kenet
Kenya Education Network

IMPACT
REPORT

Transforming Learning, Research and Working Environments Using ICT

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1. Introduction

Kenya Education Network Registered Trustees (KENET) was constituted as an irrevocable trust by five founder universities in the year 2000. The beneficiaries of the Trust were students, faculty, and researchers of member educational and research institutions (i.e., the academic community of Kenya).

KENET Trust is governed by a Trust Deed (see [second supplemental trust deed of 2020](#) that summarizes all of the changes since the year 2000). The Trust Deed had the following six irrevocable objects:

1. To provide **sustainable and high-speed Internet connectivity** for member educational and research institutions (i.e., to be sustained by the academic community)
2. To facilitate **electronic communication** among beneficiaries in member educational and research institutions
3. To support the **sharing** of educational resources and curricula
4. To support **teaching and learning over the Internet**
5. To support **collaboration** in development of local educational content for beneficiaries
6. To support **research collaboration** among beneficiaries

All of the past and current KENET strategic plans have aimed to advance the above objects. For example, the current [KENET strategic plan for the period 2022 – 2027](#) has six main strategic focus areas, namely, digital infrastructure, institutional capacity, connectivity and digital enterprise services, stakeholder engagement, educational technology and research services, and membership services.

KENET operations of the dedicated national academic network, also called a National Research and Education Network (NREN) are 100% sustained by member institutions through subscriptions to connectivity and digital enterprise and educational technology cloud-based services. The revenue generated by the community is then used to support the other strategic focus areas that advance Objects 2 – 6 above. However, through stakeholder engagement with government, development and private partners, and donor agencies, KENET aims to mobilize resources for expansion and upgrade of the advanced digital infrastructure or to advance educational and research services.

KENET achieved financial sustainability in FY 2014/2015. This was possible because of the implementation of a 2008 sustainability plan approved by the government and World Bank as a disbursement condition for $22.5 million government infrastructure grant to KENET member institutions. This was part of the World Bank Kenya Transparency and Communications Infrastructure Project (KTCIP) approved in 2007 that was used to build a dedicated academic virtual network that interconnected 55 campuses of member institutions and pre-purchased international Internet budget (satellite and undersea Internet bandwidth). The sustainability plan required that member institutions pool their Internet expenditures to operate the academic network through Internet budget commitments by connected member institutions. This initial academic network of 55 network had grown organically to 495 campuses in 46 counties of Kenya as of October 31, 2023.

KENET as a not-for-profit organization aims to achieve only modest surpluses which are used to support the non-revenue generating strategic focus areas (and objects) or to connect new campuses in **remote and isolated** areas to support blended and online learning over the Internet (i.e., KENET Trust object number 4 above).

This brief impact report aims to give a few examples of projects or initiatives that illustrate the impact of advancing the six objects in the period July 2020 – October 2023. This report is organized as follows. Section 2 contains descriptions of the impact of KENET research fund in advancing the Trust's objects 4-6. The research fund has been used to award small grants to early career PhD faculty and research in order to catalyze research and promote research collaboration. Section 3 contains testimonials of beneficiaries who have used the KENET's FREE virtual computing to support teaching and research. This advances Trust's Objects 4 –6. KENET customized a sovereign web conferencing and collaboration platform that is FREE for member institutions. Section 4 contains testimonials of beneficiaries who used the platform for emergency remote teaching. In Section 5, we provide an example of how KENET builds the capacity of beneficiaries and member institutions in blended learning using external grants. The specific example is that of Kenya Medical Training College that benefitted from an external grant awarded to KENET for institutional capacity building. We include impact direct engineering support (DES) to selected members institutions in Section 6. Section 7 are a few examples of extending high-speed last mile infrastructure to isolated and remote main campus of beneficiary member institutions. This enhances access to blended educational materials and supports research by beneficiary students, faculty and researchers.

2. KENET Research and Educational Technology Innovations Fund (Objects 4 – 6)

In the 2012, the Board of Trustees resolved that 2% of the annual Internet connectivity revenue would be used to fund research and educational technology (EdTech) innovation projects that would directly benefit member institutions and beneficiary faculty, researchers and students. The Board of Trustees therefore created what is now called a Research and Innovation Fund that supports research and education engagement and collaboration. In addition to funding research and innovation projects, the fund is also used for travel grants for beneficiaries (graduate students, faculty and researchers) whose papers have been accepted in refereed papers in the areas of computer science/information systems and engineering. These areas were selected because they were critical for the advancement of the objects of the Trust.

Table 1 in Annex one (1) shows the research and innovation grants awarded since FY 2014/2015. These grants were awarded to early career PhD faculty and researchers through a competitive process governed by the KENET Research Grant policy. The research fund has supported 41 research projects, some in Educational Technology and disbursed a total of **KES 61,500,000** for the period 2015 – 2023.

These grants have catalyzed research in emerging big data and computer-intensive areas. These projects promoted research collaboration Kenyan universities and research institutions. The projects have also been important for faculty development in new technology areas (e.g., Machine Learning or IoT applications and Big Data). The research grants also promote research collaboration among universities and research institutes with each grant involving more than one university or research institution as shown in Table 1.

The research fund has also been used to support travel grants for graduate students, faculty and researchers whose papers have been accepted to referenced conferences outside Kenya. These travels have been restricted to the KENET Special Interest Group areas of Computer Science, Engineering and Materials Sciences. These STEM areas have had low research productivity as measured by publications. The grants have supported graduate students who need to present papers at International Conferences before graduating. Table 2 is a summary of the travel grants since 2016 to 138 grantees from 32 member institutions, mainly universities.

Table 2: Travel grants awarded (2016-2023)

Summary of Travel Grants Awarded from 2016 to 2023					
Financial Year	Faculty	Graduate Students	Total No. of People Awarded Grants	No. of Institutions awarded travel grants	Total grants given within the FY (KES)
FY 2016-2017	7	5	12	7	**2,926,050.00**
FY 2017-2018	18	7	25	13	**6,943,729.50**
FY 2018-2019	12	12	24	14	**6,573,201.00**
FY 2019-2020	14	7	21	15	**5,464,050.00**
FY 2021-2022	1	3	4	4	**241,950.00**
FY 2022-2023	12	19	31	17	**3,922,077.08**

Dr. George Manyali: 'Study of Photovoltaic Absorbers and Thermoelectric Materials Using Density Functional Theory'

Dr. George S. Manyali, the head of Computational and Theoretical Physics group (CTheP) and a Senior lecturer in Physics at Kaimosi Friends University was among five (5) lead researchers who were awarded the KENET Innovation and Research Grant. Other team members (researchers) include Dr. Celine Omondi (Lecturer, Masinde Muliro University of Science and Technology), Dr. Felix Saouma (Physics Lecturer, Kaimosi Friends University) and Dr. Victor Odari (Physics Lecturer, Masinde Muliro University of Science and Technology).

