KobWeb

Collaboration | Connection | Community

RENU | 20 Years

2025 Edition

RENU's Community Magazine

Table of contents

Editorial.....4

COLLABORATION...5

6 AI, Genomics, and High-Performance Computing: Inside Uganda's ACE

8 Transforming PhD Training: International Collaboration, Ethical AI, and a New Era of Excellence at Uganda Christian University

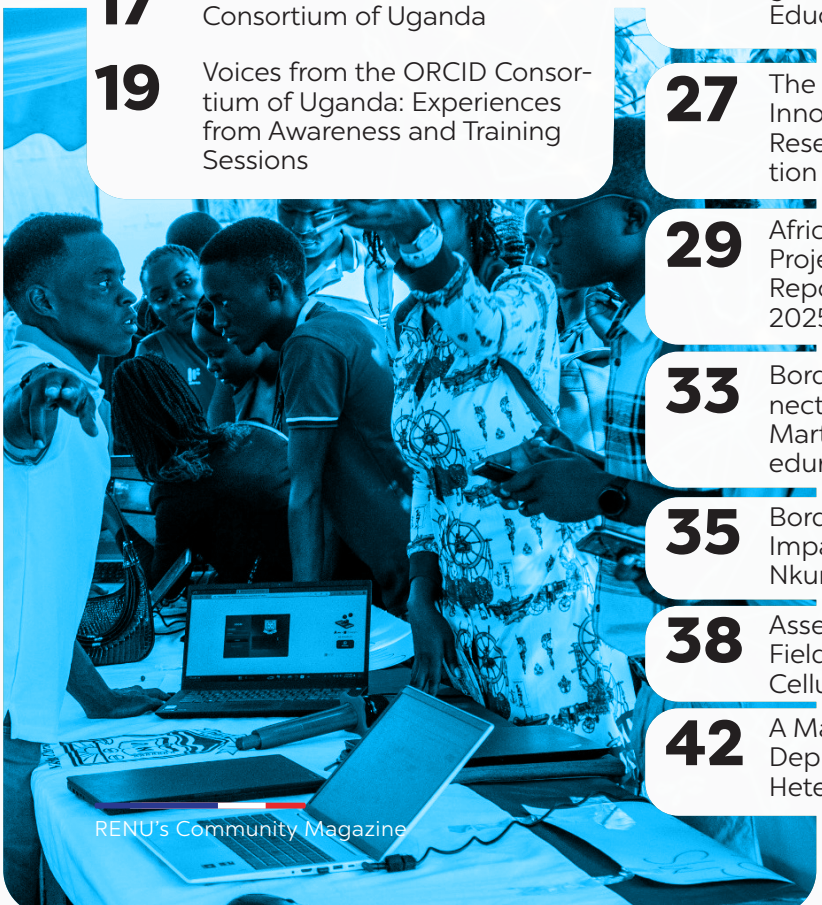
10 RENU's AI Strategy as a Construction Plan for Uganda's Digital Sovereignty

14 AI Innovation Academy Unveiled to Power Next-Generation Talent

15 Advancing Learning, Research, and the Innovation Ecosystem through the RENU-CUUL Partnership

17 RENU Launches the ORCID Consortium of Uganda

19 Voices from the ORCID Consortium of Uganda: Experiences from Awareness and Training Sessions



CONNECTION.....22

23 From 1 Gbps to 200 Gbps: RENU Marks 20 Years with a Major Backbone Upgrade, Powering the Future of Education and Research

27 The Unsung Heroes of Global Innovation: The Impact of Research and Education Networks

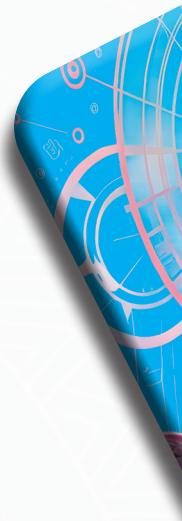
29 AfricaConnect3 Project Impact Report 2019-2025

33 Borderless Connectivity: Uganda Martyrs University's Sucessful eduroam Deployment

35 Borderless Connectivity: eduroam's Impact on Learning, Safety, and Research at Nkumba University

38 Assessment of Human Electromagnetic Fields Exposure in Close Proximity to Cellular Transmitters

42 A Machine Learning-Based Optimal Deployment Approach for UAV-Assisted Heterogeneous Networks



Community.....47

48 Kyabirwa Simulation Centre: A Scalable Model for World-Class Surgical Training in Africa

50 The Foundational Role of Culture in Organisational Success

52 Empowering the NREN Community: The Strategic Imperative of RENU's End User and Capacity Building Unit

54 African Rural University: Delivering Sustainable Rural Development

RENU at 20....58

Editorial

Welcome to the 2025 edition of KobWeb, RENU's annual community magazine that captures the people, partnerships, and platforms shaping Uganda's research and education ecosystem.

This edition is anchored on the theme, "Collaboration | Connection | Community", which reflects not only RENU's mandate, but also the lived realities of member institutions, researchers, and learners navigating an increasingly digital and interconnected world.

Under Collaboration, the magazine showcases the power of partnerships in driving impact. These articles highlight joint efforts between universities, research institutes, libraries, government agencies, global networks, and industry partners. From AfricaConnect3 Project and high-performance computing initiatives, to ethical Artificial Intelligence (AI) adoption, doctoral training, and the establishment of the ORCID Consortium of Uganda, this section demonstrates how shared vision and collective action can overcome institutional, national, and continental barriers.

The Connection section explores the digital foundations that make modern research and education possible. From national and global research and education networks, eduroam deployments, and campus connectivity, to emerging technologies such as Unmanned Aerial Vehicles-assisted networks and resilient infrastructure, these stories highlight how reliable, secure, and scalable connectivity underpins discovery, learning and innovation. They remind us that access to high-quality digital infrastructure is no longer optional, it is the backbone of academic progress.

The Community section places people at the centre of digital transformation. It tells stories of capacity building, organisational culture, rural transformation, healthcare innovation, and inclusive education. These narratives show how technology and infrastructure become truly meaningful only when they empower individuals and communities, whether through safer learning environments, strengthened institutional capacity, or education models rooted in local realities and shared aspirations.

This edition also arrives at a defining moment for RENU. As we mark 20 years of existence in 2026, the stories captured here reflect a maturing ecosystem, one that has moved beyond connectivity alone to embrace identity, trust, skills development, open research, and community-driven innovation. The RENU@20 feature brings these threads together, tracing two decades of collective progress and looking ahead to the future of research and education in Uganda.

KobWeb is more than a record of achievements; it is a platform for reflection, learning and inspiration. We hope this edition encourages readers to see themselves as active contributors to a connected, collaborative, and empowered research and education community.

Thank you for being part of this journey.

Enjoy the read.

Communications Team

Collaboration

AI, Genomics, and High-Performance Computing: Inside Uganda's ACE

By Fred Ouma, Corporate Communications Specialist, Infectious Diseases Institute

Building skills, careers, and hope—one scientist at a time.

On 21st March, 2017 a bold vision took root at the Infectious Diseases Institute (IDI) at Makerere University. Building on the earlier efforts of the first African Centre of Excellence (ACE) in Mali, which began in 2015, the African Centre of Excellence in Bioinformatics and Data-intensive Sciences (ACE) was launched to address Africa's most pressing health challenges using cutting-edge computing and data tools. Today, it stands as a continental powerhouse, training scientists, analysing genomes, and driving discoveries in diseases that affect the region the most.

Dr. Andrew Kambugu, the Executive Director of IDI, calls it a paradigm shift. "Data is the new microscope," he asserts. "With Artificial Intelligence (AI) and large language models, we're shaping the future of health science like never before, unlocking insights from vast datasets that traditional methods could never touch."

Indeed, ACE is more than just a laboratory. It's a high-performance engine for health innovation. Its 56-node computing cluster processes massive datasets from DNA sequencing and medical imaging, and a virtual reality laboratory that transforms complex biology into 3D visuals for surgeons and students. Researchers focus on antimicrobial resistance, cancer genomics, and infectious disease outbreaks, turning raw data into actionable insights.

Indeed, ACE is more than just a laboratory. It's a high-performance engine for health innovation. Its 56-node computing cluster processes massive datasets from DNA sequencing and medical imaging, and a virtual reality laboratory that transforms complex biology into 3D visuals for surgeons and students.

The numbers tell the story. Over 80 publications. More than 10 major projects. Dozens of MSc and PhD graduates, along with short courses and internships, are helping build Africa's next wave of bioinformaticians. From population genomics to AI-driven predictions, ACE has equipped scientists to handle data floods that once overwhelmed the continent.

None of this happens in isolation. Since 2017, a strategic partnership with the Research and Education Network for Uganda (RENU) has powered IDI's data-driven transformation.

High-speed Internet and bandwidth from RENU handle terabytes of genomic data streaming in and out. Cloud hosting offers scalable storage and computing power, enabling researchers to collaborate without compromising system stability. Secure Sockets Layer (SSL) certificates secure the ACE website, protecting sensitive health data shared globally, and eduroam on the Go devices keep mobile scientists connected seamlessly to the free, secure, and trusted Wi-Fi across campuses and conferences.

"Connectivity is the lifeblood of data-intensive science," says Daudi Jjingo, the ACE leader. Without RENU's reliable infrastructure, transferring sequencing

files or running remote simulations would grind to a halt.

This collaboration shines in real-world impact. During emergencies, fast bandwidth enabled rapid pathogen analysis and real-time data sharing. Scalable cloud resources have allowed surge modelling and computational expansion when demand peaks. Secure, accessible platforms have ensured that critical findings reach policymakers and researchers across Africa.

Recent highlights show ACE accelerating. A new partnership with Google DeepMind brings AI tools to African researchers, promising breakthroughs in protein folding and disease prediction, powered by the same robust network backbone RENU provides.

As ACE hits this 7-year milestone in 2026, the outlook is electric. With facilities like its Virtual Reality (VR) laboratory, pioneering surgical training, and High-Performance Computing (HPC) cluster supporting pan-African projects, the centre is poised to lead in AI-health integration.

In a continent bursting with health data but short on processing power, ACE proves what's possible. Backed by partners like RENU, it's not just analysing Africa's health challenges; it's solving them, one dataset at a time.

The next decade? Expect more discoveries, more trained experts, and healthier outcomes across the region. Uganda's data revolution is just getting started.

Recent highlights show ACE accelerating. A new partnership with Google DeepMind brings AI tools to African researchers, promising breakthroughs in protein folding and disease prediction, powered by the same robust network backbone RENU provides.

Transforming PhD Training: International Collaboration, Ethical AI, and a New Era of Excellence at Uganda Christian University

By Martin Kabanda Kwagala, eLearning Manager, Uganda Christian University

Ever imagined taking world-class Doctor of Philosophy (PhD) training in Business and Management without needing a visa? Well, imagine no more. Uganda Christian University (UCU), School of Business, is turning that dream into reality.

The School has made bold moves to transform how PhD training is delivered in the country, with a clear finish line in sight. The secret formula? A powerful mix of diverse professor collaboration, both international and local, and ethical Artificial Intelligence (AI) capability development that helps students move faster through the journey without compromising excellence.

Guided by a Mix of Local and International Facilitators, Powered by Collegial Learning

In the PhD program at the School, teaching is co-facilitated by both international professors and local experts, like an aircraft with two senior co-pilots guiding a junior through a smooth take-off into the world of doctoral research. This means engaging in a challenging journey with support from diverse scholars and world-class nurturing.

The School has made bold moves to transform how PhD training is delivered in the country, with a clear finish line in sight. The secret formula? A powerful mix of diverse professor collaboration, both international and local, and ethical Artificial Intelligence (AI) capability development that helps students move faster through the journey without compromising excellence.

Keeping Pace with the Global AI Wave Ethically

In an era where AI is reshaping every corner of scholarly life, training in the responsible and ethical use of AI has become non-negotiable. Rather than sprinting toward blind adoption, the School has chosen a more deliberate path that places robust ethical guardrails at the very heart of its AI Integration Strategy. The guiding principle is clear: AI must serve as a powerful lead for endless opportunities.

In an era where AI is reshaping every corner of scholarly life, training in the responsible and ethical use of AI has become non-negotiable. Rather than sprinting toward blind adoption, the School has chosen a more deliberate path that places robust ethical guardrails at the very heart of its AI Integration Strategy. The guiding principle is clear: AI must serve as a powerful lead for endless opportunities.

The transformation has been striking. Gone are the days when sentences drifted aimlessly across the page, when grammatical errors disrupted the flow of ideas, when arguments were left dangling like unfinished thoughts, or when methodological choices appeared fragile and poorly justified. Those once common frustrations have quietly retired into obsolescence.

This shift owes much to a purposeful program of ethical AI capability building among our PhD candidates. Today, students approach their research with renewed confidence, freely pushing the boundaries of imagination while remaining firmly anchored in intellectual integrity. A mandatory method log now accompanies every submission, offering a transparent window into precisely how AI tools were deployed, whether for literature synthesis, data cleaning, drafting initial prose, or generating alternative analytical perspectives and, equally important, where human judgment remains sovereign.

Far from fearing AI as an academic shortcut, candidates now wield it as a sophisticated research tool, one that accelerates discovery without compromising the depth, originality, or ethi-

cal standards that doctoral scholarship demands. In doing so, the School is not merely keeping pace with the global AI wave; it is demonstrating that the future of rigorous research can be both technologically advanced and ethically sound.

Time for Real Thinking

The time savings have been nothing short of liberating. What used to vanish in an endless loop of "please clarify this sentence" emails, frantic late-night proofreading, or the quiet despair of discovering a glaring typo three days after submission; those hours have been quietly reclaimed. Students now deploy AI with surgical precision on the mechanical drudgery: untangling convoluted prose in early drafts, catching inconsistencies in citation formatting, flagging repetitive phrasing, or transforming raw interview transcripts into clean searchable text. The result is a dramatic expansion of the one resource no doctoral candidate has ever had in surplus: thinking time.

Freed from these administrative shackles, candidates are rediscovering the pure joy of intellectual adventure. They can now conceptualise boldly, chasing theoretical connections that once felt too ambitious to pursue. They imagine wildly, sketching research designs that weave together disciplines in ways that would have been logistically impossible a few years ago. And they analyse deeply, diving into massive datasets sometimes harvested from obscure digital archives, forgotten government portals, or multilingual social media streams that previously demanded either superhuman stamina, divine intervention, or both.

Yet perhaps the most remarkable shift is attitudinal. Students no longer treat the research process as an endurance test to be survived. The quiet confidence comes from knowing exactly where AI ends, and their own intellectual labor begins. Every AI-assisted efficiency is documented, every creative leap remains unmistakably human, and every analytical breakthrough is earned through rigorous, personally owned judgment.

In short, the proper use of AI has removed the unnecessary grind of doctoral work, leaving behind the parts that made candidates fall in love with research in the first place: the thrill of the unexplored question, the rush of genuine discovery, and the deep satisfaction of building something entirely new with one's own mind.

Students no longer treat the research process as an endurance test to be survived. The quiet confidence comes from knowing exactly where AI ends, and their own intellectual labour begins.

A School Powered by Imagination, Ethics and AI

At the Uganda Christian University, School of Business, AI is not replacing students' minds; it is reminding them how capable they truly are. By clearing out the clutter of routine work, the AI revolution is being used to create room for thinking, innovation, and producing research that can confidently stand on the global stage.

What we are doing is no experiment confined to the African context. The deliberate integration of AI in the academic environment, ethically framed and subordinated to human judgment, is already standard practice in many of the world's leading business schools. The difference is that UCU has embedded these capabilities into the very DNA of its PhD in Business Management, maintaining ethical integration of AI while preserving the uncompromising scholarly standards that define first-tier doctoral training anywhere on earth.

As a result, the doctoral program at UCU remains intensely rigorous, with expectations targeting ABC and ABDC journal lists, encouraging presentations at international and local conferences, and a dissertation that must withstand scrutiny from external examiners of genuine world-class standing. The bar is not lowered; the scaffolding is simply smarter.

These global standard expectations, delivered through a contextually intelligent, ethically grounded, and technologically empowered journey, make the UCU PhD in Business Management a distinctive program. It is designed for committed scholars who refuse to accept that rigor and relevance must never be traded off against one another, and who are ready to meet exceptionally high targets with discipline, creativity and pride.

In short, we are not merely keeping pace with the best business schools in the world; with respect to the speed of ethical AI adoption, transparency of process, and unyielding commitment to scholarly excellence, we are demonstrating that an African doctoral program can set the standard for what a truly modern, world-class PhD looks like.

The new era has begun for doctoral training in Africa.

RENU's AI Strategy as a Construction Plan for Uganda's Digital Sovereignty

By Brian Masiga, CEO, RENUMESH Technologies

When Artificial Intelligence (AI) enters boardrooms, committee meetings, policy meetings and lecture halls, it often arrives wrapped in wonder. We talk about the chatbots that can draft essays in seconds, algorithms that grade complex assignments, or systems that predict disease outbreaks before they spread. The public conversation is dominated by the "magic" of the technology, the seemingly miraculous ability of a machine to generate human-like thought.

However, for those entrusted with leading education and research institutions, the real question is not about the magic. It is about stripping away the hype to understand the actual realities of this "wonder" and determining what we, as a nation, must actually do to harness it.

AI is not a website you subscribe to, it is an industrial system. Like the Internet, its real transformative power lies not just in the novelty of the application, but in the infrastructure that makes intelligence scalable, accessible, affordable and sovereign. That is why RENU's Artificial Intelligence Strategy is not just a policy statement but a construction plan.

At its core, RENU's Artificial Intelligence Strategy is a map for how the Ugandan research and education community is preparing itself for the AI era. It sets out to ensure that Uganda's universities, research institutes, TVETs, schools, health facilities and labs are active builders and governors of AI capabilities that serve national priorities. This strategy is deliberately grounded in infrastructure, governance, and skills, recognising that intelligence at scale does not emerge from ambition alone, but from coordinated, long-term investment.

To understand the scale of the challenge, we must first look at the hardware. Modern AI systems do not run on ordinary computers. The laptops and servers that have powered our research and education institutions for the last ten years rely on traditional Central Processing Units (CPUs).

Think of a traditional CPU as a brilliant specialist, the kind of expert who can solve the most complex equations or logic problems with great precision. However, this specialist works sequentially. They focus on one task, complete it, and then move on to the next. This makes CPUs extremely good at handling a small number of complex tasks, one at a time.

AI, by contrast, behaves very differently. It depends on millions or billions of relatively simple calculations happening at the same time. This is not a task for a single expert working alone, it is a task for a large, well-coordinated team.

This is why large-scale AI workloads rely on Graphics Processing Units (GPUs) and Tensor Processing Units (TPUs). If the CPU is a brilliant specialist, the GPU is a team of thousands of workers, each handling a small piece of the problem in parallel. Individually, each worker is less versatile than the specialist, but together they can complete massive amounts of work far more quickly.

If you attempt to run modern AI workloads on a traditional CPU, you are effectively asking one expert to do the work of an entire team. It will work, but it will take an impractically long time. GPUs and TPUs are purpose-built for this kind of parallel work, making them essential for machine learning, data analytics, and large language models.

Today, many Ugandan researchers who

want to train an AI model or analyse genomic data have only one realistic option, and that is to rent expensive compute time in Europe or North America. This model is flawed for three reasons. First, it is costly, draining our limited research grants. Second, it is slow due to Internet latency. Third, and most critically, it puts our data outside our jurisdiction.

To change this, RENU is upgrading the RENU Cloud to support AI workloads directly on Ugandan soil. We are moving to deploy high-density servers equipped with GPUs to transform our data centers from simple hosting environments into true intelligence factories. Our goal is simple, a student in Uganda should have access to close to the same class of computing power as a student in Europe or the USA, without ever having to export Uganda's data.

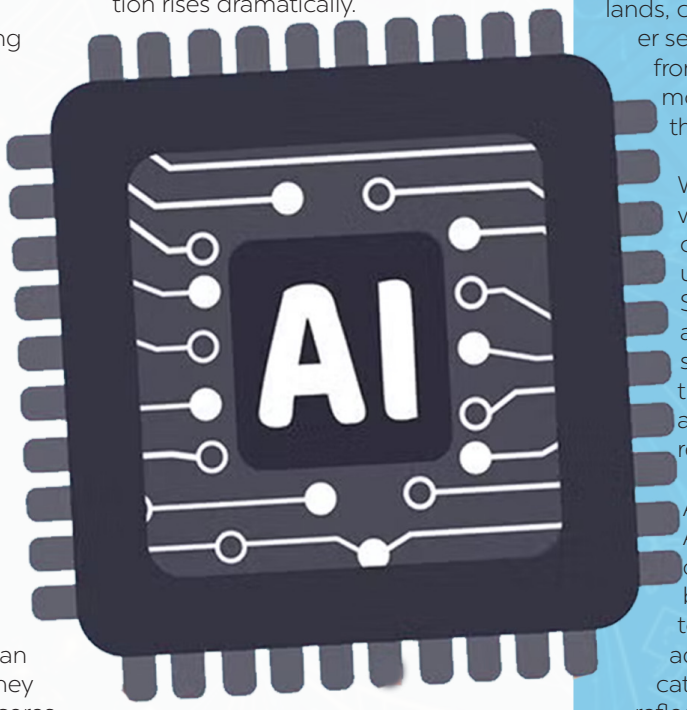
But as we build this capacity, we must be honest about the cost. Behind the glamour of AI lies a hard physical reality, electricity. Machine-learning workloads draw significantly more power than traditional computing because they rely on thousands of specialised cores operating in parallel.

This is where the numbers matter for budgeting, planning, and public understanding. We need to translate technical specifications into a unit everyone understands, such as the Yaka unit (kilowatt-hour) for Uganda.

When you top up electricity on a prepaid meter supplied by the Uganda Electricity Distribution Company Limited (UEDCL), each unit represents one kilowatt-hour of electricity. A typical urban household in Uganda might consume roughly 150 to 200 units in a month, while many rural and peri-urban households consume far less, often between 20 and 50 units per month, reflecting more limited appliance use.

By comparison, a standard data-center rack, the kind used to host websites, email servers, or university systems, consumes between 7,000 and 11,000 units of electricity per month, even before accounting for cooling and supporting infrastructure.

AI hardware changes this equation entirely. AI-capable server racks are far denser and significantly more energy-intensive. The specialised processors used for AI, particularly GPUs, consume many times more electricity than traditional processors. When multiple GPUs are combined within a single server, and several servers are assembled into one rack, monthly electricity consumption rises dramatically.



To understand the scale, consider aggregate usage. A single AI rack operating continuously for a month can easily consume around 57,600 units of electricity.

That is more power than hundreds of urban households, and well over a thousand rural households, would use over the same period. Even a relatively modest AI training cluster can burn about 1,440 units per day, adding up to more than 40,000 units in a single month.

This appetite for electricity does not just disappear, it generates heat. Training a single Large Language Model can require hundreds of megawatt-hours of energy. Cooling such workloads pushes traditional air-conditioning to its absolute limits, often prompting data center operators to adopt liquid-cooling technologies. AI facilities, therefore, become part power station, part water plant, a reality we must acknowledge as we design this infrastructure.

This energy reality explains why RENU's Artificial Intelligence Strategy must go hand in hand with the national planning process.

AI feeds on enormous datasets, genomic sequences from our hospitals, satellite imagery of our agricultural lands, climate models for our weather services, and learning analytics from our universities. If that data moves slowly across the network, the intelligence collapses.

We are seeing a global shift where Research and Education Networks (RENs) are upgrading their core capacities. Some global networks have already reached 1 Terabit per second (Tbps), recognising that high-capacity backbones are essential for data-intensive research.

