (U) Ltd (Afsat Communications)	PIP & PSP	Regional broadband provider whose core service is satellite broadband services, but has now diversified into fibre and wireless
10	Internet Solutions Uganda Ltd	PIP & PSP	Regional Data Centre, fibre infrastructure and internet services provider with headquarters in South Africa
11	Liquid Telecom Ltd (formerly Infocom)	PIP & PSP	Regional fibreCo, acquired operations of the leading ISP (Infocom) to form local unit. Provides wholesale and retail for both fibre, broadband and cloud services
12	NITA-U	PIP & PSP	Government agency that operates the NGI and provides connectivity to government MDAs
13	Roke Investments Ltd	PIP & PSP	Licensed ISP, provides fibre and wireless

No.	Operator Name	Current License	Services
			broadband infrastructure and services to commercial and residential customers
14	SEACOM Uganda Ltd	PIP & PSP	Submarine cable provider with inland PoPs in different regional countries
15	SimbaNET Uganda Ltd	PIP & PSP	Licensed provider for managed fibre and bandwidth services
16	Smart Telecom Ltd	PIP & PSP	Provides mobile voice and data services
17	Smile Communications Uganda Ltd	PIP & PSP	Provides mobile voice and data services
18	Tangerine Limited	PIP & PSP	Provides mobile data services
19	Wanainchi Cable Ltd	PIP & PSP	Owner of regional Zuku brand that provides bundled services including voice, data and TV services to the home
20	WiAfrica Uganda Ltd	PIP & PSP	Licensed ISP
21	Africa IBC Bids Info Technology Ltd	PSP Capacity Resale	Capacity resale provider
22	BT Solutions Ltd	PSP Capacity Resale	Capacity resale provider
23	Datanet.com LLC	PSP Capacity Resale	One of the oldest ISPs in Uganda
24	Satyam Technical Services Ltd	PSP Capacity Resale	Capacity resale provider
25	Sky Dot.com Ltd	PSP Capacity Resale	Capacity resale provider
26	TruIT (U) Ltd	PSP Capacity Resale	Provides retail broadband services via fibre or wireless to the premises
27	Blue Crane Communications Ltd	PSP Voice & Data	Licensed ISP
28	East Africa Radio Networks Ltd	PSP Voice & Data	Provides satellite-based broadband and audio-visual services for businesses customers
29	East African Broadband Services Ltd.	PSP Voice & Data	Licensed ISP
30	Gilat Telecom Limited	PSP Voice & Data	Provides fibre and satellite-based broadband and cloud services mainly for businesses customers
31	Hamilton Telecom Ltd	PSP Voice & Data	Mobile Virtual Network Enabler (MVNE) that provides both voice and data services
32	Sombha Solutions Store Ltd	PSP Voice & Data	Provides retail wireless broadband services

Source: UCC, 2020