The focus area of the research was Materials Science and Technology for environmental safety and health applications and was titled '*Study of photovoltaic absorbers and thermoelectric materials using density functional theory*'. This was motivated by the increasing demand for energy globally due to the ballooning human population and industrialization leading to large-scale consumption of non-renewable fossil fuels. This in turn causes emission of greenhouse gases into the

atmosphere resulting in detrimental effects on the environment.

Dr. Manyali applauded KENET for its role in enhancing education and research in institutions and encouraged more research teams to apply for the KENET Research and Innovation grants. *"The KENET grant has been a game changer in the development and support of research teams in Kenya as it has contributed immensely to the research and training of researchers in the country. "We have been able to attend conferences and participate in workshops gaining recognition as an active research group by international bodies monitoring computational work in the country",* said Dr. Manyali.

Through the KENET grant the team conducted research on the use of Density Functional Theory for simulation of solar absorbers resulting to Masinde Muliro University of Science and Technology (MMUST) revising the Bachelor of Science (BSc) in Physics curriculum to incorporate Computational Physics Courses. The grant funded a Computational Physics laboratory with six (6) high performance computers. The laboratory is linked to the Center of High- Performance Computing (CHPC) in South Africa which enables computation of heavy tasks and is currently used by students to grow their knowledge in simulation and computational physics. 15 graduate and post graduate students have graduated, and three (3) undergraduate students have defended their projects with 15 ongoing post graduate students currently under supervision and curriculum.

Dr. Peter Akuon: RF Radiation Activity of Mobile 2G, 3G, 4G, 5G+, Wi-Fi around the Human Body

In 2019, Dr. Peter Akuon, a Senior Lecturer, at University of Nairobi was among four (4) lead researchers who were awarded the KENET Research and Innovation Grant in Computer Science and Information Systems (CSIS). His research in the area of Internet of Things (IoT) focused on *"RF Radiation Activity of Mobile 2G, 3G, 4G, 5G+, Wi-Fi around the Human Body".* Other team members included Dr. Lemy Oginga (GP-Ministry of Health), Col. Andrew Nyawade (Ministry of Defence) and Mr. Tom Oloo (Senior Technologist - University of Nairobi).

The research aimed at investigating the radioactivity levels in the environment. The team collected data within the Kenyan environment using Electromagnetic field meters (EMF) to analyze the safety of the Kenyan environment. Wireless communication requires the use of frequencies from an antenna. Power is used to send a signal in the form of energy from the sender's device to the receiver changing the energy in the environment which in turn may be harmful to animal life as different frequencies carry different energy amounts.

Dr. Akuon explaining the use of the Electromagnetic field meters (EMF meters)

The research has provided widespread available data on Wireless Radiation Activity levels collected about the Kenyan environment in terms of wireless communication. Based on the data collected, it was established that the Kenyan environment is safe, and a community calculator was developed to check the safety of their environment and the devices being used and the results updated online.

Over 20 Undergraduate students involved in the research gained theoretical and hands on knowledge and skills on how to assess existence of environmental hazard from wireless communication and are also able to train and share this knowledge with others. Four (4) papers have been presented by undergraduate students in an internal conference of the University of Nairobi. The team will also prepare a policy brief based on the project research findings to be shared with relevant stakeholders.

By undertaking this research project, the team attracted further funding of up to Kshs 3M from the Royal Academy of Engineering to purchase WiFi equipment and for development of the phototherapy machine based on safe radiation levels. The WiFi equipment was installed at the Mamlaka students' hostels at the University of Nairobi. Equipment installation in other areas is ongoing. Currently, the development of the phototherapy machine by the Department of Electrical and Information Engineering (University of Nairobi) based on the learning achieved from the project is ongoing.

Dr. Akuon encouraged other researchers to apply for the KENET Research and Innovation as it provides a platform which didn't exist before researchers in Kenya. He also recommended that award of the innovation and research grant eligibility conditions include the requirement that the principal investigators applying for the grant should have a collaborator from another institution. *"As a national grant, this would bridge the research capacity gap among the various research institutions and also develop other institutions' research capacity thus increasing the impact of the grant"*, said Dr. Akuon.

3. Enhancing teaching and research innovations using KENET's virtual computing lab

KENET set up a Virtual Computing LAB (VLAB) (https://vlab.ac.ke/**)**, in the year 2017 initially as a platform for training ICT staff of member institutions. This has been expanded to provide a platform for teaching ICT courses for member institutions without a physical lab as well as a research computing lab for the community. The use of the virtual lab is FREE for graduate students, faculty and researchers.

The VLAB provides pre-configured virtual appliances running various software for sharing code and visualizations such as statistical analysis, Quantum Espresso, NumPy/Scikit which can be deployed on demand. Users can then self-provision the virtual machines by specifying and selecting the amount of CPU, RAM, and Disk Space desired to run the appliance catering to their specific needs. These include popular tools like R Studio, Jupyter Notebook, and Python, which facilitate data analysis and programming tasks.

As a community cloud, the KENET Virtual Lab is hosted and managed by KENET, ensuring a secure and reliable platform for educational activities. Member institutions leverage this infrastructure to enhance their teaching and research capabilities in various academic disciplines. Faculty members harness the capabilities of VLAB to impart the necessary technical skills to students in various disciplines, including engineering, computer science, and computational modelling thereby nurturing their intellectual growth. This dynamic platform is not just a conduit for learning but also a beacon of innovation. Researchers across the country use the KENET VLAB to conduct a diverse array of studies that hold the promise of tangible benefits for our community.

The KENET VLAB has proven to be quite useful to the KENET research and education community with students carrying out their undergraduate and postgraduate project for successful conferment of their bachelors, master's and PhD degrees to research groups completing various projects. Since inception, more than 5,000 virtual machines have been powered on the VLAB platform. Some testimonials from the platform users are highlighted below:

3.1 Emmanuel Kweyu, Strathmore University – iLab Africa

> *"I am writing to express my sincere appreciation for the excellent VLAB Service you provided us from April 3rd to July 15th, 2023. The instance was incredibly helpful for our ongoing research. We would like to request an extension of the service for the next 12 months to continue with the research. We are at a critical stage of the development and deployment of the tools (AI-Web Crawler for epharmacy regulation in Kenya), and your resources are vital to the validation and completion of the research. Throughout the period, we found the VLAB Service to be reliable, efficient, and instrumental in our work. It facilitated our team's efforts and significantly contributed to the progress we made during this time. The resources and functionality offered by the service exceeded our expectations, and we are grateful for the support it provided. Thank you for your outstanding service, and we look forward to your positive response."* said Emmanuel Kweyu of Strathmore University – iLab Africa.