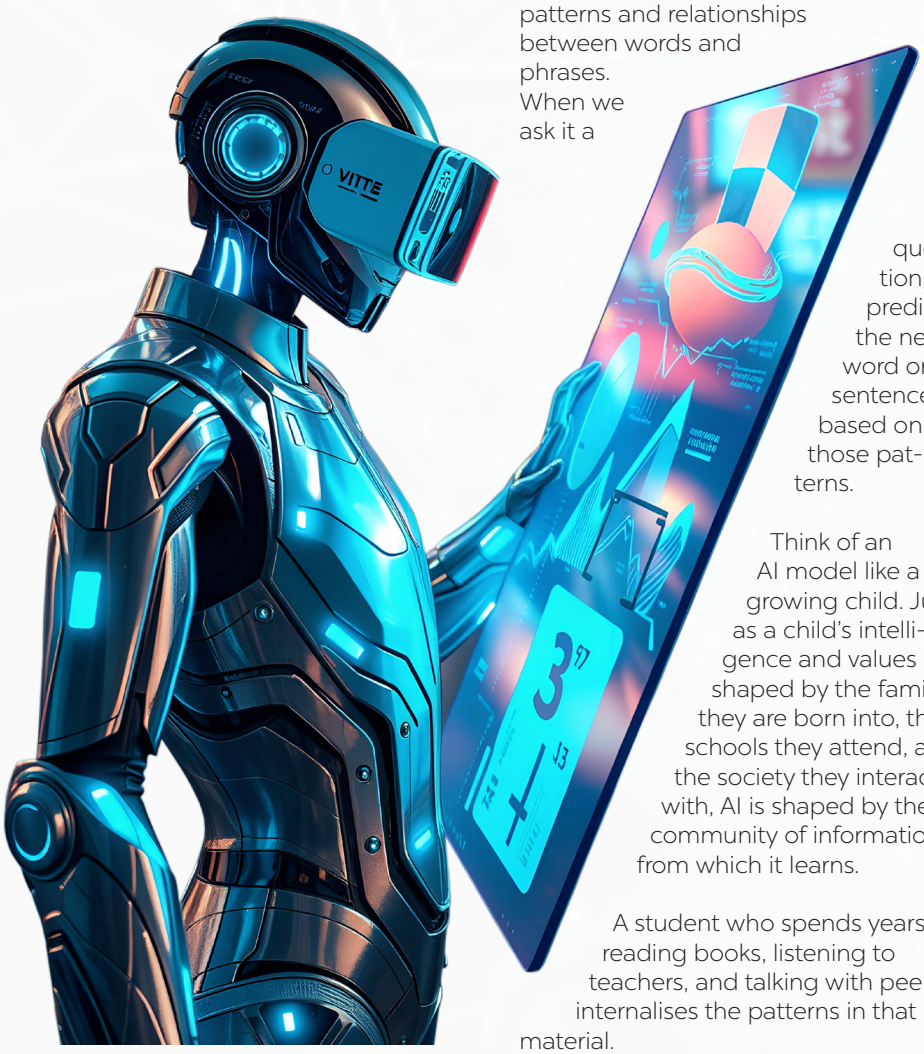
As global studies show, robust AI infrastructure from data centers to national research backbones is now foundational to scientific competitiveness in advanced economies and educational ecosystems alike. This is reflected in the work of the operational models of large-scale research networks like GEANT and other AI-optimised data center initiatives.

RENU has therefore upgraded its national backbone to 200 Gbps. This massive upgrade is designed to eliminate distance as a barrier to computation. This is not just about faster web browsing or smoother video calls. It is also about making the physical distance between an institutional lab upcountry and our central data centers and global research partners no longer a barrier.

This upgrade is also about creating research grade network environments that know how to handle large scientific data flows without compromise. Modern research increasingly depends on the rapid movement of massive datasets between labs, data centres, and collaborators. Architectures designed for this purpose ensure that high-volume research traffic can move securely and efficiently, without degrading everyday institutional connectivity. In this sense, the backbone is not just fast, it is

specialised for science.
This capability is especially critical in bioinformatics and genomics, areas in which Uganda is already a recognised leader in infectious disease research. Institutions such as the Uganda Virus Research Institute (UVRI) and affiliated labs routinely generate vast amounts of genomic sequencing data as part of pathogen surveillance and outbreak response. Modern sequencing produces datasets measured in terabytes, not megabytes.

AI-driven analysis of this data is only possible if it can move quickly and reliably from field laboratories to central computing clusters. A 200 Gbps backbone allows researchers to upload massive genomic datasets to national data centers in minutes rather than days. If a researcher in a remote lab has to wait days to transfer sequencing data, the opportunity to detect, model, and contain an outbreak may already be lost. In infectious disease research, latency is not a technical inconvenience, it is a public health risk.



We are therefore deliberately building and upgrading the nervous system before the brain, ensuring that the network can sustain AI, genomics, and data-intensive research at a truly national scale.

With the power and Internet connectivity in place, we must address the "brain" itself – LLMs.

Large Language Models (LLMs) like ChatGPT, Claude, and Gemini have captured the world's imagination. They can tutor students, summarise research, assist with coding, and enhance productivity across campus operations.

But institutional leaders must understand a critical distinction. There is a difference between using public AI tools and operating governed AI services. To understand this, we need to demystify what an LLM actually is.

An LLM is not a magic box. It is a type of AI trained on a massive collection of text and code. Deep-learning techniques teach the model to learn patterns and relationships between words and phrases. When we ask it a question, it predicts the next word or sentence based on those patterns.

Think of an AI model like a growing child. Just as a child's intelligence and values are shaped by the family they are born into, the schools they attend, and the society they interact with, AI is shaped by the community of information from which it learns.

A student who spends years reading books, listening to teachers, and talking with peers internalises the patterns in that material.

This analogy matters because the quality of the training data shapes the quality of the intelligence. Just as children become wiser when exposed to diverse experiences and fair schooling, AI models become more useful and less biased when trained on diverse, representative datasets.

Now, consider the risk. If a child grows up only reading books from a foreign culture, they will understand more of the foreign history and values deeper than their own. They will speak a foreign language perfectly but stumble over their mother tongue. AI works the same way. If infrastructure is the engine, data is the fuel, but data is not neutral. AI systems trained entirely on foreign datasets reflect foreign realities, languages, legal norms, healthcare baselines, and social contexts.

If Uganda relies solely on imported AI models, our systems will speak other people's languages better than our own. They will understand foreign legal systems better than Ugandan law. They will diagnose diseases using assumptions that do not match local populations. Incomplete or skewed training data is one of the most common causes of AI bias. Experts identify several types of bias, like selection, historical, measurement, and aggregation, that arise when certain groups are overrepresented or historical prejudices are embedded in the data. This is why sovereignty matters.

Our strategy is clear. Local data must live on local infrastructure. Whether it is legal archives, education records, agricultural datasets, or biomedical research, this information must be governed under Ugandan law and accessible to Ugandan institutions.

Hosting datasets within the RENU ecosystem enables compliance with Uganda's Data Protection and Privacy Act. It allows for trusted, governed access for universities and researchers. Most importantly, it is essential for the development of context-aware AI models that reflect Ugandan realities, our languages, our health profiles, our legal frameworks, and our social context.

But infrastructure alone does not create intelligence, and intelligence alone does not create impact.

We have already described the network as the nervous system, carrying data

rapidly across the country, and the GPU clusters as the brain, performing large-scale computation. In this system, data centers form the body, providing the physical space in which intelligence can exist, while electricity is the metabolism, supplying the energy that keeps the system alive. The LLMs are the learned behaviours, patterns of reasoning, language, and memory that emerge when the brain is trained on data.

The applications that inspire public wonder, the chatbots that converse fluently, the systems that grade assignments, or the models that predict disease outbreaks are the moments when this system appears to behave like a growing child. We recognise the wonder not because the machine is conscious, but because it demonstrates abilities we associate with human development, like the ability to communicate in language, to reason about problems, to learn from examples, and to make informed judgments.

In human terms, these are the milestones we celebrate when a child speaks clearly, solves a problem independently, or applies knowledge meaningfully. In AI, these same capabilities emerge when data, computation, and infrastructure come together at sufficient scale. The closer AI moves toward exhibiting these human-like abilities, the stronger the sense of wonder it evokes.

Yet even a child with remarkable cognitive ability requires guidance, discipline, and purpose.

In this ecosystem, skilled people are the muscle and the mentors. Researchers, engineers, data scientists, lecturers, and institutional leaders provide direction, judgment and restraint. They decide how intelligence is applied, where it is trusted, and where it must be limited. A supercomputer without skilled users is not a center of innovation, it is merely an expensive heater. Infrastructure provides the skeleton and organs, but human capability provides strength, coordination, values and accountability.

For this reason, RENU's Artificial Intelligence Strategy extends beyond networks, data centers, and compute infrastructure. It includes a comprehensive Capacity Building Framework designed to deliberately grow this muscle and mentorship. The focus is on developing the skills required to design applications, curate datasets, train and fine-tune models, govern AI responsibly, and turn computing power into results into meaningful outcomes in research, education, healthcare, and public service.

AI infrastructure creates the conditions for intelligence. Human skill and judgment determine whether that intelligence matures responsibly and serves the nation.

Uganda is not late, and it is not alone in this realisation. Across the world, National Research and Education Networks (NRENs) are being repurposed for the AI era.

In Europe, the EuroHPC AI Factories initiative is linking supercomputing centers to develop trustworthy generative models. These factories leverage massive computing capacity and are open to users from industry, research, and academia. NRENs are playing a key role in providing secure remote access to these AI-optimised resources.

Beyond Europe, New Zealand's NREN, REANNZ, has launched a national GPU initiative, showing how research and education (R&E) networks can become focal points for collective action. In the United Kingdom, Jisc is developing strategic frameworks to help colleges and universities adopt AI responsibly, supported by AI maturity toolkits and ethical guidance.

These examples illustrate a broader trend, NRENs are evolving from simple Internet connectivity providers into shared AI platforms. They recognise that high-performance computing, sovereign data spaces, and trustworthy AI services are now essential public goods.

Globally, universities are also moving toward controlled AI environments. OpenAI's ChatGPT Edu and Google's Gemini for Education are examples of affordable offerings that include enterprise-level security and administrative controls. These services allow institutions to build custom tools where data is not used to train public models. The lesson is, AI must be embedded with policy, controls, and accountability, not adopted casually.

For Vice Chancellors, Executive Directors, Headteachers, and institutional leaders, AI is about amplifying your institutional capacity. It is not just about having a chatbot on your website. With an AI-ready RENU Cloud and a 200 Gbps (and growing) backbone, we can do much more. Institutions can improve student enrolment and retention by analysing learning patterns. We can automate transcript processing, optimise complex timetables, and reduce operational costs.

For regulators and ministries, AI infrastructure offers safer innovation environments. It allows for harmonised governance and national oversight without stifling progress. Policy frameworks will be needed to ensure ethical use, data protection, and equitable access.

RENU is positioning AI as institutional infrastructure. We will build the capacity for the R&E community to deploy local LLMs, fine-tuned on Ugandan datasets, within secure environments. We will integrate emerging open-source models into the Cloud, ensuring that data stays within our borders while researchers, students, and academicians gain access to modern tools.

RENU stands ready to ensure that AI serves our people, respects our values, and unlocks Uganda's potential.

AI Innovation Academy Unveiled to Power Next-Generation Talent

On 10th October 2025, the Pathogen Economy Labs (PEL) in partnership with the Science, Technology and Innovation (STI) Secretariat, Marconi Lab, Makerere University Centre for Artificial Intelligence (MAK-AI), Makerere Innovation and Incubation Centre, and Makerere University launched the AI Innovation Academy program titled the "AI4H – AI/ML Academy Bootcamp", a ground-breaking initiative aimed at equipping undergraduate students, early career professionals, and start-ups or innovators with practical skills and a passion for applying Artificial Intelligence (AI) and Machine Learning (ML) to solve pressing local and global challenges.

The AI4H – AI/ML Academy Bootcamp program is being funded by the Science, Technology, and Innovations Secretariat, with an aim to empower AI-driven innovation in Uganda. It is an intensive program designed to run for four months, combining theoretical knowledge with hands-on projects. Participants will gain expertise in programming, data handling, visualization, supervised and unsupervised learning, model tuning, deep learning, computer vision, natural language processing, and responsible AI. They will also participate in a business incubation phase, where selected participants will receive mentorship and business development support. The top three participants will secure seed funding of up to USD 4,000 to enable further development, launch, and testing of their Minimum Viable Products (MVP) with real users.

Selected participants include students from universities and technical institutes studying technology-related fields; early-career professionals such as computer scientists and software engineers seeking to upskill in AI/ML; and founders of start-ups that aim to integrate AI/ML into their products. The participants also went through rigorous interviews to ensure they met the desired criteria.

The solutions are expected to impact a cross-section of sectors, including health, agriculture and food security, environmental and climate change, and education, among others.

The solutions are expected to impact a cross-section of sectors, including health, agriculture and food security, environmental and climate change, and education, among others.

In support of this cause, the Research and Education Network for Uganda (RENU) is supporting the program with the following;

- Cloud and AI infrastructure
- Connectivity
- Cybersecurity for AI
- Communications

By supporting the AI4H Academy, RENU reaffirms its commitment to building digital capacity for Uganda's education and research communities. This initiative not only creates a pipeline of AI-ready talent but also fosters innovation that addresses real-world challenges in sectors such as healthcare, agriculture, education, fintech, business and climate resilience.

Pathogen Economy Labs is a project that was initiated by Makerere University in partnership with clinical, governmental, and research institutions to tackle pressing health challenges. This initiative is guided by the following objectives;

- Developing an Integrated AI Disease Screening Platform to enhance the diagnosis of high-impact diseases such as COVID-19, tuberculosis, cervical and breast cancers, working closely with local health institutions.
- Establishing an AI Research and Innovation Hub as a national centre for mentorship, technical support, and infrastructure, where AI talent can thrive and innovations can be nurtured for long-term impact.
- Commercialising AI-Driven Innovations by supporting at least three AI-powered solutions through the full commercialization process — transforming research prototypes into viable businesses that strengthen Uganda's economy and health outcomes.

This academy marks a major step in building a pipeline of AI-ready talent in Uganda, nurturing solutions for national challenges, and positioning the country as a leader in AI-driven innovation in Africa.

Source: By the Pathogen Economy Labs

Published on 21st October 2025

Advancing Learning, Research, and the Innovation Ecosystem through the RENU-CUUL Partnership

By Andrew Ojulong, Executive Chairperson, Consortium of Uganda University Libraries (CUUL)

The strategic partnership between the Consortium of Uganda University Libraries (CUUL) and the Research and Education Network for Uganda (RENU) represents one of the most significant alignments of information stewardship and digital infrastructure development within Uganda's higher education ecosystem. Formalised through a Memorandum of Understanding (MoU) signed on 24th May 2024, the collaboration affirms a shared conviction that sustainable research productivity, high-quality teaching, and digital inclusion require the seamless convergence of robust connectivity and authoritative information services. This partnership bridges a critical gap between digital infrastructure and knowledge access. RENU is an ICT solutions provider that develops and manages a secure digital highway for education and research. CUUL is the curator that loads the information highway with the world's premium scholarly content, research data, and information literacy.

The partnership is grounded in the recognition that university and research libraries constitute the intellectual spine of academic institutions, hosting the content, metadata, information management capacity, and service design needed to harness the full value of national research networks.

The partnership is grounded in the recognition that university research libraries constitute the intellectual spine of academic institutions, hosting the content, metadata, information management capacity, and service design needed to harness the full value of national research networks. In doing so, CUUL acknowledges RENU's pivotal role as a connectivity enabler whose services and products, ranging from secure high-capacity networks to federated identity management, backbone through which digital scholarship is appreciated; the impact of its infrastructure is realised most effectively when university libraries are empowered to provide rich, scalable, and adaptive information services that respond to rapidly changing user needs, technological trends, and scholarly communication models. This mutual appreciation is further amplified by an awareness of the dynamic nature of information access in the twenty-first century.

Establishment of the ORCID Consortium of Uganda

Since the signing of the MoU, the collaboration has yielded significant and tangible progress. Ugandan researchers have long grappled with challenges such as limited visibility of their work, name ambiguity, fragmented research profiles across multiple platforms, heavy administrative workloads, the high cost of institutional ORCID memberships, and restricted access to international funding opportunities. To address these gaps, RENU, supported by a grant from the ORCID Global Participation Fund in 2024, worked with CUUL to formally establish the Open Researcher and Contributor ID (ORCID) Consortium of Uganda on 13th October 2025. The consortium aims to enhance the visibility, integrity, and accessibility of Ugandan scholarship, ensuring that the country's academic institutions are well positioned within the global research identity ecosystem. Member institutions now benefit from reduced membership fees, coordinated technical support for system integrations, access to advanced ORCID tools, and alignment with international open research standards.

The journey towards establishing a national consortium began during a joint awareness workshop organised by RENU and CUUL on 9th May 2025 under the theme, "Connecting Identities, Empowering Research." The workshop brought together researchers and librarians from universities and research institutes to examine the opportunities and impact of forming an ORCID consortium in Uganda. Participants were introduced to the importance of ORCID iDs in streamlining research workflows, strengthening attribution, and elevating Uganda's presence within global research networks. Insights and discussions from the event laid the foundation for building a sustainable national framework for ORCID adoption and implementation.

Capacity Building Initiatives

RENU has continued to facilitate and co-host capacity building workshops, technical demonstrations, and training sessions for library staff, enhancing their competencies in digital services delivery further enhancing their competencies in delivering secure and efficient digital services. Library systems serve as critical gateways through which students and researchers access digital repositories, academic resources, and learning platforms. Securing these systems is therefore essential to maintaining the integrity and resilience of campus-wide digital ecosystems. In alignment with this priority, RENU conducted two cybersecurity trainings for university librarians in 2025 in partnership with CUUL. The sessions were attended by over 170 participants across the CUUL community.

The trainings, facilitated by RENU's cybersecurity engineers, focused on deepening participants' understanding of cyberthreats and equipping them with practical security best practices. Through interactive discussions and demonstrations, attendees explored key areas such as threat detection, incident response, vulnerability mitigation, and secure information management. This capacity building effort is increasingly critical as cyberthreats become more sophisticated and institutions rely more heavily on digital systems to support research, teaching, and information sharing.

Launch of the African Journal of Library, Information, and Innovation

Furthermore, RENU's support and technical participation during the CUUL Annual Dissemination Conferences of 2024 and 2025 strengthened the intellectual exchange and visibility of the research and information sector. A landmark milestone has been RENU's technical assistance in developing, hosting, and maintaining the African Journal of Library, Information, and Innovation (AJLII), which was launched during the 2025 CUUL Annual Dissemination Conference. Through the partnership, RENU is offering secure infrastructure support, ensuring reliable, long-term access to Uganda's scholarly output and marking a major breakthrough in national journal stewardship. The journal is now accessible at ajlii.cuul.or.ug, symbolising the productive synergy between connectivity and scholarly communication.

Through this partnership, CUUL and RENU have laid a foundation for a resilient, knowledge-driven, and digitally empowered academic landscape. Their joint initiatives continue to model how national institutions can work together to advance research, elevate information access, and strengthen the intellectual fabric of Uganda's higher education system.

A landmark milestone has been RENU's technical assistance in developing, hosting, and maintaining the African Journal of Library, Information, and Innovation (AJLII), which was launched during the 2025 CUUL Annual Dissemination Conference.

RENU Launches the ORCID Consortium

An Interview with ORCID

RENU Launches the ORCID Consortium of Uganda

Ugandan researchers face challenges such as low visibility of their work, name confusion, fragmented research profiles across different systems, heavy administrative burdens, high costs for institutional membership to ORCID, and limited access to international funding opportunities. On 13th October 2025, RENU in partnership with the Consortium of Uganda University Libraries (CUUL), launched Uganda's Open Researcher and Contributor ID (ORCID) Consortium, a national initiative that brings together research and education institutions to strengthen the visibility, integrity, and accessibility of Ugandan research.

Lombe Tembo, the Senior Grant Program Officer/Engagement Lead at ORCID, interviewed Daniel Kawuma, a Senior Software Engineer at RENU about the NREN's journey to establishing this milestone. Below, we share the interview that was held.

ORCID: Can you share the story behind the launch of the Ugandan ORCID Consortium? How did the idea come about, and who was involved in making it happen?

The idea for the Ugandan ORCID Consortium was born out of a recognition that many of our researchers were working in isolation. Despite producing valuable knowledge, their contributions were often invisible internationally. Through RENU, Uganda's National Research and Education Network, we saw an opportunity to create a shared platform where institutions could access ORCID services affordably, receive technical support, and improve research visibility. We engaged universities and research consortia in a series of discussions to better understand their challenges and aspirations. From these conversations, the idea of a consortium quickly took root and gathered momentum. It was a team collaborative effort, spearheaded by Hellen Nakawungu, the Systems and Software Manager at RENU, and inspired by the "Ubuntu" philosophy that we are stronger together than apart.

ORCID: What was the most exciting or memorable moment during the process of forming the Consortium?

The most memorable moment came during our first national workshop, where researchers from both large and small institutions openly shared the challenges they face in gaining global recognition. When we introduced ORCID and demonstrated how it could directly connect their work to the global knowledge network, the excitement in the room was intense. For many, it was the first time they encountered a practical solution to issues of visibility and credibility.

It was also a turning point for us as the RENU team. Until that workshop, we had struggled to clearly articulate the institutional relevance of ORCID. The breakthrough came when Mr. Lazarus Matizirofa shared a compelling example of how ORCID had transformed research visibility and reporting at the University of the Witwatersrand in South Africa. His practical insights not only clarified our own understanding but also resonated deeply with the participants, creating a collective "wow" moment that confirmed we were on the right path.

ORCID: How did the Community Development and Outreach grant from the ORCID Global Participation Fund (GPF) support your work and contribute to making consortium possible?

The GPF grant was catalytic. Without it, many of our plans would have remained just ideas. The grant enabled us to organize awareness workshops within Uganda, train institutions to collaborate, train institutional representatives, and develop a governance framework for the consortium. It also gave us credibility when engaging with senior leadership at universities and government bodies—they could see that we were supported by a global initiative.

ORCID: What specific activities or milestones did the grant help you achieve in the lead-up to this launch?

Some of the key milestones include:

- Training our first group of ORCID ambassadors, each representing a cluster of institutions.
- Running sensitization campaigns that reached more than 20 universities and research organizations.
- Developing a national onboarding plan to enrol both institutions and individual researchers.
- Establishing the technical groundwork for system integrations with ORCID.

ORCID: What plans for the future do you have after the completion of the GPF cycle?

Our focus will be on sustainability. We plan to integrate ORCID services into RENU's long-term strategy so that every Ugandan researcher has the opportunity to benefit. We will also strengthen our tiered membership model to ensure that institutions and organisations of all sizes can participate. Beyond that, we want to position Uganda as a dependable partner in the region by sharing our experience with neighboring countries.

ORCID: What do you see as the main benefits for institutions joining the Ugandan ORCID Consortium?

The key benefit is visibility. Institutions that join will have their researchers' work linked globally, increasing their credibility in the international academic community. They will also gain clearer visibility into the funding awarded to their researchers, since many funders now integrate directly with ORCID to record grants. This makes it easier for institutions to track projects, demonstrate impact, and attract future support. In addition, members benefit from discounted membership fees, shared technical support, and training opportunities that would be difficult to access independently.

ORCID: How will membership make it easier for organisations to adopt and integrate ORCID compared to joining as individual members?

Joining through the consortium lowers both the financial and technical barriers. Instead of each institution negotiating and building capacity independently, the consortium provides a shared framework. This makes integration faster, cheaper, and more sustainable. Smaller institutions that could never afford ORCID membership on their own can now access it under the consortium umbrella.