3.2 Mr. Peter Kimemiah Mwangi, Murangá University

Mr. Peter Kimemiah Mwangi, a researcher at Murangá University used the KENET VLAB in his research titled *"A surrogate agent model based on reinforcement learning for improved horizontal scalability of an internet of things distributed ledger"*. Peer to peer distributed ledger technology provides security, privacy, immutability and resistance against failure and malicious nodes leading to the global growth of Bitcoin, Ethereum, IOTA Tangle and Obyte (formally Byte Ball) platforms. This has however been hindered by the issue of the horizontal scalability of the distributed ledgers in the Internet of Things ecosystem placing a limit on the number of applications adopting distributed ledgers technology. The research entailed development and formulation of a simulation model based on network theory models and a multi-agent learning theory approach and incorporation of a reinforcement.

3.3 Dr. Michael Atambo, Technical University of Kenya

Dr. Michael Atambo, a faculty member at Technical University of Kenya (TUK) has been one of the users of the KENET VLAB not only for his research, but also for training of students at TUK. Dr. Atambo attests to the fact the KENET VLAB has been quite resourceful for him as highlighted *"Kenya Education Network's (KENET) VLAB has played a pivotal role in the training and development of our final year students specializing in computational material science. It serves as an indispensable resource, offering accessibility, versatility, and reliability for a wide range of computational tasks essential for building knowledge and showcasing competence. Over the course of the past three years, three cohorts of students have harnessed this valuable resource to delve into various material science challenges. Their research endeavors have spanned diverse areas, encompassing materials designed for energy applications to the study of hard materials. Notable students who have benefited from this platform include Leah Wairimu, Charles Rotich, Bill Oyomo, and Steve Mbugua. Several of these students have nurtured a deep passion for the field, leading them to pursue further studies at the graduate level. The presence of accessible computing resources has not only made their work possible but has also endowed it with significance.*

In the realm of research, Dr. Atambo's personal focus revolves around High Throughput Computing, particularly in the study of materials at scale. *A critical prerequisite for such work is an always-on, always-connected workstation.* KENET's provision of continuously available virtual machines (VMs) has admirably met the requirements of such research. These VMs serve as a launchpad for connecting to the Center for High-Performance Computing (CHPC) and for analyzing the outcomes of automated high-throughput calculations. *Dr. Atambo further added that: "Over the past two years, our institution has had the privilege of hosting two international research and training events, SIESTA 2021 and RASESMA 2023. Both events demanded significant computing resources for the participants. KENET rose to the occasion, delivering dedicated computing resources throughout the duration of these events. This remarkable capability not only facilitated our role as organizers but also allowed us to demonstrate to funding agencies our commitment and readiness to provide the promised training. Simultaneously, it reduced our reliance on remote resources provided by foreign institutions, reinforcing our self-sufficiency in delivering quality training."*

With unwavering dedication to knowledge dissemination, research excellence, and technological innovation, KENET's VLAB is a demonstration to the organization's pivotal role in shaping the educational and research narrative of Kenya aligning with Kenya's Vision2030 Science, Technology, Engineering and Mathematics (STEM) agenda.

4. KENET's Free Web Conferencing Platform

KENET has a custom web conferencing and collaboration platform designed to cater to the unique demands of educational and research institutions in Kenya. Although it was first set up in 2016 for supporting pilot remote teaching for University of Nairobi and Daystar University, it emerged as an indispensable asset during the unprecedented challenges posed by the COVID-19 pandemic. When the government closed educational institutions, the FREE web conferencing supported the emergency migration to remote teaching by university lecturers. It was used as the primary remote teaching platform for up to **340,000** classes during the COVID-19 pandemic period. In order to support the large number of classes, KENET upgraded the infrastructure to support up to 16,000 concurrent classes by adding physical servers at a cost of **KES 39 million**.

Recognizing the importance of supporting educators in this transition, KENET provided comprehensive and free training sessions on using the web conference platform to over 3,000 educators and IT (Information Technology) administrators from various institutions. These sessions equipped them with the necessary skills and knowledge to effectively utilize the web conferencing platform, empowering them to navigate the digital teaching landscape with confidence.

4.1 KENET Web Conference use at JKUAT

The Jomo Kenyatta University of Agriculture and Technology (JKUAT) officially adopted the Web conferencing platform during the onset of COVID-19 to smoothen the transition to online learning because of the physical closure of the university and as the online meeting management system during the onset of Covid. The platform is free and has low bandwidth consumption thus making it affordable for students and institutions alike when holding either discussions or departmental meetings and to attend classes aiding in hybrid learning and interactions. All common units at JKUAT are now taught online through the online management system and different user departments hold virtual meetings and online events/forums for students like online Guidance and Counselling seminars.

Dr. Lawrence Nderu, a Lecturer and Researcher, JKUAT, who has been using the web conference platform to teach his students says, *"The platform has played a big role in blended learning as majority of the postgraduate classes are now conducted online and it also facilitates group discussions. The platform has many features that are amazingly effective for learning in a virtual classroom like the whiteboard markers, annotators and breakout rooms which are essential for interactive learning."*

The platform has enabled lecturers to freely conduct their classes, schedule makeup sessions and conduct their research without the limitation of distance or time as it provides a balance leaving room for only practical to be conducted in person. The lecturers log on to the Learning Management System, create a link for the meeting and embed it on the LMS and students can easily log on to the platform to attend the class. Exams can also be invigilated online.

Speaking about the platform, Mr. George Mwangi, University Learning Management System Administrator, School of Open Distance Learning emphasized the impact of the platform in transforming the learning experience. He noted that platform has broken down the traditional mode of learning where previously learning had to be done physically and the certification can only be authenticated when done in person. *"The KENET Big Blue Button has brought in a new norm where learning is no longer limited to physical presence and can be done online with interactive features like the breakout rooms which enable student discussions and opinion polls among others. The security features help in interaction moderation and the user interface is very friendly making it easily navigable,"* said Mr. Mwangi.

The platform enables both the physical and virtual interaction helping in easing the work as it is easily adaptable to the learner, can have meetings extended from the control panel when there is need to and the recordings can be accessed after for reference. Prof. Stephen Kimani, ICT Director, JKUAT highly recommended the use and adoption of the KENET web conferencing tool as it is opensource making it possible to add, enhance and customize features. *"We appreciate KENET for continuously improving the platform and incorporating relevant features making it relevant to the KENET community. The platform is among the many great benefits of being a member institution and I recommend its adoption by other institutions,"* highlighted Prof. Kimani.

4.2 KENET Web Conference Use at St. Leonella Consolata Medical College

One compelling testament to the transformative power of KENET's custom web conferencing platform comes from a college principal in Kenya, underscoring its vital role during the pandemic: *"As the principal at Sister Leonella Consolata Medical College in Kenya, I cannot overstate the importance of the KENET web conferencing platform during the COVID-19 pandemic. When our college faced some constraints and the daunting task of transitioning to online learning, KENET's platform came to our rescue. Thanks to KENET, our students continued with their learning without interruption. The free training sessions offered to our teachers ensured they could effectively use the platform for teaching. This support was invaluable in maintaining the quality of education during a difficult time. KENET's commitment to education and the continued provision of this platform has been useful for many institutions."*

This free web conference platform stands as a symbol of KENET's unwavering commitment to bridging the educational divide. It transcends the boundaries of financial constraints, rural settings, and underserved communities, ensuring that quality education remains within reach for all towards achieving equitable access to education.

5 Attracting Capacity Building Grant for Building Capacity of KMTC to support blended and online learning during COVID-19 pandemic

In December 2020 during COVID-19 pandemic, KENET received a capacity building grant of KES 39 million from the Foreign Commonwealth and Development Organization (FCDO) for KMTC. The grant was used to support capacity building of senior leadership and faculty of Kenya Medical Training College (KMTC), a member of KENET, in the transition to blended/online learning and remote working that was necessary during and after the COVID-19 pandemic. KENET had just completed connecting 73 campuses of KMTC in 43 counties to the KENET academic network. KENET was also hosting the LMS of KMTC during the COVID-19 pandemic period.

The migration to blended and online learning as well as use if cloud-based ERP to manage KMTC also required that KMTC learn how to mitigate the threats of cybersecurity attacks. The grant was therefore used to conduct an e-readiness and cybersecurity readiness survey of KMTC.

KENET conducted a comprehensive e-readiness and cybersecurity readiness survey of all the KMTC campuses. This included measuring the adoption of online and blended learning by faculty and students and the associated cybersecurity awareness levels of KMTC community. These results were used for online capacity building of the KMTC senior leadership team.

The project also supported the capacity building of a selected number of faculty members and champions in teaching with technology and development of blended/online educational content in teaching medical courses. The training was conducted by a team of instructional designers and faculty in health sciences that were drawn from KENET and member universities.

KMTC has used the initial training of faculty and senior leadership to enhance their adoption of blended and online learning for the 78 campuses in different parts of Kenya. An impact assessment is planned for FY 2024/2025, at least three years after the capacity building. However, anecdotal information suggests that the capacity building and cybersecurity had positive impact for KMTC as a large organization. See the comments below by Mr. Kennedy Kinyua, Deputy Head of eLearning at KMTC had the following testimonial on KENET's faculty capacity building initiatives:

> *"KENET's training program on Moodle LMS and multimedia content design helped us improve the online classes we offer. The knowledge and skills empowered our faculty members and unleashed their creativity, resulting in engaging, dynamic online courses and sessions. We are truly grateful for their commitment to enhancing education in our country".* The success at KMTC, as shared by Mr. Kennedy Kinyua, is just one example of how our training programs have catalyzed positive change across the educational landscape.

6. Enhancing the Digital Campus Infrastructure in KENET Member Institutions through FREE Direct Engineering Support services

The digital campus infrastructure (DCI) includes the campus LAN and WiFi that is used to support access to Internet and educational resources, the associated data centers or server rooms, remote teaching classrooms, and the stable and clean power infrastructure among others. The DCI is wholly owned and operated by individual member institutions.

However, KENET sometimes provides Direct Engineering Support (DES) services that include technical advisory and DCI network audit services, emergency upgrade of DCI using donated network equipment and/or WiFi. This is possible through limited annual budgets for DES to support pilot demonstration projects (e.g., remote teaching classrooms or extension of WiFi to off-campus) or KENET infrastructure grants or both. In the period 2018 – 2023, KENET executed DES projects worth KES 21 million that benefitted 46 member institutions. The cases presented below are example DES projects executed in the period 2020 – 2023.

6.1 Expansion of Student eduroam WiFi Access at Kenyatta University (Open WiFi Project)

KENET, through its Direct Engineering Support program and in partnership with TIP Africa commissioned a KES 10.5 million Open WiFi Project at Kenyatta University, Main campus. This project was jointly funded by Telco Infra Project Africa (KES 7.5 million) and KENET through the DES budget (KES 3 million). Telco Infra Project Africa is mainly funded and is testing the use of Open WiFi equipment that is lower cost and overcomes limitations of global supply chains to WiFi equipment.

The project expanded WiFi coverage to learning spaces, lecture halls and student hostels serving over 50,000 students and 5,000 faculty members. The total area covered by the project spanned approximately 15,000 square meters. This WiFi supported blended and online learning at KU.

The KU Open WiFi project involved the installation of 95 additional Wireless Access Points, 25 number network switches and upgrade of network firewall at Kenyatta University. In addition, KENET also upgraded the Network Firewall at Kenyatta University at an additional cost of KES 2.5 million with an aim of enhancing the secure access of digital learning resources by students while in Kenyatta University through the Free WiFi connectivity.

Speaking on the impact of the Open WiFi coverage in learning, Patience Wanzala, 2nd year student at Kenyatta University

said, "The *wifi has been helpful to me in my learning process. I am now able to learn more from online research supplementing the course content taught in class. I can also comfortably attend online classes from the comfort of our hostels without the worry of spending a lot of money on bundles.*"

Another comment on the project was by the Lucy Machugu, the Vice Chair of KU Student Association:

> "*The Open WiFi in the hostels has really impacted students positively academically. The provision of free WiFi up to the hostel level has enabled almost 100% turnout as far as online classes are concerned since students do not need to carry that burden of buying bundles to attend the 2-3 hours classes that we do have. This has also resulted in a positive deviation academically since almost all students attend the online classes courtesy of the freely available WiFi. In addition to this, students have found it easier to work on their research and assignments as they can now do them at their comfort zones in hostels as opposed to staying up too late in the library to get the WiFi. This has shown good results on the students' portals in the recent past semesters. The impact on our productivity and sense of community is undeniable. It's more than a technological upgrade; it's an investment in our education, research, and connectivity. As the Vice President of the student union, it is my hope that this project can be expanded to serve more students. I have no doubt about its significance to the community of learners at Kenyatta University*"

6.2 Extension of eduroam Wi-Fi to on- and Off-Campus Hostels at Laikipia University and JKUAT

During the COVID-19 pandemic, KENET requested the Communications Authority of Kenya (CA) to allow KENET to extend FREE WiFi to off-campus hostels to support blended and online learning. Students were using discounted Mobile data bundles that were not affordable to the students and did not allow unlimited access to e-learning resources. CA allowed KENET to extend WiFi on condition that KENET could authenticate the students and or faculty only. The total cost of the project was KES 3,261,170 covering the cost of WiFi Access points, fiber cables and installation.