ORCID: How do you see the consortium helping to build capacity for open research infrastructure in Uganda?

The consortium is more than just ORCID adoption—it's about creating a culture of openness and collaboration. By linking ORCID to repositories, journals, and grant systems, we are laying the foundation for an open research infrastructure in Uganda. This means researchers can easily share, track, and collaborate on their work, while institutions strengthen their digital capacity.

ORCID: In your view, what could be the advantages of forming a regional consortium that spans multiple countries, compared to a national consortium?

A regional consortium would bring economies of scale and create a stronger collective voice for African researchers in the global space. It would also help harmonize standards across borders, making it easier for researchers in Kenya, Uganda, Tanzania, and beyond to collaborate. However, starting with a national consortium allows us to build solid foundations at home first.

ORCID: Do you see potential for the Ugandan experience to inspire or connect with similar efforts in neighbouring countries?

Absolutely. Uganda's journey can serve as a model for others in the region. By documenting our processes, challenges and successes, we hope to inspire similar consortia in neighbouring countries, and eventually, perhaps a regional consortium if it makes financial and technical sense. If your institution in Uganda is not yet part of the Uganda ORCID Consortium, now is the perfect time to join and strengthen the visibility and global reach of your researchers. To learn more about membership and how your organisation can get involved, please contact the consortium lead at orcid@renu.ac.ug.

For organisations outside of Uganda that are considering forming a consortium in your own country or region, ORCID offers guidance and resources to support you. You can find more information on our membership page to start the conversation and explore how a consortium can help advance open and equitable research in your community.

Voices from the ORCID Consortium of Uganda
Experiences from Awareness and Training Sessions

Kyambogo University

By Lincoln Samuel Wamala
Library Assistant

As a committed member of the ORCID Consortium of Uganda, the university continues to embrace initiatives that strengthen research visibility, global scholarly identity, and digital research management.

The ORCID workshop, conducted for both library staff and researchers, was a resounding success. It equipped participants with practical knowledge and a clear appreciation of the importance of ORCID in enhancing research discoverability, supporting academic workflows, and ensuring long-term preservation of scholarly output. The facilitators from RENU were instrumental in providing hands-on guidance that made the training interactive, insightful and impactful.

As a direct outcome of the workshop, several participants successfully created their ORCID accounts. This practical engagement encouraged wider uptake and demonstrated the willingness of staff and researchers to align with the university's vision of strengthening digital scholarship. The university also selected a Kyambogo University ORCID Representative who will serve as the focal point for managing the institutional ORCID portal and coordinating ORCID-related activities across the University.

This next phase will involve systematic ORCID training for all academic staff, researchers, and postgraduate students, with an emphasis on account creation, profile completeness, institutional affiliation, and integration with institutional systems.

We are confident that with continued collaboration and support from RENU and the ORCID Consortium of Uganda, Kyambogo University will make substantial progress toward comprehensive ORCID adoption. The achievements recorded so far underscore the value of this partnership and our shared commitment to strengthening research identity management in Uganda.
We appreciate RENU and the ORCID Consortium of Uganda for their continued guidance and partnership. Kyambogo University remains committed to advancing this initiative and contributing meaningfully to a more visible, credible, and digitally empowered research community.

Lira University

By Andrew Ojulong, University Librarian

Lira University has strengthened its commitment to research excellence and global visibility by joining the ORCID Consortium of Uganda. To reinforce this commitment, the university hosted an ORCID awareness and hands-on training session for academic staff, postgraduate students, ICT personnel, librarians and researchers. The session was led by the Research and Education Network for Uganda (RENU), the host of the consortium.

A Message from Lira University's Leadership

Speaking on behalf of the university, Mr. Andrew Ojulong, the University Librarian and Executive Chairperson of the Consortium of Uganda University Libraries (CUUL), expressed appreciation for RENU's support. He noted that joining the consortium is already contributing to Lira University's institutional ranking by strengthening its research identity and visibility.

Mr. Ojulong emphasised that ORCID has become central to scholarly communication globally, with most reputable publishers requiring researchers to include an ORCID iD during submission. He reiterated that Lira University aims to ensure every faculty member obtains and actively uses an ORCID iD to improve authorship accuracy, reduce name confusion, and ensure proper attribution of research outputs.

These advantages support the university's ongoing efforts to enhance its research infrastructure, strengthen its institutional repository, and elevate its academic profile.

Building Sustainable Capacity through ORCID Ambassadors

The session also produced a Training-of-Trainers (ToT) cohort and institutional ORCID ambassadors drawn from ICT staff, librarians, and academic members. This team will lead campus-wide adoption, help colleagues create and manage ORCID iDs, and support integration into hiring, promotions, grant submissions, and research workflows.

Participants appreciated the interactive nature of the training, the hands-on demonstrations, and the guidance offered by RENU's team. Mr. Ojulong noted that the ambassadors will play a crucial role in ensuring the university's transition from ORCID awareness to full implementation.

A Strategic Move towards Research Excellence

Joining the ORCID Consortium of Uganda is more than an administrative step for Lira University. It is a strategic investment in research visibility, institutional transformation, and global competitiveness. Through its partnership with RENU, the university is positioning its researchers to be seen, credited, and connected locally and worldwide.

Part of the Lira University workshop attendants.

Uganda Management Institute (UMI)

By Barbara Alago, Systems Librarian

As global research ecosystems continue to evolve, digital identity management has become essential to scholarly communication. ORCID, the Open Researcher and Contributor ID, provides researchers with a persistent identifier that distinguishes them from others, unifies their research outputs, and connects their work across systems and institutions. At the Uganda Management Institute (UMI), awareness and adoption of ORCID were initially low. Many postgraduate students and early-career researchers had not registered for ORCID iDs, and several academic staff members had their research scattered across multiple platforms without a consolidated identity. Recognising this gap, the UMI Library saw an opportunity to support the institution's research agenda by improving the visibility of UMI scholarship and empowering researchers to take ownership of their scholarly profiles.

To address these needs, UMI, in partnership with RENU, launched a hands-on ORCID awareness campaign designed to increase uptake and strengthen digital identity management within the institution. The sessions introduced participants to the purpose and value of ORCID, demonstrating how it enhances research visibility, supports academic continuity, and integrates with tools such as Google Scholar, Scopus, and institutional repositories. Real-world examples of misattributed work, name ambiguity, and lost visibility helped participants appreciate the challenges that ORCID helps to resolve.

A significant part of the campaign focused on practical exercises. Participants were guided through creating or updating their ORCID iDs, completing their profiles, adding institutional affiliations, linking to external databases, and importing their publications. The RENU team provided step-by-step support, ensuring even those with limited digital skills were able to build a complete and functional ORCID re-

cord. The sessions also emphasized the importance of linking a wide range of scholarly outputs, including journal articles, conference papers, datasets, theses, projects, and even peer review activities, to create a holistic and accurate record of each researcher's work. For many participants, this was the first time they had seen their scholarly footprint consolidated in one place.

Throughout the campaign, participants shared their reflections, highlighting new insights gained and challenges encountered. By the end of the exercise, the initiative had produced notable results: 25 researchers were trained, 12 new ORCID iDs were created, 13 existing profiles were updated, and several publications were successfully linked through platforms such as Scopus and Crossref. Beyond these numbers, the campaign strengthened confidence in digital identity management, improved understanding of research visibility, deepened relationships between researchers and librarians, and reignited motivation among attendees to publish and share their work more widely.

The campaign also revealed a few challenges, including forgotten passwords, inactive email accounts, and limited access to devices, which required participants to share laptops during the sessions. These challenges offered valuable lessons, reinforcing the importance of one-on-one support, continuous capacity building, and the use of relatable examples to sustain engagement.

From these experiences emerged clear recommendations for sustaining momentum. Integrating ORCID registration into student onboarding and research proposal submission would institutionalise best practices. Encouraging staff to embed their ORCID iDs into academic profiles, email signatures, and CVs would enhance consistency. Linking ORCID with UMI's institutional repository would streamline metadata harvesting, while periodic refresher trainings would help researchers keep their profiles up to date. Schools and departments could further strengthen adoption by making ORCID a standard requirement for academic and research activities.

Ultimately, the ORCID Awareness Campaign at UMI achieved more than increased registrations; it transformed how researchers perceive and manage their scholarly identity. It improved research visibility, empowered scholars to take control of their digital footprint, and reaffirmed UMI's commitment to strengthening its presence in the global research community. Through the dedication of the library team and the enthusiastic participation of researchers, UMI has taken an important step toward becoming a digitally confident, research-driven institution. The campaign leaves behind a community of scholars who now understand that their identities, ideas, and contributions will always have a recognized place in global scholarship.

Part of the UMI workshop attendants.

Ernest Cook University

By Patience Atukunda Jaffu, Head of Department Informatics and Statistics

I created my ORCID iD a few months ago, but I must admit that I did not fully appreciate its value until I attended the ORCID training facilitated by RENU. The session was an eye-opener. I discovered how ORCID can streamline academic work across institutions, something especially important for me, as my PhD studies are based at a different university from where I work.

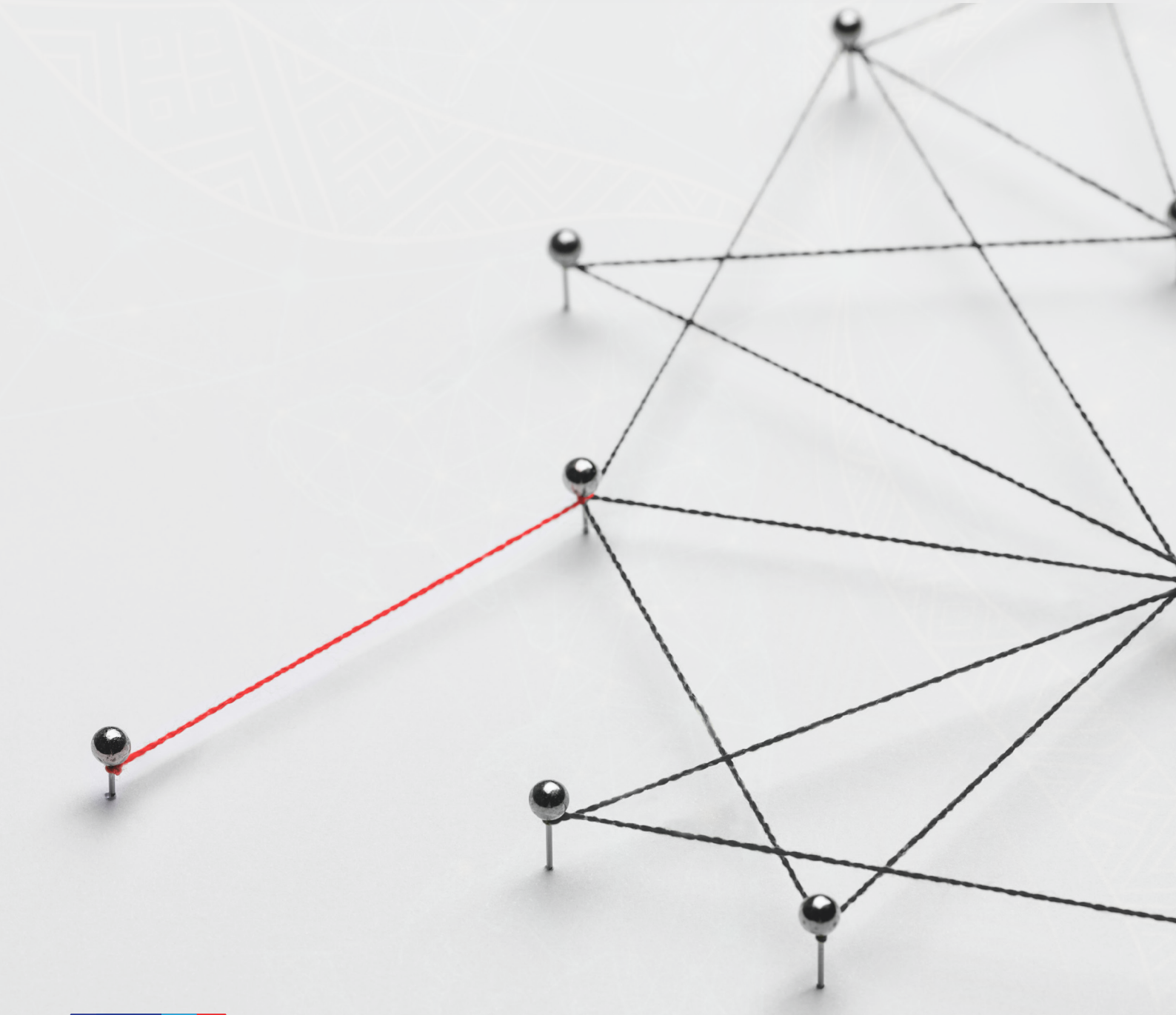
During the training, I learned how to link my ORCID record to my institutional affiliations, publisher databases, and the outputs of my ongoing PhD research. This practical understanding transformed the way I manage my scholarly activities.

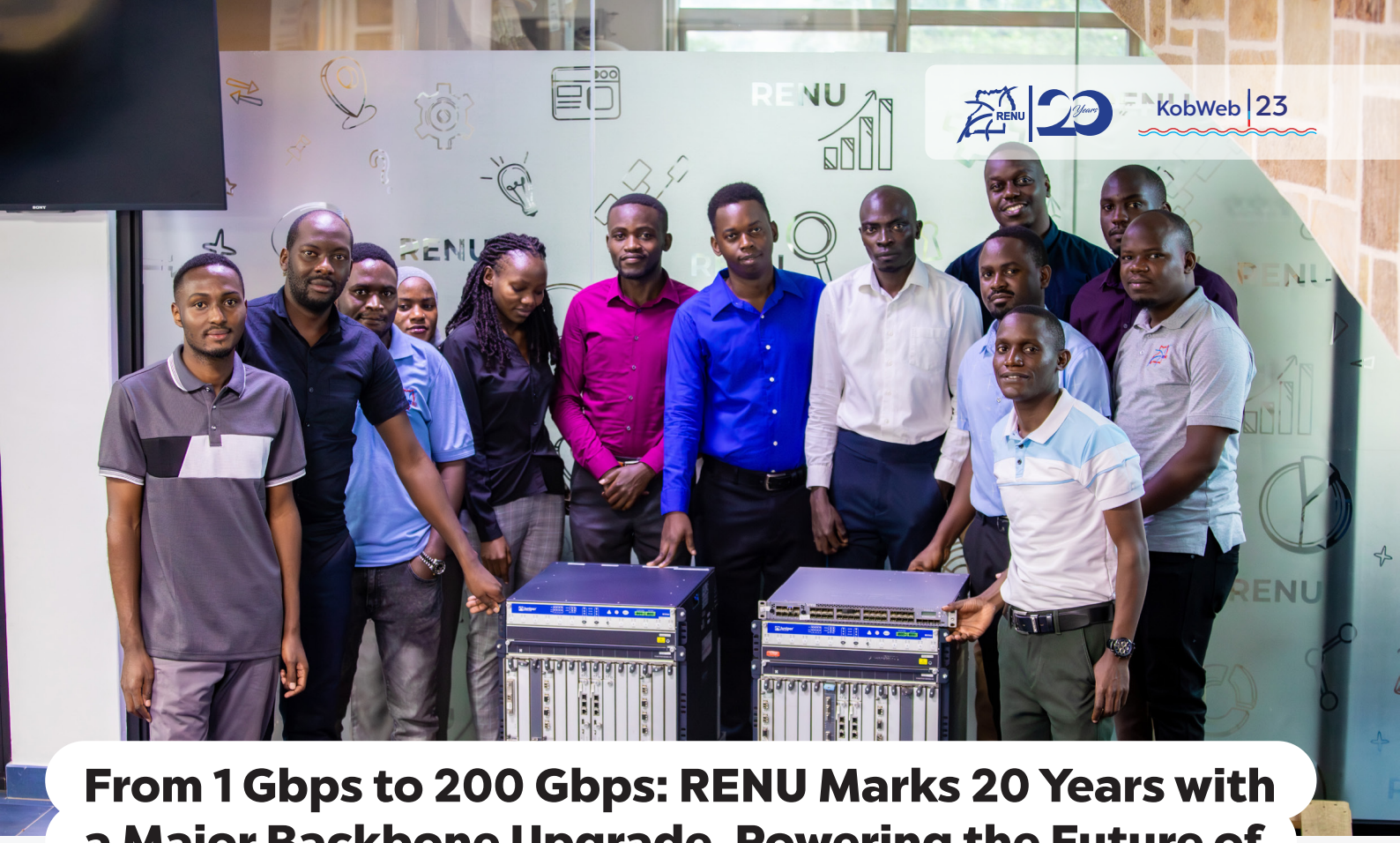
I now actively encourage fellow researchers to register for ORCID because I have seen firsthand how it enhances research visibility and simplifies academic workflows. Before the training, ORCID felt like just another online account. After the training, it has become an essential tool for managing my academic identity, increasing my visibility, and strengthening my professional networks across institutions.

Part of the Ernest Cook University workshop attendants.

ORCID CONSORTIUM

Connection





From 1 Gbps to 200 Gbps: RENU Marks 20 Years with a Major Backbone Upgrade, Powering the Future of Education and Research

By RENU Communications Team

A decade ago, the volume of data flowing through Uganda's research and education institutions was modest. Teaching content was largely text-based, datasets were smaller, and international collaboration placed little strain on the national network.

In that context, when the Research and Education Network for Uganda (RENU) became operational in 2014, a 1 Gigabit per second (Gbps) backbone was more than sufficient. But the vision went far beyond that.

At the time, RENU's priority was to transition from a telecom-led bandwidth consortium to a resilient, community-owned network, purpose-built for research and education. Ten years on, that decision has proven not only timely but transformative. Uganda's universities, research institutions, and innovation hubs are now generating and consuming data at a pace once unimaginable.

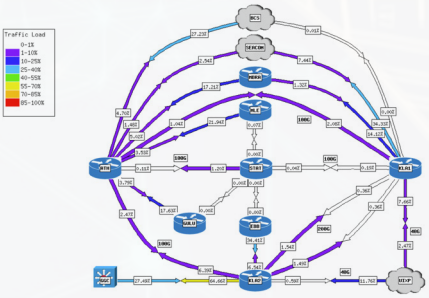
On 3rd October 2025, RENU celebrated a defining milestone: upgrading its national backbone to 200 Gbps, the largest capacity ever deployed on the network. As RENU approaches its 20th anniversary, this upgrade represents more than just raw speed; it is a symbol of how far Uganda's research and education ecosystem has come, and where it's headed.

"With the growing demand, we upgraded from 1 Gbps to 2 Gbps, then to 10 Gbps," explains Brian Masiga, former Head of Network Operations at RENU and currently CEO of RENUMESH Technologies. "But today's milestone is different. We have now upgraded our network 20 times over, from 10 Gbps to 200 Gbps."

For the network engineers who've built and managed this transformation, the growth has been unrelenting.

"Upgrading to 10 Gbps in 2017 felt massive. We were very excited and proud. But eight years later, those links could no longer handle the traffic we are pushing through the network," says Patience Nagaba, Head of Network Operations at RENU.

By 2025, the pressure was undeniable. Research workloads had intensified, cloud adoption had surged, and digital platforms were essential to teaching, collaboration, and administration. RENU responded by increasing its core backbone capacity from 10 Gbps to 200 Gbps, a 20 times jump in capability. "Having seen the network grow from 1 Gbps to 200 Gbps is truly exciting," Patience adds. "It means we now have much bigger pipes and the capacity to meet the needs of our members today and well into the future."



RENU's 2025 backbone typology after the upgrade.

Early Days of the Network

Before RENU began building its own network, connectivity for Uganda's universities and research institutions was facilitated through a Bandwidth Consortium model (2006–2014), operated

in partnership with a major telecom provider. The consortium helped a handful of institutions access subsidised bandwidth, but it lacked the scale, flexibility, and sustainability needed to support a national knowledge economy.

"From 2006 to 2014, we worked through a Bandwidth Consortium that allowed us to connect a few universities at subsidised rates," recalls Brian Masiga. "But when UbuntuNet Alliance arrived in Uganda in 2013, supported by the European Union through the AfricaConnect Project, we were able to build our own 1 Gbps network in 2014."

In 2014, the UbuntuNet Alliance commissioned its first Point of Presence (PoP) in Kampala under the AfricaConnect Project. This allowed RENU to begin building a dedicated national research and education backbone, starting with a 1 Gbps capacity. The network was officially launched in February 2014, with Uganda Christian University (UCU) Mukono as the first connected site.

The commissioning of the PoP at Statistics House enabled RENU to operate its own infrastructure and connect directly to regional and global research networks. By the end of 2014, RENU had three core PoPs namely; Statistics House, Mulago (now MUJHU), and Mbarara, and a clear mandate for growth.

In 2015, RENU expanded rapidly beyond Kampala. A new PoP was commissioned in Entebbe, connecting Nkumba University and Kisubi University, along with five major health research institutions: the Uganda Virus Research Institute (UVRI), Medical Research Council (MRC), Joint Clinical Research Centre (JCRC), International AIDS Vaccine Initiative (IAVI), and the National Institutes of Health (NIH).

Later that year, RENU implemented its own dark fibre sub-ring in Mbale, connecting Busitema University and Uganda Christian University (UCU), Mbale Campus. In July 2015, a PoP was commissioned in Mbale, opening up Eastern Uganda to high-capacity academic connectivity.

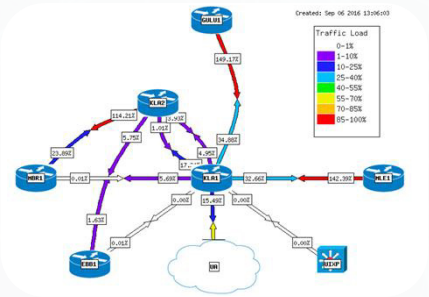
On 1st August 2015, RENU introduced a shared dark fibre model in Mbarara, connecting six sites, each with a backup fibre link for protection against fibre cuts. In practical terms, this meant fewer outages and more consistent connectivity for teaching and research.

Just weeks later, on 13th August 2015, a PoP was commissioned in Gulu, connecting Gulu University and extending RENU's reach into Northern Uganda. RENU closed 2015 with 43 connected campuses and 6 PoPs .

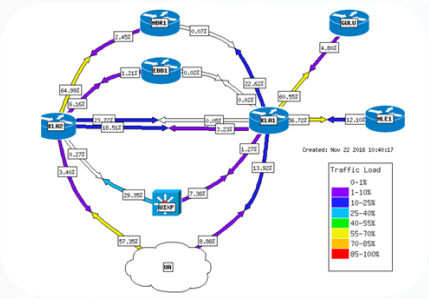
To further strengthen reliability, RENU commissioned backup links for all backbone routes, introduced shared sub-ring last-mile connections in Kampala, Entebbe, and Mukono, and established a fully equipped 24-hour Network Operations Centre (NOC). For member institutions, these investments significantly reduced downtime and reinforced confidence in the network as a mission-critical service.

Laying the Groundwork for High-Capacity Connectivity

In 2016, RENU reached another significant milestone by upgrading its backbone from 1 Gbps to 2 Gbps. That same year, autonomous system border routers were deployed at MUJHU and Statistics House. The Juniper MX5 routers, which had served well, were replaced with more powerful MX480 platforms, enabling the network to handle increased traffic and scale reliably.

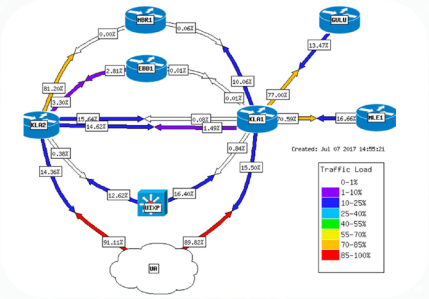


RENU backbone typology by September 2016.



RENU backbone typology by November 2016.

Momentum continued into 2017, with major sections of the backbone upgraded from 2 Gbps to 10 Gbps. By 2018, this expansion extended to the Entebbe PoP, which was upgraded to 10 Gigabit Ethernet (10GE) capability. International capacity was also enhanced, with a Kampala-London link upgraded from 1 Gbps to 3 Gbps, a new 1 Gbps link to Amsterdam, and a 10 Gbps interface to UbuntuNet Alliance.



High level network topology of the RENU backbone in 2017.

Supporting Services: Data Centres, Capacity Building, and Cybersecurity

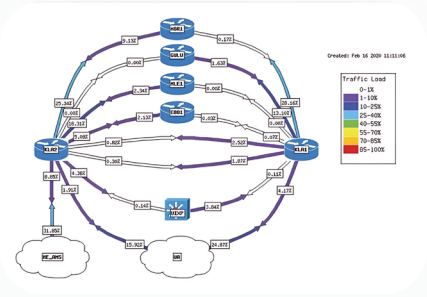
As the network grew, RENU expanded beyond connectivity alone. In March 2015, RENU commissioned its first data centre at MUJHU in Mulago, Kampala, offering affordable colocation and disaster recovery services. Member institutions could host servers off-campus and replicate data over the uncapped RENU network at speeds of up to 1 Gbps, safeguarding critical systems without the cost of building and maintaining their own infrastructure.

Capacity building also became a core priority. To strengthen campus networks and reduce reliance on external support for routine issues, RENU partnered with UbuntuNet Alliance, the Network Startup Resource Centre (NSRC), and INASP to conduct hands-on training workshops. These were held at the institutions, including Gulu University, UCU Mbale, Makerere University, Uganda Martyrs University (UMU) Nkozi, Multitech Business School, Ndejje University, and the Uganda Management Institute (UMI).

As traffic volumes increased and cyber risks evolved, RENU established a Cybersecurity Emergency Response Team (CERT) in 2016. Through coordination with regional and international partners, the CERT improved incident response and preparedness across the research and education community.

Expanding Reach, Strengthening Resilience

From 2019 onwards, the backbone capacity in metropolitan Kampala was upgraded to 20 Gbps, while secondary links were added to regional PoPs in Mbale, Gulu, and Arua. These investments strengthened resilience and reduced the proportion of institutions falling below agreed service levels to below 1%, a critical indicator of network reliability.



High level view of the RENU backbone as of February 2020.

Cybersecurity coordination and network monitoring capabilities were further enhanced as data volumes and threat landscapes continued to evolve. Institutions connected during this period included Kampala University Jinja Campus, Lira University, Baylor Uganda (Kasese), African Rural University (Kagadi), Mbale Clinical Research Institute (Soroti), and sites in Arua.

The Leap to 200 Gbps and What it Means for Members

By 2025, the limits of incremental upgrades were clear. Uganda's research community was generating massive datasets, particularly in health and genomic research. At the same time, cloud adoption, AI , and expanded digital learning platforms placed unprecedented demand on the backbone.

The response was decisive. On 3rd October 2025, RENU upgraded its core backbone to 200 Gbps, creating significant headroom for growth and ensuring the network could scale without congestion.

"This 200 Gbps upgrade means reduced cost of bandwidth for our member institutions," says Brian Masiga. "Universities and research institutions can now access more capacity at a lower cost, enabling data-heavy research, innovation, and collaboration."

The expanded backbone also strengthens services such as Metro eduroam, eduroam on the Go, and campus networks, ensuring improved performance and reliability for students, researchers, academic staff, and administrators alike.

For institutions not yet connected, the message is equally clear: RENU is ready to support high-capacity, data-driven use cases - now and into the future.

Enabling Research, Innovation, and AI Readiness

Uganda has emerged as a regional leader in infectious disease research, generating vast volumes of genomic and scientific data that must be shared, analysed, and archived efficiently.

"With 200 Gbps, large genome sequencing datasets can now move seamlessly across the network," Brian Masiga notes. "This is critical for cutting-edge research and international collaboration."

The upgrade also aligns closely with RENU's broader artificial intelligence strategy, which depends on strong, resilient infrastructure.

"This is the first step in making our infrastructure AI-ready, from our data centres to our institutions," Brian Masiga adds. "It's not just about browsing faster. It's about supporting data-heavy research, lowering costs, and preparing Uganda's education and research community for what comes next."

Powered by Partnership: The Role of Sikt

Behind this leap in capacity is a powerful example of international cooperation. The 200 Gbps upgrade was made possible through collaboration with Sikt, Norway's National Research and Education Network (NREN), demonstrating how shared purpose across borders can translate into tangible infrastructure gains.

The partnership was forged under the NREN Twinning Programme, organised and funded by GÉANT, which promotes cooperation and knowledge exchange among research and education networks worldwide. Through this framework, technical expertise, practical insight, and mutual trust were brought together to address real network needs.

"When colleagues from Sikt visited RENU in February 2024, they saw our network firsthand and identified gaps," Patience explains. "They later realised they had equipment that could significantly strengthen our backbone, and they sent it to us."
That contribution proved catalytic. Beyond the hardware itself, the contribution underscored the value of global solidarity among NRENs and directly enabled RENU to take the decisive step to a 200 Gbps backbone - faster, more cost-effectively, and with long-term sustainability in mind.

Group photo taken during Sikt team's visit to RENU in February 2024.

Twenty Years in and Looking Ahead

From its early days operating under a Bandwidth Consortium, to launching a 1 Gbps national backbone in 2014, and now running at 200 Gbps, RENU's journey reflects two decades of persistence, partnership, and purposeful growth.

As RENU marks 20 years of existence, the 200 Gbps upgrade stands as both a celebration of how far the network has come and a foundation for what lies ahead. It positions Uganda's research and education community to innovate boldly, collaborate globally, and participate confidently in the digital knowledge economy, today and into the future.

The Unsung Heroes of Global Innovation The Impact of Research and Education Networks

By Nicholas Mutegeki, Network Engineer, RENU

In today's data-driven world, where scientific breakthroughs and educational advancements hinge on seamless Internet connectivity, Research and Education Networks (RENs) serve as the invisible backbone of global innovation. These specialised networks, designed to meet the high-speed, high-capacity demands of academic and research communities, are revolutionising how we collaborate, learn, and address pressing global challenges. From the Research and Education Network for Uganda (RENU) to regional and global powerhouses like the UbuntuNet Alliance and GÉANT, RENs are bridging digital divides and fostering a connected future. This article explores their profound impact on research, education, and sustainability, highlighting their role as catalysts for progress.

The Role of RENs in a Connected World

RENs are purpose-built networks that provide reliable, high-speed Internet connectivity to universities, research institutions, schools and community organisations. Unlike commercial Internet providers, RENs prioritise the unique needs of academia and research, delivering infrastructure capable of handling massive datasets, real-time collaboration, and access to cutting-edge digital tools. Networks like Internet2 in the United States of America, CANARIE in Canada, AARNet in Australia, RedCLARA in Latin America, and the UbuntuNet Alliance in Eastern and Southern Africa connect millions of users worldwide. GÉANT, the pan-European Research and Education Network, links these RENs to a global ecosystem, creating a seamless web of connectivity that spans over 100 countries.

Accelerating Scientific Discovery

RENs empower researchers to tackle complex challenges by providing the infrastructure needed for data-intensive science. Consider a climate scientist in California collaborating with peers in Uganda to analyse global weather models, or a physicist accessing real-time data from a particle accelerator in Europe. These interactions are made possible by RENs. The U.S. Department of Energy's ESnet6, with its 46 terabits per second of bandwidth, connects 17 national laboratories and 28 user facilities, driving advancements in particle physics and climate science. In Uganda, RENU has connected over 1,000 campuses, including universities and research institutions, schools, hospitals and Other Tertiary Institutions (OTIs), enabling seamless data sharing across borders.

The UbuntuNet Alliance amplifies this impact by operating a high-speed regional backbone that connects 16 NRENs across Eastern and Southern Africa, serving over five million end-users. Through partnerships like the Networks for European, American, and African Research (NEAAR) project, co-led with GÉANT and Indiana University, the Alliance facilitates intercontinental data flows for fields such as agriculture and healthcare. GÉANT's transatlantic links further enhance this connectivity, ensuring low-latency access to global research resources. From Artificial Intelligence (AI) and genomics to astronomy, RENs remove Internet connectivity barriers, allowing researchers to focus on discovery.

Bridging the Digital Divide in Education

RENs are not just for researchers; they are transforming education by ensuring equitable access to digital resources. By connecting schools, libraries, and community institutions, RENs bring e-learning platforms, digital libraries, and virtual classrooms to underserved regions. In Uganda, RENU's network of over 1,000 campuses , including rural schools and health centres like Ishongororo Health Centre IV in Ibanda District, has brought digital learning and research to communities once limited by poor digital infrastructure. The UbuntuNet Alliance, through initiatives like the AfricaConnect3 Project, co-funded by the European Union and supported by GÉANT, has interconnected over 1,900 institutions across Africa, advancing the African Union's Agenda 2063 for equitable education.

RENs are purpose-built networks that provide reliable, high-speed Internet connectivity to universities, research institutions, schools and community organisations. Unlike commercial Internet providers, RENs prioritise the unique needs of academia and research, delivering infrastructure capable of handling massive datasets, real-time collaboration, and access to cutting-edge digital tools.

GÉANT's InAcademia Service, implemented in collaboration with other NRENs, further enhances educational access by providing secure, real-time student validation, enabling over millions of students globally to access discounted online resources while protecting their privacy. Similarly, CANARIE's connectivity in Canada's Nunavut Region and RedCLARA's linkage of 13 Latin American NRENs demonstrate how NRENs democratise knowledge, empowering the next generation of innovators.

Fostering Global Collaboration

RENs are ecosystems of collaboration, uniting institutions across borders to address global challenges. The UbuntuNet Alliance's regional backbone connects 16 African countries, fostering partnerships through initiatives like NEAAR, which supports healthcare advancements such as Kenya's Academic Model Providing Access to Healthcare (AMPATH) Program for HIV treatment. GÉANT's global reach strengthens these connections, linking African NRENs to over 100 countries through initiatives like the Asia-Pacific Europe Ring (AER), which ensures resilience during network disruptions, such as a submarine cable failure between Singapore and Europe.

In North America, Internet2 connects 335 higher-education institutions, 58 government agencies, and 46 regional networks, supporting over 80,000 community anchor institutions. These interconnected networks, bolstered by GÉANT's transatlantic infrastructure, enable researchers to tackle issues like climate change, cybersecurity, and public health through shared resources and expertise.

Innovating for Resilience and Sustainability

RENs are pioneers in building resilient and sustainable infrastructure. RENU-MESH Technologies, a subsidiary of RENU, manufactures solar-powered routers in Uganda, delivering reliable Internet access to areas with unstable power grids, such as the Kalangala Islands. These eco-friendly routers align with Sustainable Development Goal 7 (Affordable and Clean Energy), reducing carbon footprints while ensuring Internet connectivity. The UbuntuNet Alliance's partnerships with Amazon Web Services and Redington are also providing cloud solutions that enhance network scalability and resilience.

AARNet's "triversity" strategy in Australia builds redundant network paths, while Internet2's Next Generation Infrastructure achieves a 70% reduction in power consumption through advanced hardware. GÉANT's support for green computing, highlighted at UbuntuNet Connect 2025 Conference, promotes sustainable ICT practices, ensuring environmentally responsible networks that meet the demands of modern research and education.

Addressing Global Challenges

RENs play a critical role in tackling some of the world's most pressing challenges by enabling data-driven research, digital health, and secure collaboration.

In Latin America, RedCLARA has developed advanced visualization tools that help researchers analyze and communicate climate change data more effectively. In Uganda, RENU supports the Ministry of Health's digital strategy by providing reliable connectivity to more than 300 health centers, enabling real-time electronic medical records and remote medical training.

At a regional level, the UbuntuNet Alliance promotes open science and the use of FAIR (Findable, Accessible, Interoperable, and Reusable) data principles, strengthening research collaboration across Africa. Meanwhile, GÉANT enhances these efforts globally through its expertise in cybersecurity and network monitoring, ensuring that research data remains secure and trusted across interconnected NRENs.

A Call to Action for a Connected Future

Research and Education Networks are the unsung heroes of global innovation, providing the infrastructure that powers scientific discovery, equitable education, and international collaboration. As we navigate an increasingly data-driven future, the role of RENs will only grow. By investing in and supporting these networks, we can ensure that no community is left behind in the pursuit of knowledge and innovation.

CONNECTING AFRICA TO UNLIMITED POSSIBILITIES

AfricaConnect3 Project Impact Report 2019-2025

By Silvia Fiore, Communications Manager, GEANT

As AfricaConnect3 (AC3) comes to a close in 2025, the project team has published an impact report looking back at the transformative role of National Research and Education Networks (NRENs) in expanding digital access for Africa's research and education communities over the last five years.

Co-funded by the European Union, the project will soon start its fourth iteration (AfricaConnect4 Project), building on the successes of previous phases, which started in 2011.

AfricaConnect3 is structured in three geographical areas corresponding to each Regional Research and Education Network (RREN). The local NRENs grouped under each region are involved in the delivery of the project in their respective regions.

UbuntuNet Alliance for Eastern and Southern Africa: Botswana, Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Somalia, Sudan, South Africa, Tanzania, Uganda, Zambia and Zimbabwe.

WACREN for West and Central Africa: Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Gabon, Ghana, Guinea, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

ASREN for North Africa: Algeria, Egypt, Morocco and Tunisia.

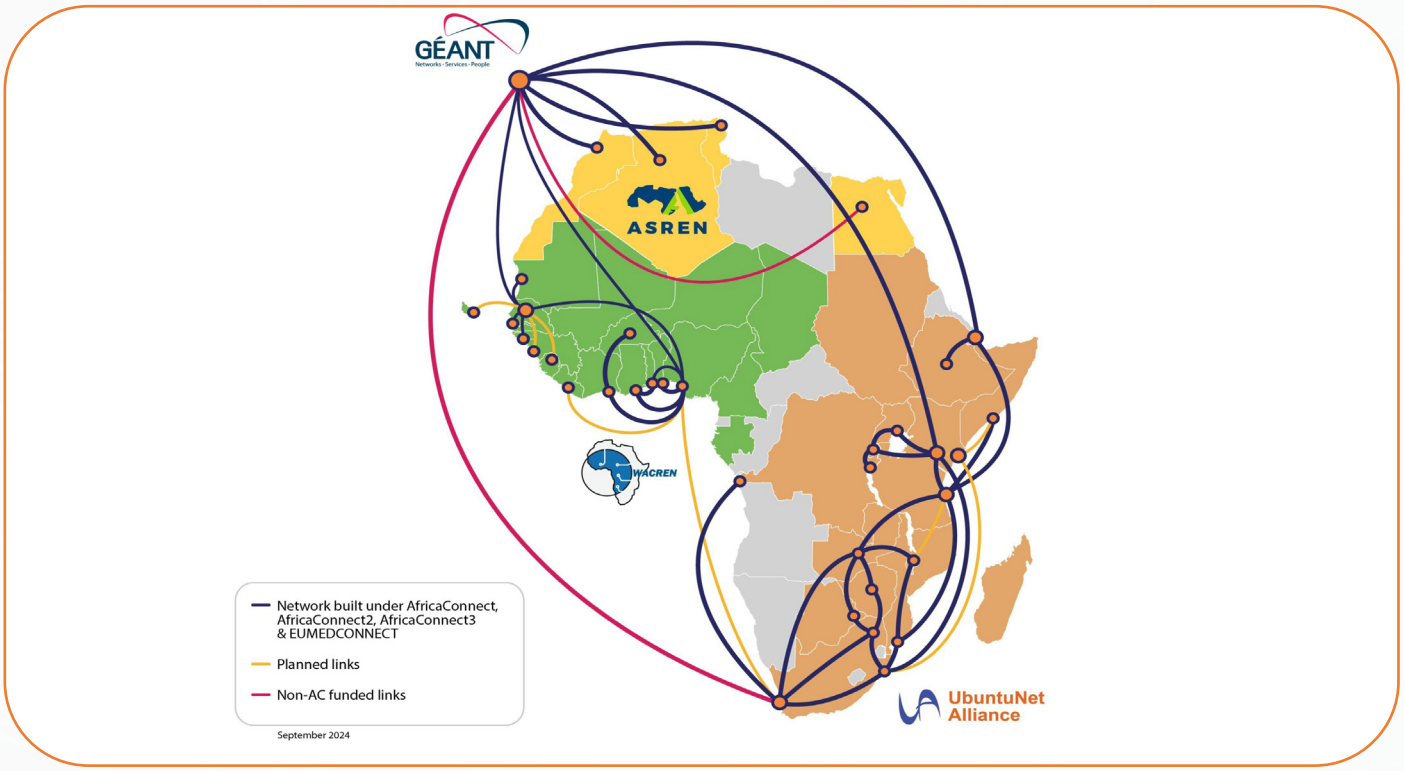
By strengthening the RRENs and supporting the NRENs, AC3 has been driving digital inclusion and catalysing the continent's contribution to the global digital economy.

Let's take a closer look at the achievements of the RENs:

Establishing secure, adequate, and affordable network infrastructures

The project's success has relied heavily on the dedication of local and regional stakeholders. By supporting NRENs, AC3 has helped connect more people, amplifying the impact of digital infrastructure as listed below.

I. 38 established NRENs across the continent.
II. 24 out of 38 countries connected to regional and international networks.
III. Over 3,000 institutions and over 9 million users connected.



Developing above-the-net services, applications, and dedicated user support

As they become more digitally-driven, academic and research institutions need specific services to support their collaboration activities and to access resources worldwide. During its iteration, AC3 has supported the uptake and local deployment of several services, as highlighted below:

Spotlight on eduroam

African countries have been leading the way with eduroam innovations, expanding the services outside of university campuses with innovations such as Metro eduroam and eduroam on the Go.

Spotlight on Identity Federations

In 2022, the UbuntuNet Alliance and WACREN launched eduID.africa, an identity federation designed for NRENs and institutions that have not yet established their own.

Through its connection to eduGAIN, a global interfederation linking 78 national federations and supporting nearly 6,000 institutions and an estimated 30 million users, eduID.africa enables students, researchers, and educators from participating African institutions to securely access a wide range of international online resources using their home institution credentials.

NRENs that have Joined eduGAIN

In 2025, Research4Life, in collaboration with the UbuntuNet Alliance and GÉANT, launched a Federated Single Sign-On (SSO) pilot for academic institutions across Eastern and Southern Africa, with support from the European Union and AC3. This initiative enhances secure access to academic resources by allowing users to log in with their institutional credentials, eliminating the need for shared passwords and improving cybersecurity. The pilots took place in Kenya, Malawi, Zambia and Uganda.

LIBSENSE
STRENGTHENING OPEN SCIENCE IN AFRICA

Spotlight on Open Science

LIBSENSE is a WACREN-led initiative that fosters collaboration among libraries, librarians, researchers, and NRENs to strengthen open science in African research and education institutions. LIBSENSE focuses on policy development and governance, open science advocacy, open access infrastructure, scholarly publishing and visibility, research ethics, data management practices and research collaboration. LIBSENSE has documented its impact on the African scholarly community.

LIBSENSE directly trained over 1,000 researchers, librarians, NREN managers, publishers and journal editors across Africa in the past four years.

Building expertise within the NRENs community

With the objective of enhancing technical proficiency and managerial abilities, the project delivered several specialised trainings, exchanges of staff members and women empowerment initiatives. Across Africa, these include:

- Over 5,000 people trained.
- 3 Emerging NREN Programme (ENP)editions at TNC.
- 2 Leadership Exchange Programmes: NREN Leadership Indabas by the UbuntuNet Alliance and NREN Academy by WACREN.
- Women hackathons alongside the UbuntuNet Connect conferences and Women-In-WACREN programme.

The Women-In-WACREN Workshop in Ivory Coast in November 2024 focused on practically using the Python programme for weather and climate data analysis.

Raising awareness of the role of digital transformation for Research and Education (R&E)

The AC3 Project partners have carried out advocacy campaigns targeted at decision makers as well as at international donors and other stakeholders to influence policy change and mobilise funding. Highlights include:

African Union

Contribution to the African Union's Digital Education Strategy

This strategy aims for the establishment and sustainability of 54 NRENs by 2027, with the UbuntuNet Alliance, WACREN, and ASREN as strategic partners, marking a significant step towards a more robust and digitally inclusive education landscape across the continent. AC3's outreach has effectively positioned NRENs as strategic pillars for digital education, reinforcing the importance of robust, continent-wide networks to support the AU's digital transformation goals for education systems.

THE WORLD BANK

Co-funding by World Bank

Engagements with the World Bank have focused on securing co-funding for NRENs through their respective national governments, leading to significant network infrastructure improvements across Eastern and Southern Africa. Notably, Botswana Research and Education Network (BotsREN) and Ethiopia Education and Research Network (EthERNet) have successfully connected to the UbuntuNet Alliance's backbone at 10Gbps each. Similarly, the World Bank has assisted Somalia Research and Education Network (SomaliREN) in upgrading its capacity to 2.5Gbps, and helped Zambia Research and Education Network (ZAMREN) expand to 20Gbps.

African RENs' Contribution to the United Nations Sustainable Development Goals

SDG4: NRENs provide affordable and high-speed Internet connectivity and advanced services in 38 African countries, and have become a lifeline for learners in the continent.

SDG5: RENs are making strides to create equal opportunities, particularly for women in STEM. The regional women hackathons are such initiatives that support women's ambition in STEM fields.

SDG8: RENs actively support education by providing online training and workshops that boost the technical skills of staff and students, paving the way for better employment opportunities.

SDG9: RENs provide advanced digital infrastructure, and reliable and secure Internet connectivity to their local beneficiaries in Africa.

SDG13: RENs contribute to climate action by supporting research institutes working on sustainability and climate change. Many NRENs are adopting greener ICT practices, aiming to reduce their carbon footprint.

SDG17: Through cross-continental and cross-sector collaborations, RENs support initiatives that are vital to the sustainability of African e-infrastructures.

And so much more, as these efforts have a multiplier effect by also contributing to other critical SDGs, which have a broader impact on global sustainability.

Engagement with Earth Observation Community

AC3 supports engagement with Earth Observation communities in Africa, such as the Global Monitoring for Environment and Security (GMES in Africa) and the African Group on Earth Observation (AfriGEO), with the aim of providing them with high-speed networks. From conducting assessment surveys to establishing the first multicast stream of EUMETCAST terrestrial data in Kenya and South Africa, the AC3 Project and its partners have prioritised enhancing collaboration on climate related global challenges.

If you are curious to read more in detail about the work of African NRENs and RRENs to drive digital inclusion on the continent, read or download the report on africaconnect3.net/resources.

Borderless Connectivity: Uganda Martyrs University's Successful eduroam Deployment

By Grace Edward Iga, Director of ICT, Uganda Martyrs University

"In education today, reliable connectivity is not an option; it's the backbone of teaching, learning and research."

At Uganda Martyrs University (UMU), we recognised early that modern students and staff no longer learn or work in static spaces. They roam from lecture halls to libraries, hostels, laboratories, and even across institutions and countries around the world. With laptops, smartphones, and tablets as constant companions, they require seamless Internet access wherever they go.

This is why, in 2023, UMU made a bold decision to join the global eduroam community. eduroam, short for education roaming, is a secure, worldwide Wi-Fi roaming access service developed for the international research and education community. By implementing eduroam across our campuses, we not only improved local connectivity but also plugged UMU into a global digital fabric of knowledge exchange.