KENET selected off-campus hostels around Laikipia University in Nyahururu and JKUAT in Juja to pilot off-campus WiFi. KENET deployed eduroam (EDUcation ROAMing), the FREE and secure Wi-Fi for the global academic community. The students and faculty are authenticated using the respective identity databases at Laikipia University and JKUAT. The off campus eduroam Wi-Fi expansion at Laikipia University and Jomo Kenyatta University covered a student population of up to 6,000 in the two universities.

The total cost extension of eduroam to the pilot off-campus hostels was KES 3,261,170 and was fully funded by KENET. It impacted a total of 600 students who live in the hostels.

Speaking on the project, Dr. Fredah Karambu Rimberia Wanzala, JKUAT Associate Professor and Dean of Students described eduroam as a big leap forward in development specifically for learning institutions highlighting how it has aided education and research. *"eduroam has transformed the education and research experience in academia with the good internet connection browsing the bulk of research materials can now be easily accessed through elibrary. eduroam has been very helpful to students as it caters to their different browsing needs",* said Dr. Karambu.

The extension of eduroam WiFi to the hostels has encouraged uptake of online services by the university and helped in the facilitation of online classes making it easier to access information and catering to the educational needs of the students. It has also reduced traffic in the library as there is good internet connectivity in the hostels compared to when only the library had good connectivity. "*eduroam has a positive impact as it is affordable and cost effective compared to other internet options. It also does not buffer no matter the number of users making it easy to browse and conduct research online",* said Lewis Nyambega, a resident of Mwenge House, one of the eduroam connected hostels.

Mr. Arthur Wainaina, Department of ICT, Head of Infrastructure and Support Services at JKUAT emphasized on the need to support the eduroam WiFi project and have it expanded to densely populated student residential areas to ensure more students benefit from it. *"Eduroam is also essential for cooperation within universities as users can still be authenticated when visiting other institutions and use their bandwidth to roam. It provides unlimited capacity for teaching and internet access and aids in conducting research for references",* said Mr. Wainaina.

Saif Trisha Pagasa, 2nd year student at Laikipia University explained the impact of the on- and off-campus as follows: "*In today's digital era most assignments and classwork are online and with eduroam we have been able to conduct the classwork and assignments successfully because of the good connection*",

With eduroam, the students can stay updated on the current global issues making online research easier and reducing the financial burden of the students. The project has attracted the attention of students living in other residential areas near Laikipia University who have now expressed interest in having their hostels connected.

6.3 Digital Campus Infrastructure Expansion at University of Eldoret

KENET implemented a digital campus infrastructure at the University of Eldoret to extend internet services inside the campus environment. The scope of work included installation of network switches, Wi-Fi access points, network cabinets and fiber infrastructure to connect the various buildings. It also included delivery of internet services to UoE Main Campus, Eldoret Town Campus, and Nairobi Campus. The aim of the project is to promote digital inclusivity within the university environment and deliver digital services to all individuals. This project was partially funded by the University of Eldoret and KENET at a total cost of **KES 8,484,015.62**. KENET contributions were in the design of the campus expansion project and financing the extension of fiber optic fiber to on-campus student hostels from the server room at a Direct Engineering Support cost of **KES 3,861,415.62.**

The design of the network increased the core network throughput from 1Gb/s to 10Gb/s. It also improved the network coverage by extending digital services to areas previously isolated within the university. The project entailed replacement of 24 old network switches, installation of 2,500 meters of fiber optic cable and installation of 57 wireless access points. It also included power stabilization equipment to protect equipment and ensure network availability during an extended power outage. The figure 1 below shows the google map coverage of the University of Eldoret infrastructure.

"The project has immensely benefited both the students and staff fraternity at University of Eldoret by ensuring digital inclusion and open access to digital resources. Students are now able to not attend online classes at the comfort of their hostels but also seamlessly access locally hosted services, and online repositories while collaborating with each other. Similarly, staff can access online journals and repositories for their research while collaborating with other faculty and researchers in partner universities", - Dr. Victor Kimeli, Director ICT - University of Eldoret
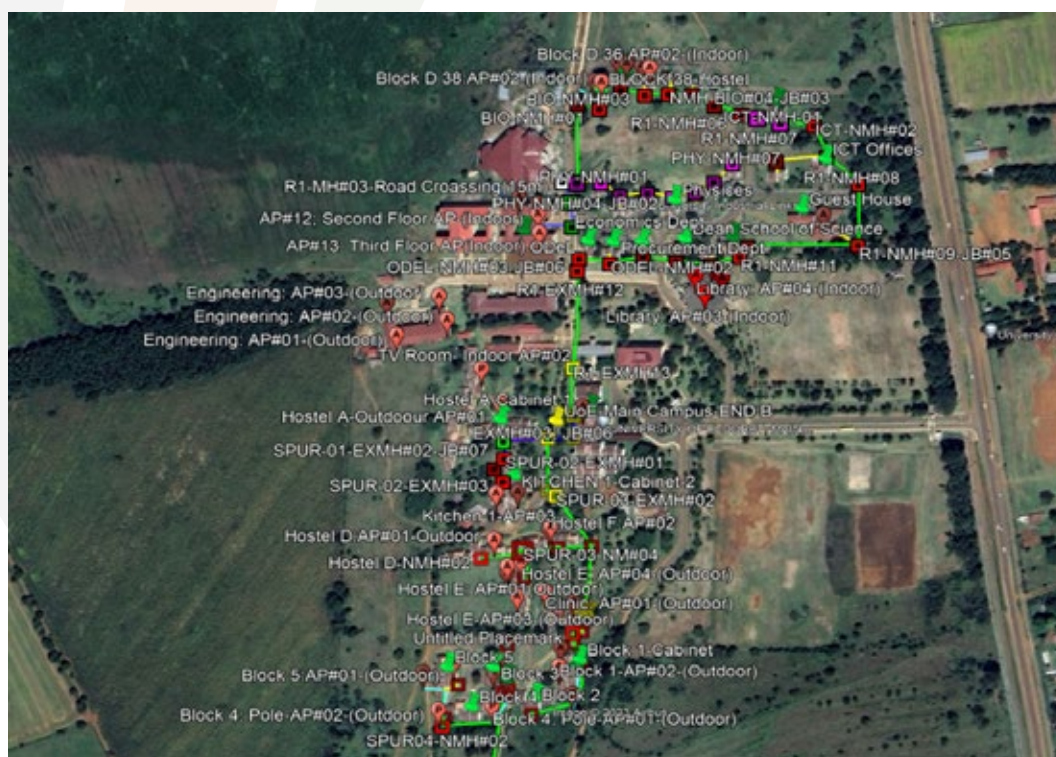
The implemented network design supports 12,090 students, 703 teaching staff and 816 admin support staff within the University environment.