The journey of deploying eduroam at UMU was strategic and transformational. This is the story of how we made it happen and why it matters for students, staff, and the future of higher education in Uganda.

Before the implementation of eduroam, UMU, just like many other universities, relied on traditional Wi-Fi networks with campus-specific logins. These passwords were often shared amongst the students and staff, who also shared them with other people. We therefore had many more connections than the intended number, which often caused slowness and security problems. Users also often complained about dropped Internet connections when moving between buildings, while staff struggled to maintain access to university Wi-Fi while on the move across campuses. More significantly, our users were locked within campus boundaries: once they left, Internet connectivity ended.

With eduroam, therefore, the promise was far greater:

Seamless roaming: Users authenticate once with their UMU credentials and enjoy uninterrupted Internet access across campus.

Global mobility: Students and staff can now access Wi-Fi at any eduroam-enabled institution, cafe, airport, and other zones worldwide without requiring new logins. Better still, with the eduroam on the Go innovation, they can move with their Internet connectivity literally anywhere.

Deploying eduroam also revealed that federated identity management and advanced network systems required deeper expertise than was initially available among the university ICT staff. Rather than seeing this as a weakness, the university embraced it as an opportunity for growth.

Security and trust: eduroam uses the latest encryption and our authentication standards, ensuring safe access to academic, research and administrative networks.

Deploying eduroam at UMU was not simply a matter of switching to a new Wi-Fi network. It required careful planning, strategic upgrades, and strong collaboration. From the onset, we recognised that success depended on building both the right technical foundation and the right human capacity.

Our priority was infrastructure readiness. We strengthened the campus backbone with fiber links, redundant connections, and enterprise-grade

switches capable of handling thousands of concurrent sessions. This provided the resilience and performance needed to support eduroam. We integrated the service with our identity management system, enabling staff and students to log in seamlessly using their institutional email credentials. Visitors from other eduroam institutions authenticate using their home credentials.

Coverage was another critical consideration. High-density wireless Access Points (APs) were strategically installed in classrooms, offices, residence halls, libraries, and open spaces where students congregate. By design, over 80% of the campus now enjoys reliable Internet access. Anticipating the surge in usage, we also doubled Internet capacity to keep pace with demand.

Capacity building was equally important. Our ICT staff underwent training to manage the system effectively, while users were sensitised through guides, training sessions, and campus-wide campaigns. Orientation for new students now includes eduroam awareness, and in September 2025, a major campaign by the Research and Education Network for Uganda (RENU) saw hundreds of students and staff successfully onboarded.

Collaboration with RENU, the National Roaming Operator (NRO), proved invaluable. Their technical support, Direct Engineering Assistance (DEA), and even equipment donations ensured smooth deployment and long-term sustainability.

The Impact: Transforming Teaching, Learning and Research

The difference was immediate and profound.

For students, classrooms became truly digital. Students could stream lectures, access e-resources, collaborate on shared documents, and stay connected even in transit. Confidence in campus Wi-Fi soared, with many reporting improved Internet connectivity experience.

For staff, lecturers could now conduct hybrid classes better and access global academic resources on the move. Administrative staff now enjoy more reliable online systems.

For research, cross-border collaborations blossomed. Visiting researchers from eduroam-enabled institutions connected instantly, while our scholars enjoyed access when travelling abroad. All UMU students and researchers on various exchange programs were excited to see that they could connect to the Internet seamlessly.

Overcoming the Challenges

Every transformative initiative encounters hurdles. Deployment of eduroam was no exception. Yet, rather than being stumbling blocks, these challenges became stepping stones that reshaped how the university thinks about technology and sustainability.

The cost of deploying dozens of APs and upgrading core infrastructure was initially difficult. Instead of allowing financial constraints to stall progress, the university reframed the challenge as an opportunity to plan smarter. A phased roll-out strategy ensured that each stage of implementation delivered tangible benefits without overburdening resources. This approach also created space for meaningful partnerships, most notably with RENU, whose infrastructural and capacity support reinforced the university's broader digital transformation journey. RENU, through RENUMESH Technologies, for instance, installed solar-powered routers that extend eduroam, the free, secure, and trusted Wi-Fi at selected hostels close to the university campus.

Deploying eduroam also revealed that federated identity management and advanced network systems required deeper expertise than was initially available among the university ICT staff. Rather than seeing this as a weakness, the university embraced it as an opportunity for growth. Continuous professional development became a central pillar of the strategy, with RENU playing a critical role again in delivering specialised training. The result was not only a technically competent ICT team but also a culture that values ongoing learning, collaboration and innovation.

In retrospect, what appeared as barriers at the start of the eduroam journey ultimately accelerated institutional progress. By transforming infrastructural and capacity challenges into opportunities, the university not only delivered seamless wireless roaming Wi-Fi but also laid the foundation for a smarter campus.

Despite these challenges, resilience and collaboration ensured success. The UMU Management, especially the Vice Chancellor, Prof. Patrick Edrin Kyamanywa, offered great support throughout the process.

The Future: Beyond Internet Connectivity

While eduroam has been a game-changer, it is only the beginning. We are now exploring:

i. Smart campus solutions: Leveraging eduroam for Internet of Things (IoT) applications and smart classrooms.
ii. Hybrid and online learning expansion: With seamless Internet connectivity in place, UMU has now fully embraced blended learning at scale.
iii. Home links: UMU now plans to have key faculty and administrators have eduroam at home to ensure ease of access to university resources and tasks.

Conclusion

eduroam has transformed UMU into a truly connected institution locally, regionally and globally. It has empowered students to learn without borders as well as enabled staff to teach and research more effectively. We therefore see this not simply as a technology project, but as a prime investment in the future of education. With eduroam, our campuses have no boundaries, and our learners have no limits.

Borderless Connectivity eduroam's Impact on Learning, Safety, and Research at Nkumba University

By Kato Sserwadda Mustapha, Director, NUICTS

In today's digital world, universities become successful when they can provide the faculty and students with easy access to information and digital resources. Accessing the Internet is not a luxury but a lifeline to teaching, learning and research. At Nkumba University, the foundation of providing a seamless digital experience was the deployment of eduroam (education roaming) as an improved way for the Nkumba University community to access the Internet and connect to the rest of the world.

This initiative was funded through the Mastercard Foundation Uganda eLearning Initiative, operated in partnership with Cyber Schools Technology Solutions. This collaborative vision and funding enabled the creation of several eduroam hotspots wherever possible-on campus, in student hostels, and even outdoor sites, enabling safe, reliable, and international connectivity for the Nkumba University community.

The success of eduroam in Uganda, and specifically at Nkumba University, cannot be told without acknowledging the role of the Research and Education Network for Uganda (RENU). RENU has been the national champion of eduroam, ensuring its availability, sustainability, and reach across most institutions of learning.

eduroam: Connecting Nkumba University to the World

eduroam is a worldwide secure roaming access service designed for the international research and education community. Once students and faculty at Nkumba University connect to eduroam using their university credentials, they can access the wireless Internet not only on campus but also at of participating institutions and public hotspots around the globe. For Nkumba University, establishing an account is a click away to immediately join a global academic community where guaranteed mobility, collaboration, and digital access are the normal features for the region. The impact of this exciting development is being experienced daily in classrooms, hostels, research laboratories, and even off-campus.

RENU's Role: Driving Innovation in Connectivity

The success of eduroam in Uganda, and specifically at Nkumba University, cannot be told without acknowledging the role of the Research and Education Network for Uganda (RENU). RENU has been the national champion of eduroam, ensuring its availability, sustainability, and reach across most institutions of learning.

One of RENU's most remarkable innovations is the solar-powered router. These routers:

- Provide coverage of up to 300 meters, enabling connectivity across wide-open spaces.
- Operate without direct cable connections to electricity sources, relying instead on solar energy.
- Can receive Internet connectivity through of-sight links, making them especially effective in areas without nearby buildings or traditional infrastructure.

At Nkumba University, this innovation has enabled eduroam installation in open areas such as courtyards, sports grounds, and pathways where traditional cabling would have been costly or impractical. This not only expands coverage but also demonstrates a sustainable approach to technology adoption.

In addition, RENU also introduced the eduroam on the Go device, a pocket-size routing device designed specifically for researchers and university staff. This portable device enables secure connection to eduroam and the Internet anytime, anywhere, ensuring that teaching, research, and collaboration are no longer confined to campus grounds but can continue seamlessly across campus and beyond.

The Mastercard Foundation Uganda eLearning Initiative

We would like to make particular mention of the Mastercard Foundation Uganda eLearning Initiative, which was conducted in collaboration with Cyber School Technology Solutions. Using this funding, the project also addressed a long-standing issue: The Internet access challenges faced by students and faculty alike. The project funded thousands line-the deployment of eduroam hotspots on the entire Nkumba University campus and in student hostels, which increased the teaching and learning opportunities available to students as a result of this expanded capacity.

Transforming the Student Experience

Internet at the Comfort of Hostels

Before eduroam, many students had no choice but to remain on campus late into the night to upload coursework, conduct research, or attend virtual lectures. Today, thanks to eduroam's hostel coverage, they can connect to the Internet from their rooms. This has improved personal safety, reduced fatigue, and created a more conducive learning environment.

24/7 Access to Learning

eduroam has introduced flexibility. Students can now study at any time of the day or night, accessing digital libraries, academic journals, and the university's Learning Management System (NUELE). Whether an early riser or a night owl, students enjoy an uninterrupted learning experience.

Equitable Digital Access

For many learners from low-income backgrounds, purchasing personal data bundles was a constant burden. eduroam eliminates this inequality by providing free, reliable, and secure access for all registered users. Every student, regardless of financial background, now has the same opportunity to learn online.

Off-campus Access

The availability of Metro eduroam hotspots across Uganda means that Nkumba University students can continue their studies even when away from campus. Whether attending an internship in Kampala or visiting another eduroam-enabled institution, they can still log in with their university credentials. This borderless access has expanded the very definition of the learning space.

Faculty and Research Benefits

eduroam has similarly empowered faculty and researchers at Nkumba University. Lecturers can now create and upload course content with greater ease, facilitate virtual tutorials, and join webinars remotely without disruption to their Internet connectivity.

For researchers, eduroam has unlocked opportunities for collaboration with colleagues around the world. They now enjoy seamless access to digital journals and cloud-based research tools, and can join international conferences without interruption. Additionally, researchers from Nkumba University visiting other institutions with eduroam deployed, around the world, can log in using their home university credentials without a hitch, realising the full potential of academic mobility.

Institutional Impact and Growth

At the institutional level, eduroam has raised Nkumba University's digital profile. Its integration demonstrates alignment with international standards in higher education, making the university more attractive for partnerships, grants and collaborations.

It also strengthens the uninversity's strategic objective of embedding ICT into teaching, learning and research. eduroam has become a backbone for digital adoption, supporting Nkumba University Elearning Environment (NUELE), online assessments, blended learning, and cross-border research partnerships.

Student Voices: Stories of Transformation

The true impact of eduroam comes alive in the voices of students:

"I used to stay in the library until late at night just to upload assignments. Now, I do everything from my hostel room. It feels safer and more convenient." – *Bwire Derrick Emmanuel, undergraduate student, Bachelor of Information Systems and Technology.*

"eduroam has made it possible for me to study late at night after leaving campus to improve my coding skills when it's calm. As a student, this flexibility is invaluable." – *Kibirige Henry, second year student, Bachelor of Information Systems and Technology.*

"I was surprised when my phone suddenly connected to a hotspot in Kampala, with my university credentials, and messages started popping up. It worked seamlessly, and I realised learning is no longer limited to campus." – *Namuli Maria Jascent, final year student, Bachelor of Business Administration.*

These testimonies reflect how eduroam has broken barriers, enabling safer, more inclusive, and flexible learning.

Student Safety, Well-being and Equity

One of the less visible but profound impacts of eduroam is improved student safety. With reliable Internet access in hostels, students (particularly female learners) no longer need to walk across campus late at night. This has reduced exposure to risks and improved peace of mind. By promoting equity, eduroam ensures that no student is left behind in the digital learning journey. It has removed cost barriers and provided a shared platform for innovation, exploration and growth.

eduroam and the Future of Nkumba University

eduroam is more than a network, but rather a foundation for Nkumba University's digital future. As the university strengthens its ICT infrastructure and teaching approaches, eduroam provides the backbone for:

- Virtual classrooms and e-assessments.
- Remote learning during emergencies.
- Cloud-based research collaborations.
- Global mobility and academic exchange.

With this foundation, Nkumba University is well-positioned to embrace the next frontier of digital transformation. The introduction of eduroam at Nkumba University is more than just a technological upgrade, but rather a transformation of the academic experience. Students and staff now enjoy seamless, secure, and global Internet connectivity both on and off-campus, empowering them to learn, research, and collaborate beyond traditional boundaries.

This success was made possible through the Mastercard Foundation Uganda eLearning Initiative, in partnership with Cyber School Technology Solutions, which supported the installation of hotspots across the university and hostels. Above all, special credit goes to RENU, whose innovations, ranging from solar-powered routers with wide coverage to portable eduroam on the Go devices, have made Internet connectivity sustainable, reliable, and accessible anywhere.

RENU has not only impacted Nkumba University but also positively influenced the future of higher education across Uganda, demonstrating that access to the Internet is not a privilege but a right of every learner and researcher. Their leadership in facilitating the concept that innovation means the dream of a connected community of researchers and learners, i.e., safe, inclusive and infinite, is finally alive.

Thanks to RENU's leadership, Nkumba University is now a model of digital transformation in higher education, and its students can learn, research, and collaborate without limits.

Assessment of Human Electromagnetic Fields Exposure in Close Proximity to Cellular Transmitters

By Ben Kyemba, Senior Network Engineer, RENU

The telecommunication industry in Uganda has undergone rapid growth marked by the latest introduction of 5G technology, a 64% Internet penetration rate, 34.9 million mobile subscriptions, and over 4,963 base stations serving a growing mobile user base of over 34.9 million mobile subscriptions as of June 2023.

Introduction

Wireless communication systems, particularly cellular network systems, are the primary source of Non-Ionizing Radiation (NIR) due to their radio frequency electromagnetic fields (RF-EMF) emission. Excessive exposure of the human body to the RF-EMF has been associated with various potential health risks, including nerve stimulation, skin cancer, and alterations in cell membrane permeability. To safeguard human health and the environment, international regulatory bodies such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) have established guidelines that define the maximum permissible levels of RF-EMF exposure. These guidelines are essential for ensuring that radiation levels remain within safe limits. This article references the ICNIRP 2020 guidelines to evaluate the whole-body exposure compliance of cellular system deployments in Kampala District against the permissible levels.

Background

The telecommunication industry in Uganda has undergone rapid growth marked by the latest introduction of 5G technology, a 64% Internet penetration rate, 34.9 million mobile subscriptions, and over 4,963 base stations serving a growing mobile user base of over 34.9 million mobile subscriptions as of June 2023. This has led to increasing installation of radio transmitters in proximity to human settlements, raising public concerns about potential exposure to RF-EMF. The introduction of new cellular technology like 5G, which employs advanced features such as small cell access points, high-gain directional antenna arrays, high data rates, and beamforming techniques, further amplifies this concern.

This article characterised the RF-EMF exposure from cellular system transmitters in proximity scenarios. This was achieved by measuring the Power Density (PD) from all the frequency bands in use in Uganda today. To achieve this, points of investigation (POIs) were strategically selected near radiating antennas at each identified cellular deployment site. At each POI, PD measurements were taken by directly aligning a spectrum analyser with the radiating sector antenna. An Aaronia AG spectrum analyser (Spectran HF 60105, 700MHz - 2.5GHz) was utilised, paired with an omnidirectional antenna (Omni log 90200) to accurately measure PD levels.

The main focus of this article was to characterize the RF-EMF exposure from cellular system transmitters in close-proximity scenarios. By referencing the international guidelines for whole-body RF-EMF exposure assessment, the aim is to produce reliable and comparable results that can inform regulatory practices and public health policies. The measurement POIs were strategically chosen to represent different proximity scenarios and BTS types, ensuring a thorough assessment of exposure levels across Kampala. At each site location, a close proximity POI was determined by measuring the highest received signal strength in the 900 MHz or 1800 MHz bands. This was based on the fact that the two frequency bands are widely used for voice which is the biggest technology service at each BTS.

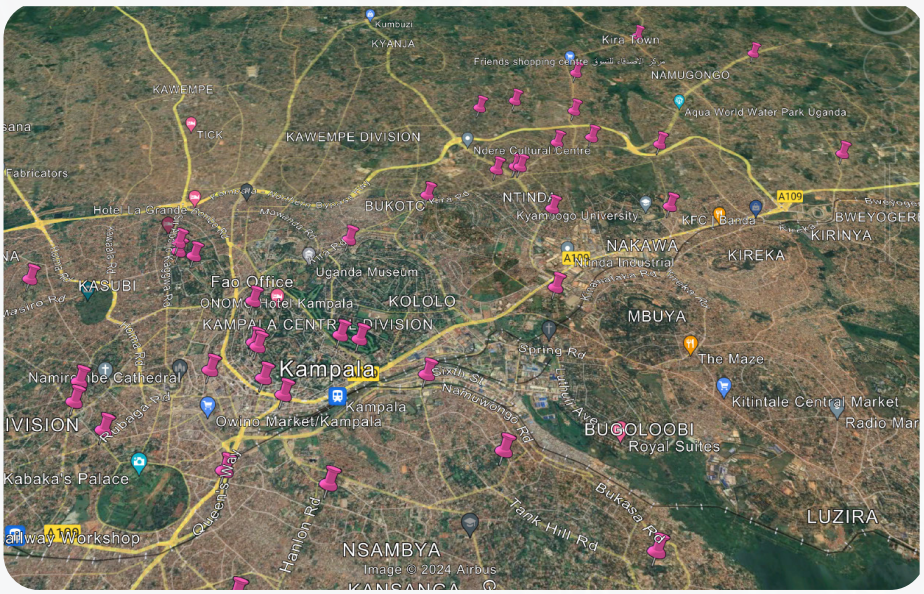


Figure 1: Site locations for POI selection.

RF-EMF Measurement at the POIs

The RF-EMF measurement protocol encompassed various aspects critical to obtaining accurate and reliable data, as described:

a) Positioning of the measurement antenna: The Hyperlog directional antenna – 60100 EMC was faced directly at each radiating antenna in each sector on the BTS within the POI.

b) Measurements were taken across multiple frequency bands currently being used by the mobile network operators (MNOs) in Uganda, as shown in Table 1 below.

Operator	Technology	Band	Frequency (MHz)
MTN	E-GSM	900	900
	DCS	1800	1800
	UMTS	B1 & U900	2100 & 900
	LTE	L2600 & L1800	2600 & 1800
	5G	NR	2300
Airtel	E-GSM	900	900
	UMTS	B1	2100
	LTE	B7	1800
	5G	NR	3500
Lyca Mobile	GSM	900	900
	UMTS	2100	2100
	LTE	B20	800

Table 1: Frequency bands currently used by mobile network operators.

a) Body to antenna distance: Measurements were performed at various body-to-antenna distances at each POI, ranging from 1 meter to 34 meters on average.

b) Body exposure averaging time: A whole-body exposure average time of 30 minutes was considered, ensuring that the data reflects prolonged exposure rather than instantaneous peaks.

The measured RF-EMF levels were compared with ICNIRP limits using specific calculations. The compliance assessment involved determining the percentage of the ICNIRP maximum permissible PD for each frequency band and expressed it as a percentage of the ICNIRP standard using Equation 2. The total exposure at each location was obtained using Equation 1.

$$ICNIRP\ Max\ (\%) = \sum_{all\ f\ (MHz)} S(\%)_{per\ band}$$

Where $S(\%)_{per\ band}$ is calculated as;

$$S(\%)_{per\ band} = \frac{S_{measured}}{S_{ICNIRP}} X100\%$$

In equation 2, $S_{measured}$ represents the measured PD from a specific frequency band, and is the ICNIRP guideline limit for that frequency band as summarised in Table 2 below, an extract from the ICNIRP 2020 guideline. By calculating the percentage of the ICNIRP maximum allowable PD, it is possible to assess the compliance of the measured RF-EMF levels with the ICNIRP international safety standards.

Frequency Range (MHz)	S_{ICNIRP} (W/m^2)
400 – 2000	$\frac{f(MHz)}{200}$
>2000	10

Table 2: Reference values of ICNIRP guidelines for PD.

Mean RF-EMF Exposure Levels

Figure 3 illustrates the mean RF-EMF exposure levels at the different sites measured. This data was derived from PD measured from the 8 bands at the different POIs at each site location. The significant variability observed in this analysis was attributed to several factors including proximity to radiating antennas, setup types, and the specific cellular technology deployed. Notably, locations that exhibited elevated mean exposure of 1.408 W/m^2 and 1.313 W/m^2 were Garden City rooftop and Church House respectively. They both had POIs at very close proximity, in the range of 1.5 meters from radiating antennas since they were rooftop BTS and 5G ready sites as well. In contrast, the site

location with the lowest mean exposure levels of 0.00413 W/m^2 was Makerere University Library and this was attributed to the fact that POIs were identified in the far field body to antenna distance range of 100 meters

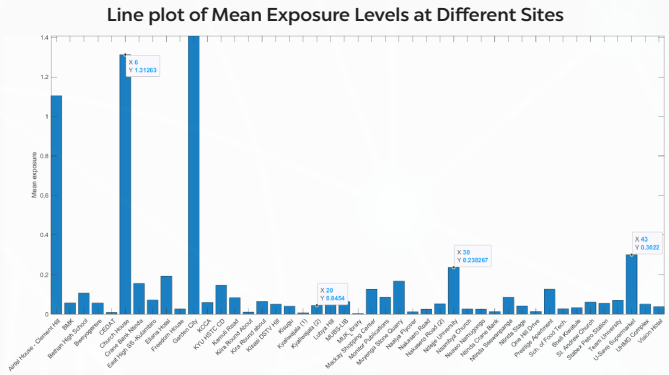


Figure 2: Mean RF-EMF exposure at each site location.

Conformity to the International RF-EMF Exposure Limits

The ICNIRP guidelines for the 3 MHz to 300 GHz frequency range were used to benchmark the measured RF-EMF values. Figure 4, below, illustrates that all the exposure levels obtained were far below the ICNIRP exposure limit, indicating overall compliance with the guidelines, thus indicating safety.

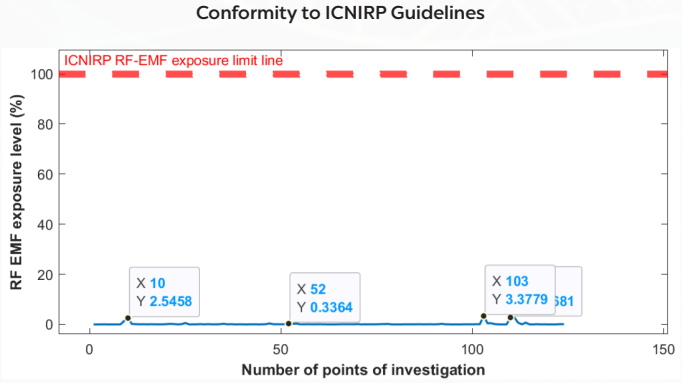


Figure 3: Comparison of the measured RF-EMF exposure levels with ICNIRP limits.

However, to have a more comprehensive assessment, the results were compared with other exposure limits such as national exposure limits used by Serbia and Poland expressed in electric field strength. The relationship between electric field strength (E) and power density (S) was given by;

$S = \frac{E^2}{Z_0}$, where Z_0 is the impedance of free space, which is approximately 377Ω. Figure 5 reveals that the measured exposure level at most locations was compliant, but a few locations such as Airtel House on Clement Hill and Garden City exceeded the Serbian limit of 11V/m.

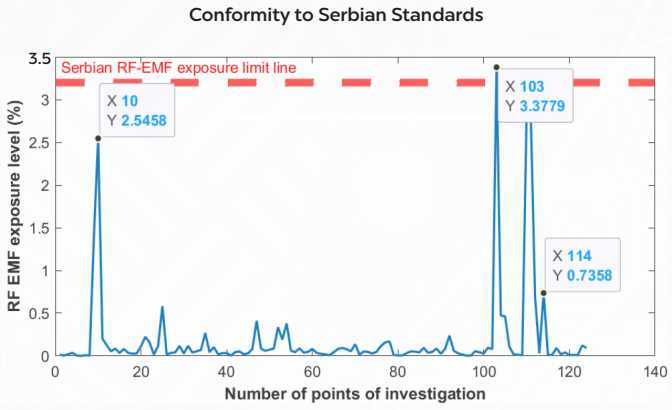


Figure 4: Comparison of the measured RF-EMF exposure levels with Serbian national limits.

Similarly, Airtel House, Garden City, and Church House were still found non-compliant with the stricter Polish regulation of 7V/m, as illustrated in Figure 5 below.

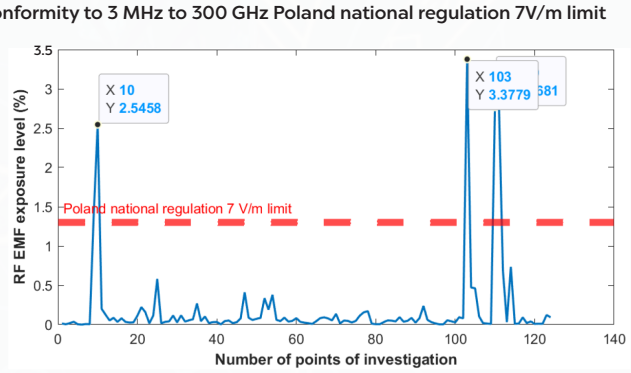


Figure 5: Comparison of the measured RF-EMF exposure levels with Poland national limits.

Contribution of 5G Deployments to the Overall RF-EMF Exposure

Measurements from 5G frequency bands, while still within the ICNIRP safety limits, exhibited elevated RF-EMF exposure levels compared to those from other cellular technologies. This trend was attributed to the fact that most 5G BTS were rooftop types with very close body to antenna distance in addition to the advanced features of 5G such as beamforming and massive MIMO which contribute high energy disposal to the body.

On average, the RF-EMF exposure level from 5G deployments was measured at 0.244% of the ICNIRP safety threshold, indicating that while 5G technology contributes a substantial portion of the recorded RF-EMF, the exposure remains well within the established safety limits. This result underscores the significant contribution of 5G technology to the overall RF-EMF exposure in close proximity scenarios.

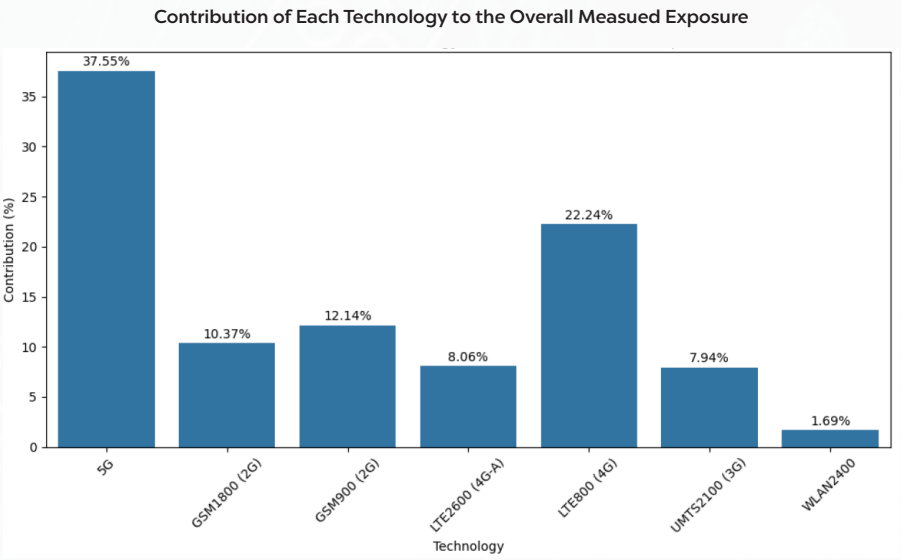


Figure 6: Contribution of 5G deployments to overall RF-EMF exposure in Kampala.

Challenges and Limitations

1. At some POIs, some sector radiating antennas were not measured due to accessibility issues or lack of clear POI for effective measurement.

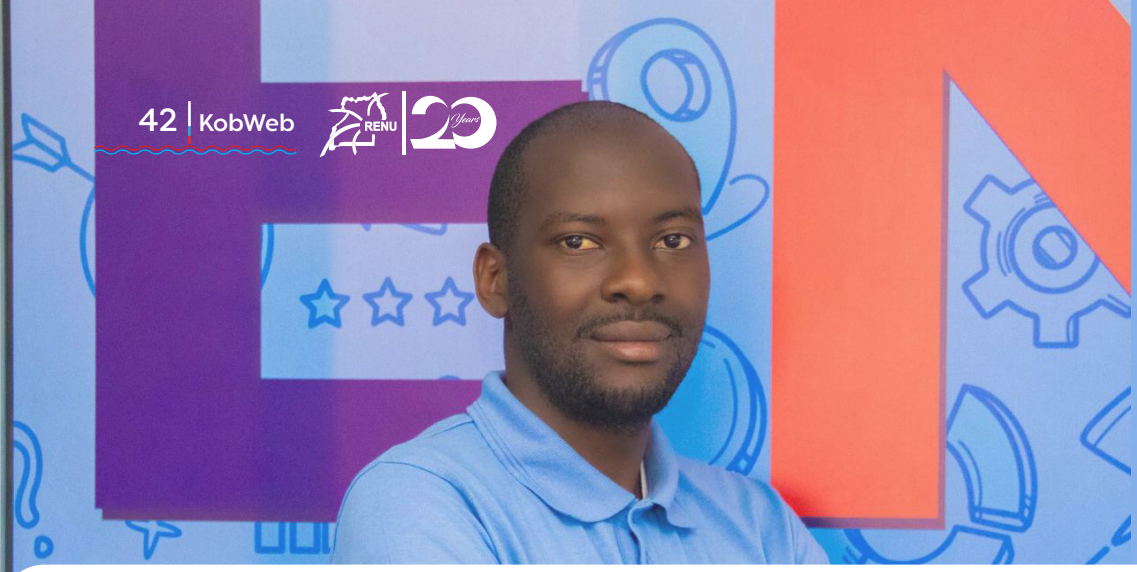
2. The benchmarked standards such as ICNIRP, Serbia and Poland are based on current standards which are subject to modifications. Any future revisions to these guidelines could alter the interpretation of the study's results. For example, the Polish guidelines have since been changed to match those of the ICNIRP 2020 guidelines.

Appendix: Sample of Considered POIs

Conclusion and Recommendations

Across 46 deployment sites, a total of 639 measurements were taken from 8 different frequency bands at 127 POIs. The results indicated an average overall exposure level of only 0.19% of the ICNIRP threshold, demonstrating minimal exposure. Notably, 5G technology contributed 37.56% to the total RF-EMF, measured in Kampala District. This translates to an overall average exposure of just 0.244% of the ICNIRP threshold from 5G deployments, further emphasizing its low impact on overall exposure levels. However, a few isolated sites were also identified with slightly elevated exposure levels, highlighting the need for ongoing monitoring to ensure they remain within safe limits.

On average, the RF-EMF exposure level from 5G deployments was measured at 0.244% of the ICNIRP safety threshold, indicating that while 5G technology contributes a substantial portion of the recorded RF-EMF, the exposure remains well within the established safety limits. This result underscores the significant contribution of 5G technology to the overall RF-EMF exposure in close proximity scenarios.



A Machine Learning-Based Optimal Deployment Approach for UAV-Assisted Heterogeneous Networks

By Arthur Tumwesigye, Senior Network Engineer, RENU

Abstract

The integration of Unmanned Aerial Vehicles (UAVs) into terrestrial Heterogeneous Networks (HetNets) offers a promising solution for enhancing mobile network connectivity and coverage. This article focuses on a dynamic UAV deployment strategy that adapts to network traffic conditions using machine learning (ML) for traffic forecasting. By considering both traffic demand and network topology, UAV Base Stations (UAV-BSs) are strategically positioned to enhance network capacity, reduce interference, and improve network energy efficiency. The goal is to obtain simulation results that demonstrate a significant improvement in network capacity and energy efficiency while reducing interference between the UAV-BSs and terrestrial Macro Base Stations (MBSs) and Pico Base Stations (PBSs). The ML approach employed a comparison of three forecasting models: Long Short-Term Memory (LSTM), Seasonal Autoregressive Integrated Moving Average (SARIMA), and Exponential Smoothing. Among these, LSTM demonstrated superior performance. Forecasted traffic data is then linked to sum rate metrics obtained from system-level simulations. To optimise UAV-BS locations, Particle Swarm Optimisation (PSO) was selected, and it was chosen for its simplicity and population-based design. Simulation results show PSO significantly outperforms random deployment. This approach demonstrates substantial improvements in throughput, latency, and energy efficiency, providing a robust framework for future UAV-assisted HetNet deployments.

Introduction

Over time, cellular networks have undergone a significant evolution and development history. The substantial rise in mobile users has led to a notable increase in data traffic and improved coverage. By the climax of 2022, the total global mobile data traffic reached 118 monthly exabytes (EB). Projections indicate substantial growth, with an anticipated increase by a factor of 3.5, reaching 472 EB per month by the conclusion of 2028.

The implementation of small cells, including micro, pico, and femtocells, has been a strategy utilised to augment capacity and enhance the coverage of macro cell infrastructure, forming heterogeneous networks (HetNets). These networks are typically designed according to long-term traffic patterns, despite the dynamic nature of traffic. The need for additional BSs is more pronounced in cellular hotspot areas that exhibit a steep surge in traffic demand during events, such as sports games and concerts, or when existing terrestrial BSs are temporarily unavailable. This mismatch results in cost inefficiency and reliability issues over time. Consequently, there is an opening for Unmanned Aerial Vehicle (UAV)-assisted HetNets to address such challenges. Through the use of Machine Learning (ML) techniques, it is possible to learn from spatiotemporal traffic patterns and predict future traffic demand at different times and locations for better network planning and appropriate distribution of base stations.

Over time, cellular networks have undergone a significant evolution and development history. The substantial rise in mobile users has led to a notable increase in data traffic and improved coverage.

The Particle Swarm Optimisation (PSO) algorithm effectively addresses complex global optimisation challenges, drawing inspiration from the social behaviours of birds and fish. It was originally conceived by observing how social animals enhance food access through collective information sharing. PSO simulates this by having random particles work together to find optimal solutions. It is on this basis that PSO was chosen for this research before other optimisation algorithms. PSO variables represent possible locations for UAVs in applications involving the optimisation of UAV-assisted HetNets deployment. These locations are optimised to achieve the best signal-to-interference-plus-noise ratio (SINR) and the highest sum rate for each user and the entire network.

Network Layout

The article explores a three-tier Heterogeneous Network (HetNet) configuration comprising Macro Base Stations (MBSs), Pico Base Stations (PBSs), and UAV-BSs, each with distinct transmit power: $P_{t,m}$, $P_{t,p}$ and $P_{t,v}$, respectively. UAV-BSs are modelled as low-altitude fixed-wing drones for simplified analysis and are quasi-stationary, deployed using either a PSO algorithm or random positioning. MBSs and PBSs are statically placed using coordinates from the selected mobile network operator (MNO) in Uganda. Each User Equipment (UE) connects to the base station tier with the strongest received signal, optimising connectivity. The conceptual network layout is shown in Figure 1.

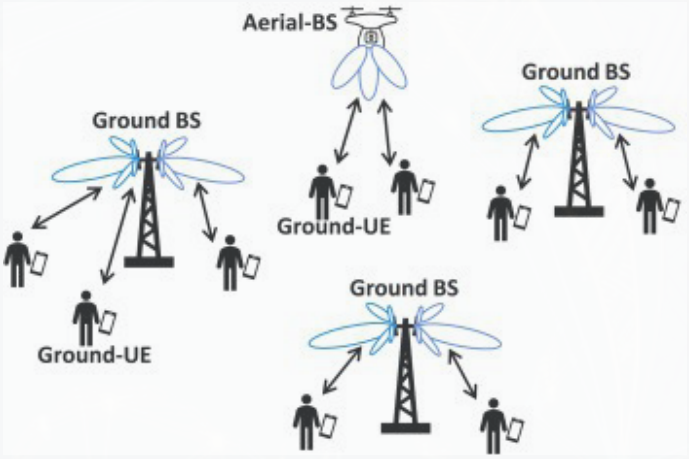


Figure 1: Conceptual overview of UAV-assisted HetNet.

Signal to Interference and Noise Ratio (SINR) Analysis

The SIR for a user is calculated by;

$$SIR_{u,i} = \frac{Pr_{u,i}}{\sum_{j\epsilon\mathcal{M}, j\neq i} Pr_{u,j}},$$

where $Pr_{u\,i}$ is the best power received, and $\sum_{j\epsilon\mathcal{M}, j\neq i} Pr_{u,j}$ is the sum of interferences from other BSs operating on the same channel.

Network Capacity and Spectral Efficiency

$$EE = \frac{SE}{\sum P_c},$$

Where SE is the network spectral efficiency, and $\sum P_c$ is the total power consumed by the network.

PSO Optimisation Framework

The objective function of the optimisation problem shown in Algorithm 1 below is to maximise the network sum rate while deploying the UAV-BSs, denoted R. This is done by varying the density and locations of UAVs being deployed while trying to achieve a target network sum rate.

Algorithm 1 PSO to Maximize Network Sum Rate

Require: Number of particles N_p, number of iterations N_{iter}, cognitive and social coefficients c_1, c_2, inertia weight ω

Initialization

(a) Initialize the position $x_i(0)$ in 3D and velocity $v_i(0)$ of each particle $i \in \{1, 2, \ldots, N_p\}$ randomly within the feasible solution space.

(b) Evaluate the fitness $R(x_i(0))$ of each particle based on the sur rate of the network using the equation (3.6).

(c) Set the personal best position $p_i(0) = x_i(0)$ and the global bes position $g(0)$ as the position of the particle with the highest fitness.

Main Loop

for each iteration $t = 1$ to N_{iter} **do**

for each particle $i = 1$ to N_p **do**

(a) Update the velocity $v_i(t)$ using equation

(b) Update the position $x_i(t)$ using equation

(c) Evaluate the fitness $R(x_i(t))$ of the updated position using equation

(d) Update the personal best position:

if $R(x_i(t)) > R(p_i(t-1))$ **then**

$p_i(t) = x_i(t)$

end if

(e) Update the global best position:

if $R(x_i(t)) > R(g(t-1))$ **then**

$g(t) = x_i(t)$

end if

end for

end for

Output

(a) Return the global best position $g(N_{iter})$ corresponding to the maximum sum rate.

(b) Return the maximum sum rate $R(g(N_{iter}))$.

3.3 Spatiotemporal Data Analysis

Data traffic from a mobile network operator's 4G network was gathered from 26 base stations, including 5 MBSs and 21 PBSs, distributed across Kampala, Uganda. To achieve a comprehensive overview of the network's capacity, data from each of the 26 sites was aggregated. The global performance of the trained forecasting model was evaluated by accuracy measures of Root Mean Squared Error (RMSE) and the Mean Absolute Error (MAE) using:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_{true} - y_{pred})^2},$$

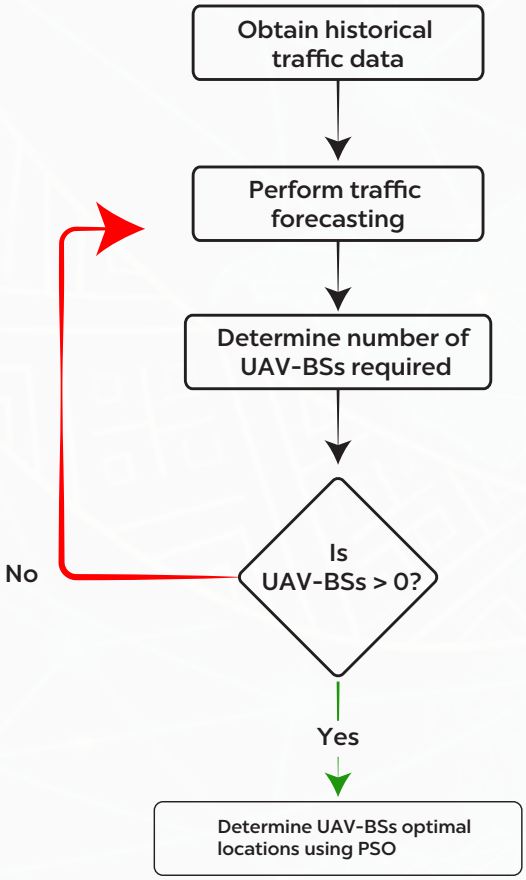
$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|y_{true} - y_{pred}\right|,$$

where y_{true} and y_{pred} refer to actual and predicted traffic values, respectively.

3.4 Traffic-Aware UAV Deployment Model

Figure 2 was designed to facilitate the deployment of UAV-BSs for each traffic level or traffic demand.

Figure 2: Network sum rate for PSO UAV-BS deployment flowchart.

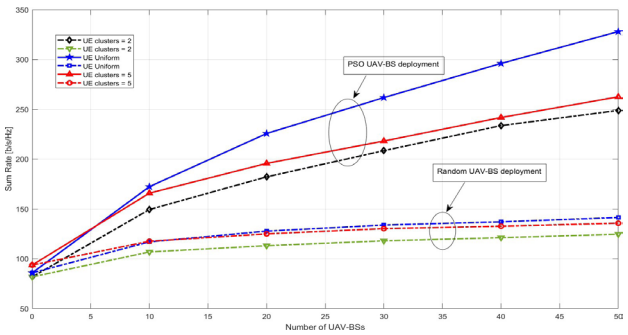


Results

Network Sum Rate

As shown in Figure 3, the analysis shows that adding more UAV-BSs increases the network sum rate, which measures total network capacity. PSO for UAV-BS placement significantly enhances performance compared to random deployment. For example, with 10 UAV-BSs, PSO raises the sum rate from 116.954 to 172.33 bits/s/Hz, a 55.376 bits/s/Hz gain, equivalent to 553 Mbps on a 10 MHz LTE channel. PSO achieves better performance by minimizing interference through the strategic placement of UAV-BSs. Also, uniform distribution leads to better performance than clustered distributions, due to reduced interference. Within clustered cases, 5-cluster configurations outperform 2-cluster ones, as they are less compact and thus reduce interference.

Figure 3: Network sum rate for uniform and cluster-based UE distributions



4.1 Network Efficiency

Figure 4: EE for uniform and cluster-based UE distributions.

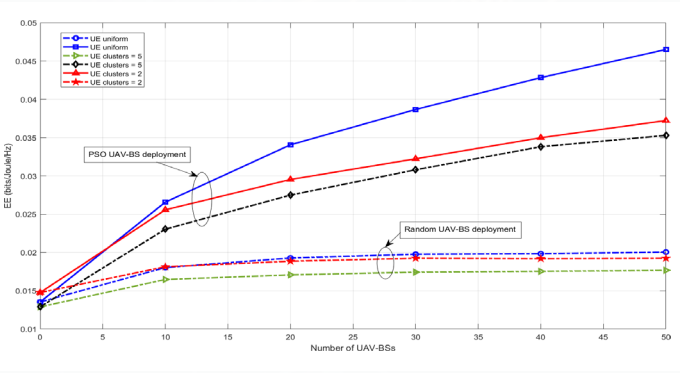


Figure 4 illustrates that the network EE increases with the deployment of the PSO algorithm than the random deployment of UAV-BSs. This means that fewer UAV-BSs are required to be deployed in the network to provide the same sum rate, resulting in reduced power consumption. Furthermore, the 5-cluster distribution outperforms the 2-cluster UE distribution in terms of EE. This behaviour occurs because when the distribution of UEs is uniform, few UAV-BSs are required and are spread out across the network. As a result, there is less interference with PSO, leading to a higher sum rate and reduced power consumption.

4.2 Traffic Data Analysis

The collected data comprised 4G cellular data traffic from 26 sites in the same area, measured in Gigabytes (GB). The data constitutes a classical time series between 1st January 2023 and 1st March 2023, with a granularity of 1 hour, resulting in 1,427 time segments across the 2 months. Figure 5 shows the average daily traffic from the 26 BSs across the 2 months. Generally, it shows that traffic varies spatiotemporally in all the cells: (a) in the time domain, minimum traffic was recorded between 2 am and 6 am, and it peaked at some period during the day; (b) in the space domain, some cells have more traffic than others, usually due to the prevailing spatial distribution of cellular users.

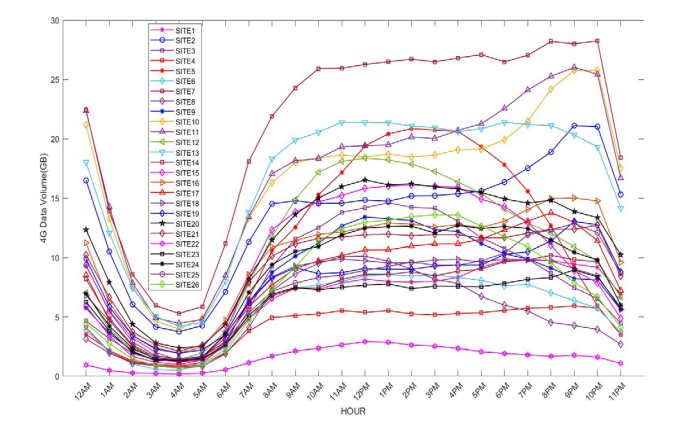


Figure 5: Average daily traffic for 26 BSs.

This variation can be an opportunity to deploy UAV-BSs at peak hours. As shown in Figure 6, the average daily data was aggregated to create an estimated traffic profile, which represents the network's capacity in that area. While the daily traffic pattern is typically consistent, it varies from day to day due to temporal fluctuations in traffic.

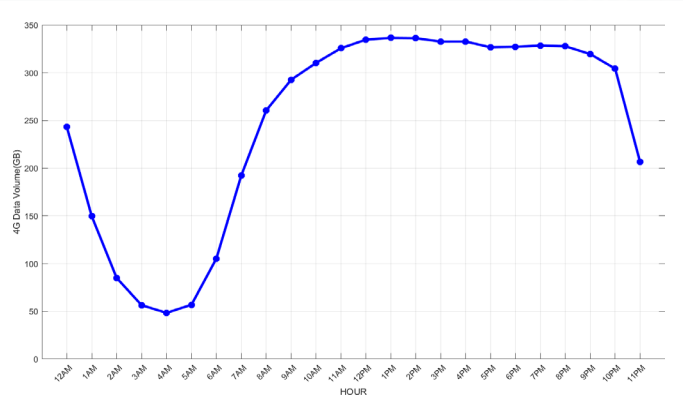


Figure 6: Total sum of average daily traffic.

The LSTM model was selected as the preferred model for cellular traffic forecasting in this research due to its lowest values of RMSE and MAE. LSTM's MAE value of 0.1669 represents an error of 166.9 GB across the network of 26 sites, which is an average of 6.42 GB per site over 1 day.