Figure 2: Access points installed in various locations at University of Eldoret

6.4 Pilot remote teaching classrooms at Technical University of Mombasa and St. Paul's University (2022 – 2023)

In the period 2016-2017, KENET selected three universities to pilot remote teaching classrooms that would reduce the need for faculty to teach at multiple satellite or rural campuses of the same university. The universities that participated were the University of Nairobi (3 remote teaching classrooms at main campus, Mombasa campus and Kisumu campuses), Catholic University of Easten Africa (2 remote teaching classrooms at main campus and Eldoret campus) and Daystar University (2 campuses at Athi River and Nairobi campuses). These remote teaching classrooms were set up by KENET at a total cost of KES 9,240,188.80. It these remote teaching classrooms pilot project that prepared KENET for supporting remote teaching during the COVID-19 pandemic of 2020-2021.

In 2022, KENET established another four remote teaching classrooms for St Paul's University (2 classrooms – Limuru main campus and Nakuru main campus) and at Technical University of Mombasa (2 classrooms – Mombasa main campus and Kwale main campus) at a total cost of KES 7,594,473.60. These classrooms are operational, and SPU even upgraded one of the classrooms to a fully-fledged studio. The VC will be sharing the experience during the 2023 Heads of Institutions forum in Mombasa as way of encouraging adoption of educational technology classroom technology innovations.

> *"We remain grateful for the gift of this facility that has contributed to substantial improvement in e-learning capabilities, ensuring a seamless environment for students and educators. The facility has become a hub for faculty professional development, offering training sessions and workshops that empower educators with the latest teaching methodologies and technological tools. The hybrid nature of classes has resulted in increased student engagement, as participants have the flexibility to choose between online and physical attendance, thereby promoting active participation and interaction",* Grace Wangui Kinyanjui, SPU Virtual Campus Team.

The remote teaching classrooms for TUM have also been operational and have made it possible for faculty to reduce travel to Kwale in areas with limited number of lecturers and to increase access for students in Kwale area. The following quotations illustrate the classrooms have a positive impact. KENET will fund a research project to assess the impact of classrooms on the learning outcomes and institutional efficiency over a period of 2 to three years.

> *"The Remote teaching classroom is located on the third floor, School of Medicine, in Main Campus, TUM, next to the Board room, and at Kwale Campus, it is housed in the computer lab. The set-up of a remote audio-visual teaching classroom at Main campus and Kwale campus have been completed and operational. The remote teaching classrooms are fitted with Audio-Visual equipment to enable the university to conduct interactive video conferencing sessions between the remote campuses; accommodate virtual sessions with external speakers to enable the schools to conduct blended dissertation defense sessions. Thank you, KENET, for your continued support".* Mr. Swaleh, ICT director, TUM

"Overall, I believe that digital classrooms have provided us with a valuable tool that can improve the learning experience for both students and teachers" Dr Abdulkadir Banafa, the Director, Kwale Campus.

We would like to thank KENET for the installation and commissioning of the digital infrastructure for a model digital/ virtual classroom that can allow remote teaching. This has made it easier for TUM faculty to train students from Kwale Campus remotely via virtual classrooms. It has also broadened students' options as they can learn without traveling to the main campus, and lecturers can teach multiple classes simultaneously thus reducing the burden of hiring additional teaching staff - Dr Obadiah Musau, Director of Open and Distance Learning, TUM

The above quotations suggest that the remote teaching classroom projects have had a positive impact on teaching and learning at TUM. Photos for the remote classroom setups have been included in a separate link.

A more comprehensive assessment of impact of remote teaching classroom shall be undertaken by the KENET partnership with the five beneficiary universities in the FY 2024/2025 using the research and innovation grants.

7. Special KENET Community-funded projects – extending last mile fiber connectivity in remote and isolated main campuses of new universities.

One of KENET's objects is to provide sustainable high-speed Internet to educational institutions to support blended and online learning (I.e., teaching and learning over the Internet. The high-speed was supposed to support sharing of educational resources and for collaboration among beneficiaries.

In 2007, the government of Kenya, through the Kenya Transparency and Communication Project, extended last mile fiber to 14 main campuses of universities and university colleges outside Nairobi. This included Egerton University, Moi University, Laikipia University College, Kimathi Institute of Technology (now DKUT), Pwani University College, Narok University College and Meru University College among others. KENET was the implementation agency for the project. High-speed for all the connected campuses was defined as infrastructure with speeds of at least 1 Gb/s.

Although KENET member institutions have not received government funding since 2013, KENET community has continued to extend last mile fiber to remote and isolated remote campuses using KENET surpluses and in some cases infrastructure grants (e.g., Google infrastructure grant) and contributions from the beneficiary member institution. Consequently, as of October 2023, all of university main campuses were KENET-community owned last mile fiber infrastructure.

Table 3 shows some of the last mile infrastructure projects undertaken in the period 2017-2023. The table the total CAPEX of last mile fiber links and the Monthly recurrent costs for maintaining the infrastructure. The most recently completed in October, was the extension of last mile fiber to Tharaka University, Tharaka Nithi County. This includes Kabianga University in Kericho County, Karatina University in Nyeri County, Taita Taveta University in Taita Taveta County, Jaramogi Oginga Odinga University of Science & Technology (JOOUST) in Siaya County, Rongo University in Migori County, Kaimosi Friends University on Vihiga County, Bomet University College in Bomet County and Tharaka University in Tharaka Nithi County, just to mention but a few. A selection of the investments in the fiber infrastructure projects in rural areas made by the KENET community are highlighted in the Table 3 below.

Table 3: Example last mile infrastructure projects completed 2017 – 2023

University	County	Year	Capex Costs (KES)
University of Kabianga	Kericho	2017	15,322,800.00
Karatina University	Nyeri	2019	1,425,000.00
Rongo University	Migori	2017	10,318,050.00
JOOUST	Siaya	2019	3,450,000.00
University of Eastern Africa, Baraton	Nandi	2019	2,692,200.00
South Eastern Kenya University	Kitui	2017	28,500,000.00
Machakos University	Machakos	2019	1,470,000.00
Kaimosi Friends University	Vihiga	2019	11,498,742.00
Bomet University College	Bomet	2023	18,037,182.00
Tharaka University	Tharaka Nithi	2023	5,947,509.00

7.1 The Case of Tharaka University Last Mile Connectivity Project (2023)

KENET activated the last mile fiber to Tharaka University (TU) in October 2023. The university had been connected using radio based Safaricom leased line with a limited capacity of only 100 Mb/s since 2019. This was inadequate for TU that has student population of 4,561 in October 2023 (KENET target is 100 Mb/s per 1,000 users).