4.3 Determining an Optimal Number of UAV-BSs

A comparison between PSO and random deployment of UAV-BSs reveals that during peak traffic at 3.00 PM, PSO requires fewer UAV-BSs compared to random. Neither approach deploys UAV-BSs during low-traffic hours (12:00AM–10:00 AM). Figure 7 illustrates how UAV-BS requirements vary over 24 hours based on UE distribution. A uniform distribution demands fewer UAV-BSs than cluster-based distributions, with the 5-cluster setup needing fewer UAVs than the 2-cluster setup. Figures 8-9 depict the integration of optimally placed UAV-BSs locations into the terrestrial HetNet, visualized using MATLAB and Google Earth. The displayed coordinates are converted from degrees to kilometres for clearer representation.

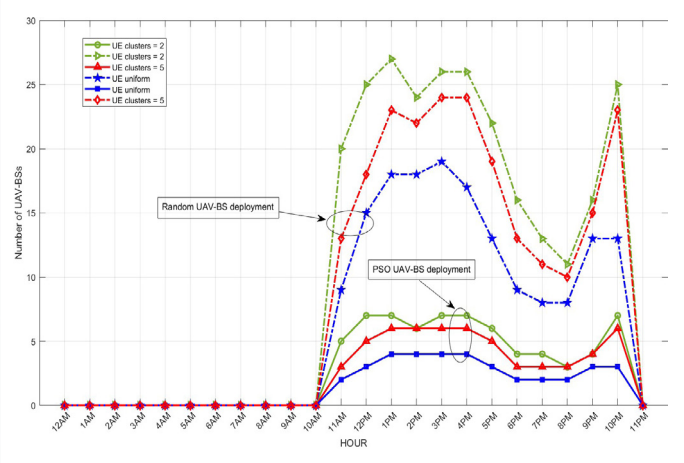


Figure 7: Number of UAV-BSs for uniform and cluster-based UE distributions.

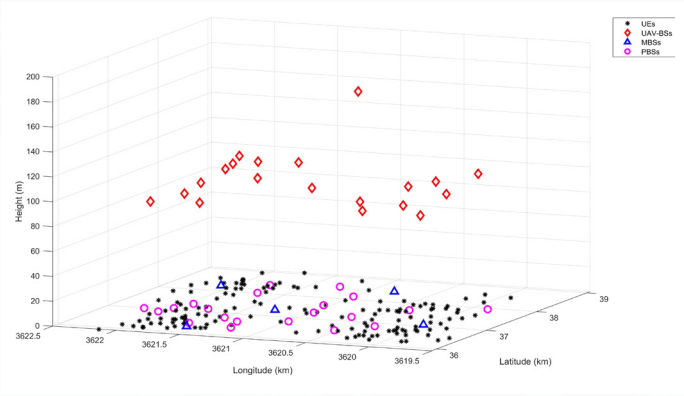


Figure 8: 3D network layout.

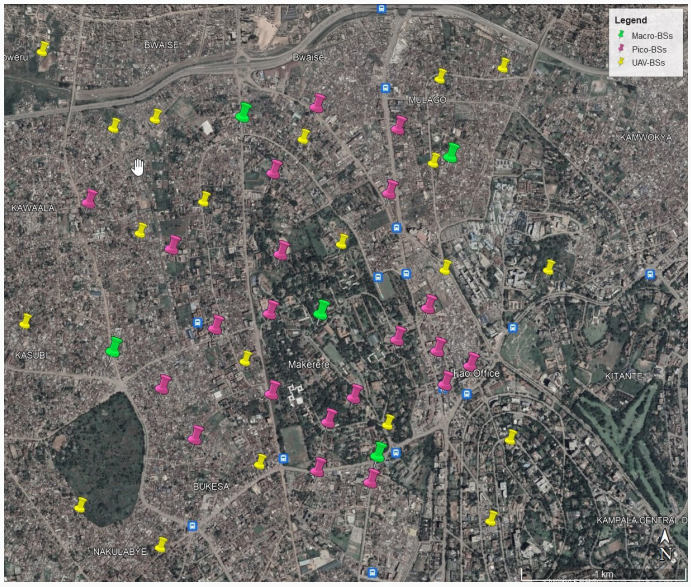


Figure 9: Network layout portrayed using Google Earth after optimisation.

Conclusion

The surge in mobile data usage has compelled telecom operators to expand their networks by deploying more base stations (BSs). Leveraging recent advances in UAV technology, this article aimed to optimise the placement of UAV-based BSs to boost network capacity and coverage cost-effectively. An ML approach, specifically using LSTM networks, was developed to predict traffic patterns from 26 sites in Kampala. LSTM outperformed SARIMA and exponential smoothing models, achieving the lowest MAE of 0.1669, indicating high prediction accuracy. The traffic forecasts were used to simulate a HetNet, and PSO was applied to determine optimal UAV-BS deployment. Evaluation metrics showed that PSO-based deployment significantly enhanced sum rate and energy efficiency compared to non-optimised and random deployments. Specifically, PSO yielded a sum rate improvement of 55.376 bits/s/Hz, equivalent to 553 Mbps in a 10 MHz LTE system, and enabled transmission of 86 Kbits more data per joule than random methods. This ML-PSO approach effectively reduces operational costs while improving performance.

Community

Kyabirwa Simulation Centre: A Scalable Model for World-Class Surgical Training in Africa

By Aldo Esilu, Strategic Communications Officer, Kyabirwa Surgical Centre

For doctors, hospital owners, and health leaders looking to build competence and confidence among their teams, the KSC Simulation Centre is more than a facility; it is an opportunity to elevate Uganda's surgical and clinical care to world-class levels.

Kyabirwa Surgical Centre (KSC) has built a state-of-the-art simulation centre that is transforming how doctors, nurses, and other healthcare professionals learn and practice. Established in early 2024 under the leadership of GSI-KSC Management, with support from Mount Sinai, Surgical Science, SAGES and Olympus, this facility offers high-fidelity, hands-on simulation training that meets international standards.

For doctors, hospital owners, and health leaders looking to build competence and confidence among their teams, the KSC Simulation Centre is more than a facility; it is an opportunity to elevate Uganda's surgical and clinical care to world-class levels.

Raising the Bar for Medical Training in Uganda

The simulation centre gives healthcare professionals a safe and controlled environment to refine technical skills before stepping into the operating theatre. Here, trainees perform realistic procedures using advanced equipment that mimics the complexity of real-life surgeries.

In a country where access to specialised surgical training is limited, the centre bridges the gap between theory and practice, offering structured programs that reduce error rates, strengthen teamwork, and improve patient safety.

In a country where access to specialised surgical training is limited, the centre bridges the gap between theory and practice, offering structured programs that reduce error rates, strengthen teamwork, and improve patient safety. It is a model of how innovation and collaboration can change the story of healthcare in rural Africa, not through guesswork, but through precision, repetition and mastery.

Globally Accredited, Locally Impactful

KSC's Simulation Centre is officially accredited by SAGES as a Fundamentals of Laparoscopic Surgery (FLS) Training and Testing Centre, the first in Uganda and across Africa. This means doctors can now complete internationally recognised laparoscopic training and certification without leaving the country.

The team behind the centre includes certified FLS GSI-KSC and Global Laparoscopic Advanced Program (GLAP) Faculty, an FLS Champion, and a Certified FLS Proctor, ensuring trainees are guided by top-tier expertise. Additionally, the American Heart Association has accredited three Advanced Cardiovascular Life Support (ACLS) and four Basic Life Support (BLS) instructors, making KSC a recognised training site under Mount Sinai Training Centre. Hospitals and clinics can now send their staff for lifesaving ACLS/BLS certification right here in Uganda.

What you can Learn

The KSC Simulation Centre offers a diverse set of programs designed to strengthen both surgical and emergency care capacities. Courses include:

- Fundamentals of Laparoscopic Surgery (FLS)
- Fundamentals of Endoscopic Surgery (FES)
- Advanced Cardiovascular Life Support (ACLS)
- Basic Life Support (BLS)
- Practice of Surgical and Nursing Skills
- Gynaecology Simulation
- Anaesthesia Skills Practice for Enhancement

For hospital owners and administrators, these programs represent a practical solution for staff capacity building, enabling in-service training that directly improves the quality of care delivered in health facilities.

Powered by Advanced Simulation Technology

KSC's Lap Mentor and Endo Mentor simulators replicate real surgical and endoscopic procedures, allowing trainees to practice with realistic instruments and feedback systems. These high-fidelity simulators are used globally to build skill, confidence, and accuracy before operating on real patients. For doctors seeking to master minimally invasive techniques or hospitals aiming to standardise surgical performance, these tools offer a measurable, safe, and cost-effective training method.

KSC's Lap Mentor and Endo Mentor simulators replicate real surgical and endoscopic procedures, allowing trainees to practice with realistic instruments and feedback systems. These high-fidelity simulators are used globally to build skill, confidence, and accuracy before operating on real patients.

Measurable Impact

Since its establishment, the centre has conducted multiple simulation sessions and trained professionals from Uganda and beyond. In 2024, it hosted Uganda's first Global Laparoscopy Advanced Program (GLAP), followed by a second cohort in 2025, both milestones that placed the Centre firmly on the global map of surgical education.

Through the GLAP and Self-Paced FLS programs, 39 tutors have been trained and tested, while 10 others have completed ACLS/BLS provider training. Another 16 doctors have trained on the Endo Mentor to master the Fundamentals of Endoscopic Surgery.

Beyond doctors, the facility continues to train nurses, anaesthesia providers, and gynaecology teams, ensuring that knowledge gained in Kyabirwa flows back into hospitals and communities across Uganda.

Why it Matters

Simulation training is not about technology for its own sake. It is about patient safety. Every skill honed at KSC reduces the risk of error in real operating rooms. Every simulated procedure builds the teamwork, communication, and confidence that save lives.

Hospitals that invest in simulation-based training benefit from more skilled teams, fewer complications, and better patient outcomes. For the Ministry of Health, this is a scalable model for strengthening the national surgical ecosystem, training more people faster, and at a higher standard.

Current Challenges and Future Goals

The centre continues to grow. Unlocking all simulator modules, including gynaecology (GYN), ERCP, urology (URO), and bronchoscopy remains a key focus. Expanding partnerships with local universities, referral hospitals, and international training programs will further enhance the facility's reach and impact.

With the right collaboration and investment, the KSC Simulation Centre can become a regional training hub for East and Central Africa, attracting both learners and trainers from across the continent.

A Call to Action

For doctors, this is where your next level of surgical skill begins. For hospital administrators, this is where your staff can safely sharpen their expertise and improve care outcomes. For the Ministry of Health, this is a proven model worth supporting and scaling. The KSC Simulation Centre is open for training, collaboration, and institutional partnerships. Health professionals and institutions are encouraged to reach out, visit, and experience first-hand how simulation-based training is changing the landscape of healthcare education in Uganda.

Transforming Healthcare, One Simulation at a Time

The Kyabirwa Simulation Centre proves that world-class medical training does not have to be confined to big cities or foreign institutions. With the right vision and partnerships, rural Uganda is leading the way.

Every session conducted here shapes a better trained doctor, a safer hospital, and a stronger healthcare system. In doing so, Kyabirwa is not just transforming medical and surgical practice; it is building the future of healthcare in Uganda and beyond.

The Foundational Role of Culture in Organisational Success

By Sanyu Irene Namutebi, Manager, People and Culture, RENU

Culture isn't what's painted on the walls; it's what happens in the corridors. It shapes decisions, drives behaviours, and ultimately determines whether a company thrives or unravels. While organisations often focus on strategy, processes, and technology, culture is the underlying force that powers or paralyses these initiatives. Neglect it, and even the best strategy will stall. Nurture it, and your results can surpass expectations.

Organisational culture, often described as the "brand personality" of an organisation, includes the shared values, beliefs, and practices that shape employee behaviour and attitudes. It influences not only how employees interact internally, but also how they engage with customers and other stakeholders, approach problems, and deliver value. In today's hyper-competitive landscape, building and sustaining a healthy culture is not optional; it's essential.

Culture is the operating system: Think of organisational culture as the invisible operating system that governs everything else. It determines how people interact, solve problems, navigate change, and make decisions under pressure. Two companies can have the same strategy on paper but deliver vastly different outcomes. Why? One has a culture rooted in clarity, accountability, and collaboration. The other operates in silos, with politics and blame, undermining progress.

The four types of organisational culture

There are four types of organisational culture, and each type has different characteristics and consequences for organisational performance and employee satisfaction:

- Clan Culture emphasizes a family-like environment focused on mentoring, nurturing, and involvement.
- Adhocracy Culture encourages innovation and creativity by focusing on being dynamic and entrepreneurial.
- Market Culture is results-oriented; it emphasizes competness, achievement, and "getting the job done."
- Hierarchy Culture emphasises values structure, stability, and control with clear lines of authority and standardised procedures.

Key Drivers of a Successful Organisational Culture

1. Alignment with Strategic Goals: Culture must align with an organisation's strategic objectives. When employees understand and believe in the mission, their actions naturally support its success. For example, Toyota's "Kaizen" culture of continuous improvement supports its commitment to quality and operational efficiency. This alignment ensures that behaviours and decisions across the company reinforce its strategic direction.

2. Effective Leadership: Leaders are the architects of culture. Their actions, not just their words, shape the environment. Transformational leaders inspire employees through a clear vision and consistent values. Steve Jobs, for instance, embedded a culture of innovation and excellence at Apple, which continues to define the company today. Leadership must model desired behaviours, reward alignment with cultural values, and challenge actions that undermine them.

3. Communication and Transparency: Open communication fosters trust, engagement,

and alignment. When employees feel informed and heard, they are more likely to take ownership and contribute meaningfully. Transparent organisations build resilience, especially during change. Google's open-door policy, for example, allows employees to share ideas and concerns freely, supporting a culture of innovation and inclusion.

4. Continuous Development: Culture must evolve with the organisation. Regularly assessing and updating cultural practices ensures relevance and alignment with changing goals, market conditions, and employee expectations. International Business Machines (IBM)'s transformation from a hardware-focused company to a services and solutions provider involved a significant cultural shift. By prioritising learning and adaptation, IBM remained competitive in a rapidly changing industry.

5. Employee Empowerment and Autonomy: A culture that encourages autonomy and initiative enhances job satisfaction, innovation, and performance. Empowered employees feel a sense of ownership that fuels creativity and accountability.

6. Diversity and Inclusion: Diverse teams bring broader perspectives, better decision-making, and more innovative solutions. Inclusive cultures improve morale and reduce turnover, as employees feel respected and valued. Microsoft's strong focus on diversity and inclusion has helped it attract top talent and foster a dynamic, collaborative environment.

7. Adaptability and Resilience: Organisations with adaptive cultures can respond swiftly to challenges and change. Flexibility, learning agility, and a solutions-oriented mindset are cultural assets. During the COVID-19 pandemic, Zoom rapidly scaled its operations to meet soaring demand. This agility was possible because of a culture that values responsiveness and innovation.

8. Psychological Safety: In high-performing cultures, employees feel safe to speak up, take risks, and make mistakes without fear of retribution. This psychological safety fosters innovation, trust, and continuous learning. Google's Project Aristotle identified psychological safety as the most critical factor in team success, underscoring its foundational role in culture.

Organisational culture, often described as the "brand personality" of an organisation, includes the shared values, beliefs, and practices that shape employee behaviour and attitudes.

The Consequences of a Weak Organisational Culture

A toxic or misaligned culture can derail even the most promising strategies. Common symptoms include:

- Lack of strategic alignment, leading to confusion and inconsistent execution.
- Poor communication, which erodes trust and disengages employees.
- Resistance to change, which makes adaptation and innovation difficult.
- Lack of diversity, resulting in limited perspectives and missed opportunities.

The Role of Culture on Organisational Success

1. Culture can be a strategic imperative. Culture is not a buzzword; it is a strategic asset. It directly impacts employee engagement, customer experience, and financial performance. Leaders must take ownership of culture, ensuring that it aligns with business goals and promotes innovation, resilience, and inclusion. This means investing in leadership development, fostering open communication, empowering employees, and embracing change.

2. Culture drives performance, or undermines it. A strong culture creates alignment and purpose. Employees act with ownership and intent, leading to improved talent retention, productivity, and innovation. Conversely, a weak culture breeds disengagement, confusion and inefficiency. It can erode momentum, drive away talent, and undermine execution. Research confirms that companies with strong, adaptive cultures outperform their peers in revenue growth, customer satisfaction, and employee retention.

3. Leaders set the tone. Culture is shaped moment by moment. What leaders reward, ignore, or tolerate signals the real values of the organisation. If a company claims to value innovation but punishes failure, employees quickly learn that risk-taking isn't safe. Culture is built through consistent behaviours, not slogans.

4. Culture is built by design, not default. You can't plaster culture onto an organisation. Real culture change requires:

- **Clarity** about authentic values and purpose.
- **Consistency** in applying those values across policies, decisions, and leadership actions.
- **Courage** to challenge misalignments and make hard choices that protect the culture.

Culture is everyone's responsibility, but it must be led from the top. Without intentional effort, culture drifts, and the drift is dangerous.

Culture is the Foundation

Success isn't just about what an organisation does, but how and why it does it. That "how and why" is culture. It's not an add-on or Human Resources initiative. It is the foundation upon which strategy, performance, and sustainability are built. Get culture right, and everything else becomes easier. Get it wrong, and no strategy will be enough.
"Start with culture. It's where lasting success begins."

Empowering the NREN Community: The Strategic Imperative of RENU's End User and Capacity Building Unit

By Rajjab Kaboggoza, Customer Experience Specialist, RENU

RENU's End User and Capacity Building Unit is indispensable because it elevates the NREN from a mere connectivity provider to an enabler of profound transformation. By addressing capacity gaps, it ensures equitable access to digital tools, boosts institutional performance, and strengthens community bonds.

In an era where digital connectivity is the backbone of knowledge creation and dissemination, National Research and Education Networks (NRENs), such as Uganda's Research and Education Network (RENU), play a pivotal role in bridging the digital divide. However, true transformation extends far beyond the deployment of infrastructure. RENU's End User and Capacity Building Unit exemplifies this by catalysing institutional empowerment, ensuring that connectivity translates into tangible capabilities for education, research and innovation. This unit is not just a support arm; it is the heartbeat of sustainable digital adoption within the NREN community, fostering resilience, equity, and growth across diverse member institutions, including universities, hospitals, schools, research centres, and Other Tertiary Institutions (OTIs) in Uganda and beyond.

The Core Mission: Bridging Internet Connectivity to Capability

At its essence, the End User and Capacity Building Unit serves as a vital intermediary between RENU's robust service portfolio encompassing Internet connectivity, eduroam, cloud hosting, Moodle Learning Management System (LMS), cybersecurity, domain services, and more, and the real-world needs of end users. Unlike traditional Internet connectivity providers that focus solely on bandwidth, this unit prioritizes proactive engagement to build technical competence and institutional readiness.

By collaborating closely with IT teams, administrators, and academic staff from member institutions, the unit delivers tailored training, on-site assessments, and ongoing support. This hands-on approach addresses common barriers, such as limited technical skills, understaffed ICT departments, and infrastructure gaps, ensuring that no institution is side-lined in the digital race. For the broader NREN community, this model underscores the unit's relevance: it transforms passive users into active participants, amplifying the network's overall impact on national and regional development goals.

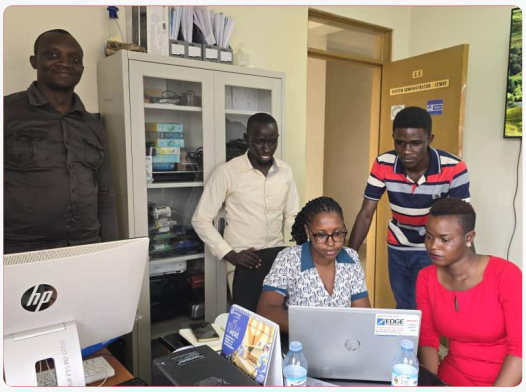
Campus Network as a Service (CNaaS) – Overcoming Bottlenecks for Optimal Performance

One of the unit's flagship initiatives, Campus Network as a Service (CNaaS), highlights its transformative power. Many RENU member institutions grapple with underperforming Local Area Networks (LANs) due to budget constraints, outdated equipment, and limited knowledge, which bottleneck high-speed Internet utilization. CNaaS alleviates this by assuming responsibility for network planning, installation, monitoring and maintenance, allowing institutional IT teams to focus on end-user support.

Through detailed assessments and enterprise-grade implementations, the unit has resolved performance issues in institutions reliant on consumer-grade routers and misconfigured devices. Results are striking: up to 90% of reported bottlenecks are eliminated, leading to enhanced work efficiency, reduced downtime, and higher user satisfaction. For instance, institutions facing business continuity challenges from staff turnover now benefit from visualised, standardised networks that ensure seamless handovers.

In the NREN context, CNaaS exemplifies why capacity building is indispensable. It not only optimises resource use but also reduces costs for member institutions, enabling smaller institutions to leverage NREN expertise without building bigger IT teams. This shared-service model promotes equity, ensuring even resource-limited entities in Uganda's education sector can compete globally.

Extending Reach: Direct Engineering Assistance and Cross-Border Impact



The unit's influence transcends borders, as seen in the Direct Engineering Assistance (DEA) program, which was executed with support from the Inter University Council for East Africa (IUCEA) and the UbuntuNet Alliance. In 2025, DEAs were conducted at three member universities in Uganda i.e., Muni University, Ndejje University (Main Campus), and Uganda Technology and Management University (UTAMU), and three institutions in South Sudan i.e., University of Juba, Catholic University of South Sudan and the Ministry of Higher Education, providing stable Internet connectivity, eduroam access, and tools for global collaboration. Catholic University of Sudan, previously hampered by unreliable mobile broadband, now seamlessly accesses research databases and webinars, opening "a real window into the world," as noted by its IT Director. Such initiatives demonstrate the unit's role in promoting digital equity within the NREN ecosystem. By narrowing the digital divide in underserved regions, it fosters international partnerships, enhances research output, and builds a resilient network of institutions capable of collaborative innovation. For NRENs worldwide, RENU's approach serves as a blueprint: capacity building isn't optional, it's essential for sustaining member engagement and driving cross-border knowledge exchange.

Fostering Retention and Engagement through Proactive Strategies

Retention of member institutions is a key metric of NREN success, and the unit excels here by building trust through empathetic and responsive interactions. In 2025, five institutions contemplating disconnection reversed their decisions after targeted engagements involving WhatsApp follow-ups, onsite visits, and clear communication to resolve misunderstandings. Complementing this are regional workshops across Eastern, Northern, and Western Uganda, with support from the Uganda Communications Commission (UCC), reaching over 200 schools with interactive sessions on region-specific challenges like network topologies and staff training. Free services, such as LAN assessments and eduroam deployments, further act as gateways to deeper adoption, revealing gaps and paving the way for comprehensive solutions. These efforts highlight the unit's strategic value: by emphasising relationships over transactions, it achieves a 99% retention rate, a testament to its importance in a competitive landscape. For the NREN community, this underscores how capacity building enhances loyalty, reduces churn, and maximises the return on infrastructure investments.

Collaborative Ecosystem and Data-Driven Outcomes

The unit's effectiveness stems from seamless cross-departmental collaboration, integrating with RENU's Network Operations Centre (NOC), Engagement, and Communications teams for unified support. This holistic approach ensures consistent, high-quality service delivery. Data reinforces its impact. By July 2025, the unit engaged 700 of 1,000 connected sites through trainings, phone calls, and webinars, with 359 member institutions adopting eduroam as of the end of November 2025, a marker of digital maturity. These metrics narrate a story of nationwide progress, where capacity building drives measurable growth in education and research.

Looking Ahead: Scaling for the Future

Plans include a self-service portal with AI-driven support, expanded DEA to remote institutions, and certification programs for IT teams. These innovations will amplify personalisation and scalability, solidifying the unit's role in evolving NREN capacity building and engagement strategies.