The fiber link had a maximum capacity of 1,000 Mb/s (or 1 Gb/s) but could be upgraded to 10 Gb/s with replacement equipment. The TU consumption jumped to over 350 Mb/s when the fiber link was activated. The backup for the fiber shall be a radio link with a capacity of up to 850 Mb/s.

Tharaka University is in an area where even the quality of 3G or 4G mobile Internet is very poor (even telephone coverage is poor). Tharaka University has also unstable power as the nearest KPLC substation is at Embu Ishiara which is 200 KM away. KENET engineers shall provide technical advisory services for upgrading the digital campus infrastructure including stable power infrastructure.

The total CAPEX cost for the TU connectivity extension and upgrade was KES 5,947,509.00 while the annual recurrent cost to support the infrastructure shall be KES 3,302,395.50.

TU is partly connected via leased NOFBI from Nkubu to Gatunga TTC via Mitunguu TTI, 86 KM fiber distance, but with 5 KM of last mile overhead fiber (on KPLC poles) to the TU server room. This extension also allowed for other educational institutions such as Mitunguu TTI along the route to TU to be connected be connected to last mile fiber whenever they are ready. The fiber infrastructure is also protected over a 850 Mb/s high-speed radio to Nkubu and ensures that TU achieves 99.5% uptime. The institutional network security appliance/firewall was also upgraded from 100Mb/s capacity to 1,000Mb/s capacity to ensure that all access to digital resources is done in a secure and safe environment. Figure 1 below shows the layout of the setup and the installation pictures at Tharaka University.
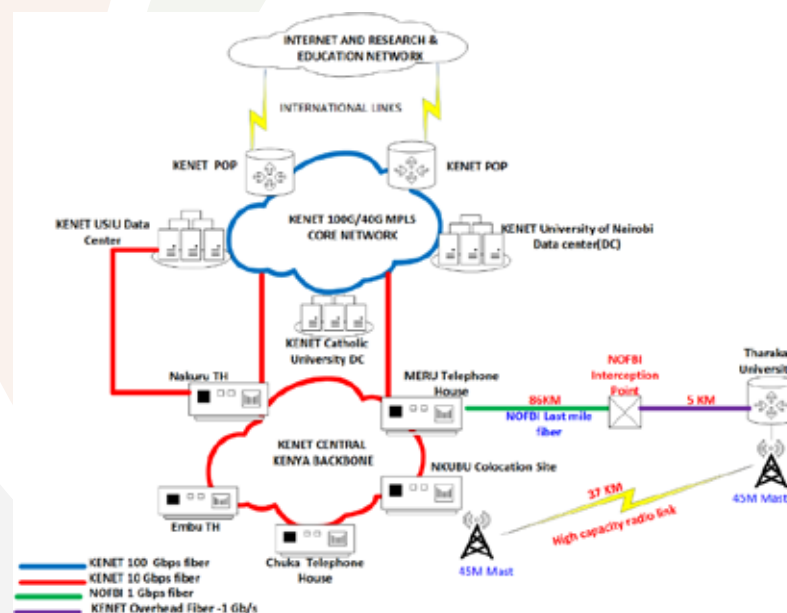

Figure 3: Network diagram for last mile fiber connection to Tharaka University

Figure 3 shows the terrain of the 5 KM overhead fiber to Tharaka University while Figure 3 shows the mast at Tharaka University that is used to mount the backup radio to Nkubu.

Figure 4: Last mile overhead fiber on KPLC poles

Figure 5: Mast installation and solar power equipment at Tharaka University

"The improved connectivity has not only facilitated seamless communication and collaboration among students, faculty, and staff but has also enhanced the overall learning and research experience at Tharaka University. Our students can now access online resources, participate in virtual classrooms, and engage in research activities without any lag or interruption. This has not only increased their productivity but has also opened up new avenues for innovative teaching methods and academic pursuits. Our faculty members are now able to conduct virtual lectures, share multimedia content, and collaborate with international peers, creating a more dynamic and enriching learning environment", said Joseph Mutwiri, Tharaka University.

7.2 Testimonial from Kaimosi Friends University (2023)

"The impact of such a massive leap in speed cannot be overstated with a general increase in operational efficiency, academic and research focused activities based on the ease of access to information. With the infrastructure put in place, and as KAFU grows in size and student population, the Directorate of ICT Services can comfortably plan for an information and knowledge focused future", said Eugene Masinde, In-Charge ICT, Kaimosi Friends University.

8. Conclusions

KENET is incorporated as an irrevocable trust with objects that include providing sustainable high-speed to educational institutions in any part of Kenya, promoting teaching and learning over the Internet, and collaboration in development of educational content. KENET supported member institutions in emergency migration to remote teaching using a sovereign remote teaching and collaboration platform. This impact report also contains stories of beneficiary grantees of KENET research and innovation grants. This is funded from 2% of the connectivity revenue.

Annex 1: Research and Innovation Grants – 2015 -2023

Special Interest Group	Principal Researcher	Lead Institution	Collaborating Institutions	Project Title	Amount
FY 2023/2024					
CSIS	Dr. John Wandeto	Dedan Kimathi University of Technology	Karatina University Nyeri County and Refferal Hospital	Microscopic urinalysis test using a convolutional neural network model for early disease detections and monitoring	1,500,000.00
	Dr. Gibson Kimutai	Moi University	University of Bremen University of Rwanda	An IoT -based Federated Learning Approach Based on CNN and Majority Voting Techniques for Sustainable Agriculture	1,500,000.00
	Dr. Mathew Egessa	Technical University of Mombasa	Kenya Marine Fisheries and Research Institute Kaimosi Friends University	Towards a machine learning-based early warning system for fish kills in cage fish culture	1,500,000.00
CMMS	Dr. Anthony Pembere	Jaramogi Oginga Odinga University of Science and Technology	Alupe University University of Eldoret Masinde Muliro University of Science and Technology	Theory guided Engineering of Zeolite Templated Carbons for enhanced selective CO_2 capture for Fuel Applications	1,500,000.00
	Dr. James Munyao Kingoo	Technical University of Kenya	Institute of Primate Research	Development of vibriophage derived endolysin computational library for application in rapid detection and control of Vibrio cholerae pathogen	1,500,000.00
	Prof. Calvin A Omolo	United States International University -Africa	Pwani University Kabarak University University of Kwazulu-Natal	Computational Design and Synthesis of Plant-Inspired Antimicrobial Peptides for Targeted Drug Delivery Against Antimicrobial Resistance	1,500,000.00
Engineering	Dr. Nicholas Oyie	Murang'a University of Technology		Digital Twin and Internet of Things Technologies for Sustainable Precision Maize Production in Kenya (DIGI-PreM)	1,500,000.0