Conclusion

RENU's End User and Capacity Building Unit is indispensable because it elevates the NREN from a mere connectivity provider to an enabler of profound transformation. By addressing capacity gaps, it ensures equitable access to digital tools, boosts institutional performance, and strengthens community bonds. For RENU, this unit has driven member retention, cross-border equity, and innovation, proving that empowered users are the foundation of a thriving NREN. As digital demands intensify, investing in such units isn't just strategic, it's essential for building a resilient, inclusive future in research and education.

The End User and Capacity Building Unit serves as a vital intermediary between RENU's robust service portfolio encompassing Internet connectivity, eduroam, cloud hosting, Moodle Learning Management System (LMS), cybersecurity, domain services, and more, and the real-world needs of end users.

African Rural University: Delivering Sustainable Rural Development

By Joseph Odoi, Planning, Marketing, Communication, and Knowledge Management Officer, African Rural University

All around the world, university graduates typically move to crowded, congested urban centres chasing better jobs and higher salaries. For decades, this model of university education and career development has been the dominant path to success. But what if education didn't mean abandoning the rural countryside? What if universities could produce graduates who return to rural communities not out of necessity, but by choice, to catalyse environmentally sustainable economic development in rural areas?

The Two-Generation Approach involves a parent and child learning together, jointly working towards a shared family vision.

That's exactly what's happening at African Rural University (ARU) in Western Uganda. Located in the greater Kibaale region of Uganda, ARU is an all-women, values-based university that is quietly flipping the script on higher education. Here, success means turning rural areas into hubs of innovation and growth. Students are not trained for jobs; they are trained to promote innovative, prosperous, and sustainable rural transformation.

A University Unlike any Other

While most universities prepare students to compete for urban employment, ARU equips women to become transformative change agents within the African context. ARU's education model is bold and unique, blending 60% theoretical learning with 40% field-based practice through two flagship programs: the Bachelor of Rural Development and the Bachelor of Science in Sustainable Agriculture (BSSA).

These programs span three years of academic and field study, followed by a crucial fourth year of practical application. During this final year, students live and work within rural communities. They not only apply and transfer their academic knowledge but also engage deeply with local community members to identify and carry out substantial community improvement projects. These may take the form of building new roads, schools, or marketplaces; setting up savings societies and farmers' cooperatives; revitalising sustainable agriculture and creating value-added agricultural products. Rather than traditional internships, these students serve as catalysts for positive change, innovation and community growth.

As part of the field experience, ARU students work closely with local parish and subcounty governments. ARU students also work closely with mentors, the Epicentre Managers, who are also graduates from ARU, now employed by its founding organisation, the Uganda Rural Development and Training Programme (URDT). Together, the Epicentre Managers and the students train community members in life-changing skills, sustainable farming, health, sanitation, leadership, visioning, and appropriate technologies.

African Rural University (ARU) is part of a unique education continuum that begins from primary school and extends all the way to university. Under this continuum, during their internship and practicum, ARU students work using the Two-Generation Approach.

The Two-Generation Approach involves a parent and child learning together, jointly working towards a shared family vision. This vision is set up when the child joins URDT Girls' School in Primary 5. The approach is holistic, involving the entire family, including the child, to collaboratively develop and realise their vision. For example, if a family's vision is to become an educated and empowered home by 2030, they set specific action steps and hold each other accountable to achieve it. Even after meeting their goals, the family asks, "What next?" to continue sustaining their progress and embracing ongoing creation and growth.

Additionally, ARU students actively support back-home projects initiated by girls from URDT Girls School, reinforcing this strong education continuum and community impact.

The Visionary Approach: A Shift from Problem-solving to Creative Orientation

A group photo of a family under the Two-Generation Approach with their child Margaret, showcasing their family vision and Structural Tension Chart (STC), alongside ARU student, Immaculate Nyangoma (left).

At the core of ARU's model is the Visionary Approach. Unlike conventional problem-solving models, this creative approach emphasizes enabling community members to create the lives and the environment they truly want.

With this approach, people learn that they are key to their own development. Therefore, they formulate visions of what they want to create in relation to their current reality and work towards achieving them, using the Principles of the Creative Process, as described by Robert Fritz, the creator of the Visionary Approach, in his book of "Your Life as Art" (Fritz, 2022), as well as in his many other published works and workshops.

Education that Touches Lives

A team from ARU engaging communities during practicum on what they want to create for their community.

ARU doesn't teach in isolation. During their internships, ARU students produce results aligned with the university's Community Engagement Strategy, achieving impactful outcomes at four crucial levels;

- **Individual:** Recognising the individual as the highest leverage point in social transformation.
- **Family:** Acknowledging the family as a fundamental unit for transformation.
- **Community:** Operating at the group, village, parish, and sub-county levels.
- **Institution:** Collaborating with institutions such as schools and sub-county councils for comprehensive impact.

ARU Council members, students and alumnae after a community action planning session with community members in Kabasenkende Subcounty in Kagadi District.

Professors Without Papers: How ARU Leverages Indigenous Knowledge/Traditional Wisdom for Rural Transformation

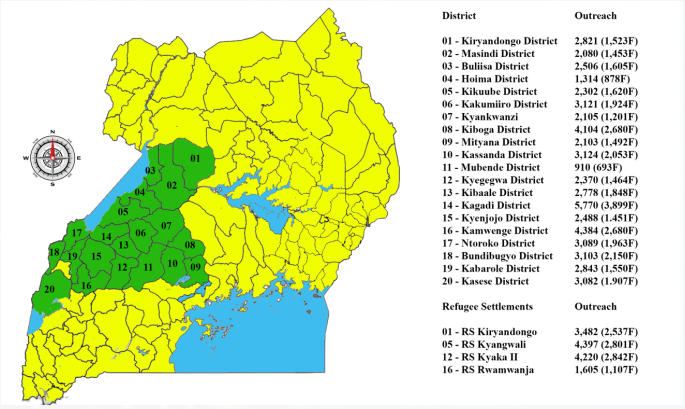
Twesiime Paulino engaging a community member on ethnomedicine.

In all its work, ARU recognises the power of indigenous knowledge and local knowledge preservation for sustainable development. From the very beginning, the university embedded Traditional Wisdom Specialists into its curriculum. These are professors without papers. They are not formally trained in universities, but have acquired expertise through years of hands-on experience and cultural transmission. At ARU, the professors without papers, currently five in number, provide practical instruction in areas like ethnomedicine, natural resource conservation practices such as soil conservation and water harvesting, sustainable agriculture, and appropriate technologies that are affordable and locally available. Their lessons are grounded in what has worked for decades, thus offering students context-rich insights that modern textbooks often overlook. This ensures ARU students are not only equipped with academic theory but are also deeply rooted in the cultural, ecological, and practical realities of rural life.

The fusion of ancient wisdom and contemporary learning enables graduates to better engage with communities, enabling local people to reclaim valuable practices and take the lead in shaping their own development.

Real Impact, Real Numbers

As of 2025, ARU's ripple effect has reached over 20 districts and four refugee settlements in Uganda. Its graduates are actively working in 36 sub-counties across Kagadi, Kakumiro and Kibaale, spearheading change and facilitating community development. More than 70,000 young people have been trained in rural communities, with each one holding a vision (a "mind map") of the future they want to create.



District	Outreach
01 - Kiryandongo District	2,821 (1,523F)
02 - Masindi District	2,080 (1,453F)
03 - Buliisa District	2,506 (1,605F)
04 - Hoima District	1,314 (878F)
05 - Kikuube District	2,302 (1,620F)
06 - Kakumiiro District	3,121 (1,924F)
07 - Kyankwanzi	2,105 (1,201F)
08 - Kiboga District	4,104 (2,680F)
09 - Mityana District	2,103 (1,492F)
10 - Kassanda District	3,124 (2,053F)
11 - Mubende District	910 (693F)
12 - Kyegegwa District	2,370 (1,464F)
13 - Kibaale District	2,778 (1,848F)
14 - Kagadi District	5,770 (3,899F)
15 - Kyenjojo District	2,488 (1,451F)
16 - Kamwenge District	4,384 (2,680F)
17 - Ntoroko District	3,089 (1,963F)
18 - Bundibugyo District	3,103 (2,150F)
19 - Kabarole District	2,843 (1,550F)
20 - Kasese District	3,082 (1,907F)
Refugee Settlements	**Outreach**
01 - RS Kiryandongo	3,482 (2,537F)
05 - RS Kyangwali	4,397 (2,801F)
12 - RS Kyaka II	4,220 (2,842F)
16 - RS Rwamwanja	1,605 (1,107F)

Transformation work is already bearing fruit. Villages are turning into organised, visionary communities, and families are becoming self-reliant. Institutions are becoming centres of innovation. And this is just the beginning.

ARU's education model has already attracted global attention. The Chair of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) has recognised its work, as have many academic institutions, such as MIT, Unity College, MasterCard Foundation, but many more partnerships are needed to scale the impact and adapt the ARU model elsewhere.

ARU students and staff during an engagement with community members in Buyaga East County.

From Vision to Reality: How ARU's Community Engagement is Driving Real-time Impact in Local Communities

Water is life, yet not everyone has access to clean and safe water. In line with Sustainable Development Goal 6 (Clean Water and Sanitation), in 2024-2025, Irene Tusiime, a final-year Bachelor of Rural Development student at African Rural University (ARU), engaged the community of Kaigulumba Village, Nalweyo Subcounty in Kakumiro District through participatory action research on water accessibility, a topic identified by the community itself.

Guided by ARU's Visionary Approach and facilitated by Irene, community members came together to draw a shared vision for their village, a vision of having clean and safe water by 2026. With support from the local sub-county leadership, the community translated their aspirations into action.

Today, that vision has become a reality. Two new boreholes were constructed in Kaigulumba Village.

Community members, including school-going boys pumping water as a mother looks on, at the first-ever borehole in Kaigulumba Village.

Before, people shared water sources with animals. Now, they enjoy clean and safe borehole water.

This is one of many examples of how ARU's community engagement contributes to the national development agenda and awakens people to bring to reality what they truly care about based on the following principles.

The people of Uganda, like people world over, are key to their own development. Lasting change can come only if people shift from reacting or adapting to events and circumstances to being the creators of events and circumstances. People who share a common vision can transcend traditional barriers and prejudices caused by tribal, religious, political, and gender differences, and work together to achieve that which is truly important to them all.

People have innate power and wisdom which they can tap to transform the quality of their lives and that of their communities. Training, education, and sharing of information are key and strategic components of rural transformation programs. The goal of this work is social, economic, and human transformation in rural Africa in general, and in Uganda in particular.

If you're a philanthropist, educator, or policymaker searching for a transformative model that links education to community-based impact, we welcome you to visit ARU. See for yourself how this extraordinary university is proving that education can be the heartbeat of rural transformation on the links.

https://www.youtube.com/watch?v=zWTBMlHCB3w

https://www.youtube.com/watch?v=ZwIs0Ln9qFc&t=35s

https://aru.ac.ug/from-vision-to-reality-irene-tusiimes-research-spurs-first-safe-water-access-in-kaigulumba-village-nalweyo-subcounty/

https://www.youtube.com/watch?v=pwGU2u1D1e0&t=107s

From the very beginning, the university embedded Traditional Wisdom Specialists into its curriculum. These are professors without papers. They are not formally trained in universities, but have acquired expertise through years of hands-on experience and cultural transmission.

20 Years of Research and Education Transformation

RENU at 20: Two Decades of Connecting Uganda's Research and Education Community to the World (2006–2026)

By the RENU Communications Team

In 2026, the Research and Education Network for Uganda (RENU) marks a significant milestone, 20 years of transforming how Uganda's scholars, educators, and researchers connect with each other and with the global research community.

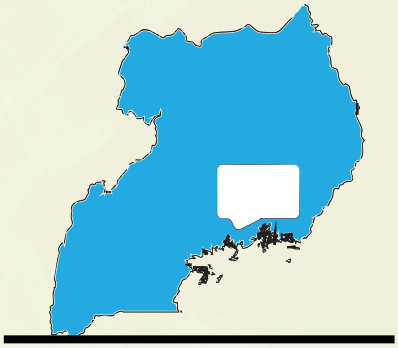
What began in 2006 as a bold response to high Internet connectivity costs and academic isolation has grown into a powerful enabler of digital scholarship, institutional development, and international collaboration. RENU's evolution mirrors the broader story of National Research and Education Networks (NRENs) worldwide: from overcoming foundational infrastructure challenges to building sophisticated digital ecosystems that empower science, innovation and learning.

2006: The Vision is Born

The story began in January 2006, when Vice Chancellors of leading Universities and Chief Executive Officers of research institutions in Uganda recognised that limited Internet access and high bandwidth costs were hindering academic progress. Their collective resolve to establish a community-owned research and education network set the foundation for RENU. Inspired by the African philosophy of Ubuntu, the idea was simple but transformative: build a shared infrastructure that could connect scholars, accelerate research, and strengthen institutional collaboration.

2008: Formal Incorporation

In January 2008, RENU was formally incorporated as a company limited by guarantee. Later that year, RENU joined the UbuntuNet Alliance, opening the door for Uganda to participate in regional and global research networks. These early steps laid the groundwork for the organisation's ambitious future.



2009: National Recognition

In November 2009, the Ministry of Education and Sports formally recognised RENU as Uganda's National Research and Education Network (NREN), a major validation of its mandate and long-term strategic purpose.

2010: Regulatory Empowerment

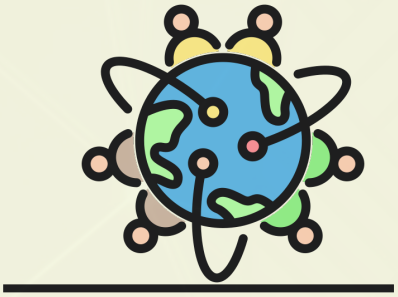
By July 2010, RENU received a licence from the Uganda Communications Commission (UCC) to operate a private network for the research and education sector. This decision permitted RENU to expand aggressively and independently, ensuring that institutions could connect through a secure, purpose-built academic network.

2014: Launch of the Network Backbone

RENU's first Points of Presence (PoPs) went live in Kampala District in 2014, marking the operational debut of its private academic network. A second PoP was established in Mulago and thereafter, more PoPs were set up in Mbarara and Kabale Districts, extending Internet connectivity to institutions beyond the capital and signalling the rise of a national digital backbone shaped specifically for research and education.

2015: A New Home and Data Centre

March 2015 saw the commissioning of RENU's first data centre, an investment that strengthened hosting capabilities and institutional resilience. Later that year, RENU moved from sharing an office with the Makerere University Directorate of ICT Support (DICTS) into House No. 31, The Edge, at Makerere University-Main Campus, anchoring the organisation at the heart of Uganda's academic environment.



2016: Uganda Joins the Global eduroam Community

In January 2016, RENU launched eduroam, the free, secure and trusted Wi-Fi in Uganda, becoming the 75th National Roaming Operator worldwide. For Uganda, this meant that students, lecturers, and researchers could move between campuses locally and internationally with seamless Wi-Fi access, an essential advancement for academic mobility. That same year, RENU joined the perfSONAR network and commissioned a redundant link to London via UbuntuNet Alliance, marking Uganda's emergence as a globally connected research hub. New services such as video conferencing, and RENU Identity Federation (RIF) were also introduced, laying the foundation for a more secure and capable digital ecosystem.

2017: Expanding Membership and Digital Infrastructure

In May 2017, Nabisunsa Girls' Secondary School became the first secondary school to join RENU, demonstrating the network's widening reach. With major upgrades such as a 10 Gbps backbone and an expanded suite of digital services, including cloud hosting and access to open-source software mirrors, RENU entered a new era of capacity and capability.

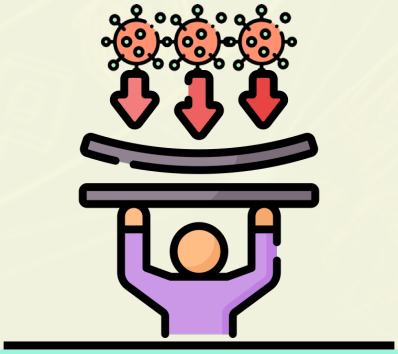
2018: Global Identity Integration and Network Growth

January 2018 marked a historic moment when RENU's Identity Federation joined eduGAIN as the 55th federation globally, and the first in Sub-Saharan Africa outside South Africa. By July, RENU had surpassed 100 connected sites, and eduVPN became a widely adopted solution for secure off-campus Internet access.

2019: Strengthening the National Research Ecosystem

In April 2019, RENU signed a Memorandum of Understanding (MoU) with the Uganda Communications Commission (UCC) to connect over 50 schools to the high-speed, reliable connectivity. Plagiarism

detection software was added as a service for member institutions, and by year's end, the network had grown to 150 connected sites, a clear indicator of national adoption and trust.



2020: Resilience in a Global Pandemic

The year 2020 was one of the most defining in RENU's history, marked not only by the global disruption of COVID-19 but also by major technological milestones that strengthened Uganda's research and education ecosystem. As institutions across the world transitioned to remote teaching and learning, RENU responded with agility and foresight. Early in the year, Metro eduroam was launched, extending secure academic Wi-Fi beyond institutional gates and into public community spaces, enabling mobility at a time when movement and access were severely limited.

By mid-2020, RENU had connected 200 institutions to its network, an achievement that reflected growing trust in the organisation's services and its expanding national footprint. Recognising the sudden shift towards online learning, RENU introduced an open-source Learning Management System (LMS) as a service, giving member institutions a ready, reliable platform for teaching continuity at an affordable cost.

To ensure that institutions could meet the surge in online activity, RENU also rolled out a Shared Bandwidth Capacity Package, allowing small member institutions to access high-capacity international bandwidth more affordably and efficiently. This initiative, combined with the temporary lifting of international bandwidth caps during the lockdown, ensured that research, teaching, and collaboration continued despite national restrictions.

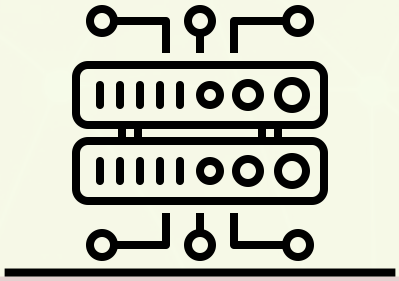
Through these efforts, 2020 became a powerful demonstration of RENU's resilience and its commitment to supporting Uganda's academic community in times of crisis, strengthening not only digital infrastructure but also institutional confidence in the face of global uncertainty.

2021: A Year of Innovation and Expansion

2021 began with a celebration as RENU marked its 15th anniversary on 13th January. In February, the organisation deployed its first Long Ranger Wide Area Network (LoRaWAN) gateway, reinforcing its commitment to emerging technologies. In March, RENU integrated a Google Global Cache (GGC) to significantly improve user experience for web-based services. Later in the year, in October, Heritage International School became the first school in Uganda to join eduroam, expanding the service to 25 institutions nationwide. It was a year that blended maturity with innovation, signalling a renewed commitment to expanding national digital inclusion.

2022: Accelerating Connectivity and National Reach

In 2022, RENU's growth gained speed. In January, the HIV/AIDS research facility at The AIDs Support Organisation (TASO), Soroti,became the 300th site to join the network. By May, Metro eduroam had expanded to 15 upcountry towns, making community connectivity a national reality. The milestones continued: the World University Service of Canada became the 400th connected site in July; in August, UCC partnered with RENU to connect 90 secondary schools; in September, eduroam on the Go was launched as a new mobility tool for researchers and academic staff; and in December, the Makerere Joint AIDS Program in Kamuli became the 450th site to join the RENU network. This was a year defined by scale and momentum.



2023: Strategic Presence and Technological Innovation

In 2023, RENU took bold steps to strengthen its national presence and user experience. On 1st February, it opened a second office at Plot 6B, Mabua Road, Kololo, a strategic move to improve engagement and support. Two months later, RENU marked 500 sites connected to the network. RENU then launched eduroam Spot Application in May, a mobile app designed to help users locate eduroam hotspots and stay connected as they travel. In July, RENU established a subsidiary, RENUMESH Technologies, to manufacture solar-powered routers, the first routers to be made in Uganda.

2024: Community Engagement and National Recognition

2024 was a year of visibility and impact. In January, RENU launched KobWeb, its community magazine dedicated to storytelling, knowledge sharing, and celebrating excellence within the RENU community. By March, the Ministry of Education and Sports had joined eduroam, solidifying government commitment to secure academic mobility. Later in the year, in October, RENU received national recognition when it was awarded Best-Governed Small and Medium Sized Enterprise (SME) by the Institute of Corporate Governance of Uganda. The year closed on a compassionate note as RENU launched a Corporate Social Responsibility (CSR) Program for special needs schools in Uganda.

2025: Leadership, Standards and Strategic Partnerships

In 2025, RENU entered a period of international alignment and institutional strengthening. On 10th January, RENU achieved ISO 9001:2015 certification for Quality Management Systems, followed by ISO 27001:2022 certification for Information Security on 21st February. These certifications affirmed RENU's commitment to global standards. On 13th February, RENU partnered with UCC to connect 85 additional schools, expanding its reach among young learners. On 2nd April, RENU joined the International Telecommunication Union, marking a significant step towards global digital diplomacy.

The organisation's role in research identity took centre stage on 9th May when it hosted Uganda's first Open Research and Contributor ID (ORCID) Workshop; this momentum continued on 13th October with the launch of the ORCID Consortium of Uganda. In parallel, the AI Innovation Academy supported by RENU debuted on 10th October, and the RENU Leadership Academy was launched on 24th October to cultivate future-ready leaders. Lastly, on 17th November, RENU rolled out free access to research premium journals through Research4Life using single sign-on, benefiting students, researchers, and staff from member institutions that are part of the RENU Identity Federation (RIF); a major boost to Uganda's research ecosystem.

What 20 Years Mean for Uganda's Research and Education Community

The 20th anniversary of RENU is not simply a celebratory moment; it reflects a profound transformation in Uganda's academic and research capabilities. Two decades ago, most research and education institutions struggled to participate in global research conversations due to poor Internet connectivity and limited digital infrastructure. Today, because of RENU's expansive network, identity federation, eduroam footprint, cybersecurity frameworks, and research-support services, Ugandan researchers, students, and academic staff stand alongside their global peers with confidence and visibility.

RENU's work has also reshaped access and equity. Institutions in rural and underserved regions now enjoy the same high-quality Internet connectivity as those in the capital, enabling students

and researchers across Uganda to collaborate, publish and innovate. At the human level, thousands of ICT staff, librarians, lecturers, and researchers have benefitted from RENU's capacity-building programs, creating a digitally equipped academic workforce capable of navigating complex modern technologies.

Equally significant is the cultural transformation that RENU has nurtured. Through shared infrastructure and community-driven governance, Uganda's research and education institutions now operate as a cohesive national community rather than isolated entities. This unity has strengthened collaboration, improved service delivery, and positioned Uganda as a rising contributor within global academic networks.

Twenty years of RENU reveal what is possible when institutions rally behind a shared vision of connection, collaboration and community. As RENU embarks on its next chapter, marked by deeper integration with global networks, next-generation infrastructure, and expanded research services, the NREN remains steadfast to connect Uganda to the world and to open doors of opportunity for every learner, researcher and institution.

Participants who attended the workshop to consider the proposed network of education and research institutions in Uganda, held at Windsor L. Victoria Hotel, Entebbe from 12th – 13th January 2006.

Contact us

Tel: (+256) 393516521

Email: info@renu.ac.ug

www.renu.ac.ug

Rashida Towers, 5th Floor, Plot 6B,
Mabua Road, Kololo.

@RENU_256

@renu_uganda

@RENU256

@RENU