	Dr. Davies Segera	University of Nairobi		Improving Neonatal Care: Affordable Phototherapy and CPAP Solutions in Kenya	1,500,000.00
	Dr. Abraham Mutunga Nyete	University of Nairobi		Development of a Decision Support System for the California Bearing Ration (CBR) Test Using Machine Learning	1,500,000.00
FY 2022/2023					
CSIS	Dr. Kennedy Senagi	International Centre of Insect Physiology and Ecology (ICIPE)	Strathmore University	Using Machine Learning Approaches to Infer Relationships of Insect Songs, Behavior and Weather Variables for improved Productivity of Cricket Farms for Food and Income generating in Kenya	1,500,000.00
	Dr. Dennis Kuburu Mugambi	Jomo Kenyatta University of Agriculture and Technology	Tharaka University Kenyatta University	A Machine Learning approach for Estimating Maize Yield using Bio-Physical Parameters Retrieved from Remote Sensed Dataset	1,500,000.00
	Dr. Moses M. Thiga	Kabarak University		An Integrated Clinical Trial and Machine Learning Operations Model for Artificial Intelligence Projects in Healthcare	1,500,000.00
	Dr. Betsy Muriithi	Strathmore University		Machine Learning (ML) Tools for Decision Support and Modelling of Public Health Care Resources	1,500,000.00
CMMS	Dr. Mariam Kassim Ali	Jomo Kenyatta University of Agriculture and Technology	Dedan Kimathi University of Technology	Standard Computational Approach for the Design of Doped Carbonaceous Materials for Energy Generation and Storage Applications	1,500,000.00

	Dr. Thomas Musyoka	Kenyatta University	Technical University of Kenya Jomo Kenyatta University of Agriculture and Technology International Centre of Insect Physiology and Ecology (ICIPE)	Exploration for anticancer natural bioactive compounds in East African plants against known human protein targets using In Silico approaches	1,500,000.00
	Dr. Francis Otieno	Maseno University	Maasai Mara University	Simulation of polymer: non-fullerene acceptor (NFA) complexes within the framework of density functional theory (DFT) and time-dependent-DFT (TDDFT)	1,500,000.00
	Dr. Ian Kaniu	University of Nairobi	Kenyatta University	Machine Learning Assisted Diffuse Reflectance Spectroscopy and Molecular Modelling for Rapid Screening of Pesticide Residues - A Case Study of Chlorothalonil	1,500,000.00
Engineering	Dr. Waweru Njeri	Dedan Kimathi University of Technology		Bio signal controlled electric wheelchair for people with motor disabilities	1,500,000.00
	Dr. Mutua James Mutuku	Jomo Kenyatta University of Agriculture and Technology		Integrated Research and Innovations in Additive Manufacturing for Customized Solutions Healthcare	1,500,000.00
	Dr. Cosmas Raymond Mutugi Kiruki	University of Nairobi		UNReLo Network: LoRa Ground Network for Remote Sensing with Satellite Backhauling	1,500,000.00
FY 2020/2021					
Education Technology	Moses Karani	Africa Nazarene University		Automated Artificial Language Learning using Complier Reverse Engineering	1,500,000.00
	Dr. Paul Wanyeki	Dedan Kimathi University of Technology		Teaching Engineering Drawing in an Interactive Multimedia and Augmented Reality Setup	1,500,000.00
	Dr. Ronoh Kennedy Kibet	Technical University of Kenya		Practical and Projects Based Learning (PPBL) for IoT	1,500,000.00

	Prof. Heywood Ouma	University of Nairobi		A Student-Driven, Quasi-Flipped Learning Program for Embedded Design and Machine Learning Using the Raspberry-Pi Platform	1,500,000.00
CSIS	Dr. Evan Wanjiru Murimi	Jomo Kenyatta University of Agriculture and Technology		Monitoring and prediction of domestic animals' health using internet-of-things (IoT) technologies	1,500,000.00
	Dr. John Tarus	Moi University	University of Bremen Sisibo Tea Factory	A Black Tea Fermentation Monitoring Model based on IoT and Image Processing Techniques	1,500,000.00
	Dr. Stanley Githinji Muturi	United States International University	Kenya Water Institute Kenya Agricultural Research Liverstock Organisation Ministry of Water and Sanitization	Smart Monitoring of Water Quality for Urban Irrigation and Domestic Supply by Exploiting IoT in Nairobi River	1,500,000.00
	Dr. Peter Akuon	University of Nairobi	Ministry of Health Department of Defence	RF Radiation Activity of Mobile 2G, 3G, 4G, 5G+, Wi-Fi around the Human Body	1,500,000.00
FY 2019/2020					
CMMS	Dr. Winfred Mulwa	Egerton University		Density Functional Theory investigation of possible Fe2 P-type materials for near-room temperature refrigeration	1,500,000.00
	Dr. James Mutua	Jomo Kenyatta University of Agriculture and Technology		Modeling and Additive Manufacturing of Frontier Materials for Electrochemical Energy Conversion and Storage Systems	1,500,000.00
	Dr. Lucy Kiruri	Kenyatta University	University of Embu	Building of Heavy Metal Cations -Binding of Heavy Metal Cations - Ethylenediamine (Modified) Maize Tassel Complexes: Insights from the Density Functional Theory – Molecular Dynamics (DFT-MD) Simulations	1,500,000.00

	Dr. George Manyali	Masinde Muliro University of Science and Technology	Kaimosi Friends University	Study of photovoltaic absorbers and thermoelectric materials using density functional theory	1,500,000.00
	Dr. Holliness Nose	Technical University of Kenya	United States International University - Africa	Computer-aided design and development of porphyrin-based photosensitizers for Water purification	1,500,000.00
FY 2018/2019					
CSIS	Dr. Amos Gichamba	Africa Nazarene University		Development of a framework for Automatic Identification of Hate Speech on Social Media by leveraging sociolinguist features and text-mining techniques	1,500,000.00
	Prof Geoffrey Muchiri	Muranga University of Technology	Meru University of Scince and Technology	Real Time Surveillance of Crop Pests and Diseases Using Deep Learning Techniques	1,500,000.00
	Dr. Joseph. Sevilla	Strathmore University		Digitize academic certificate using Blockchain to curb fraud: the case of a Local University in Kenya	1,500,000.00
	Dr. Andrew Kahonge	University of Nairobi		Distributer Ledger Technologies in Land Registry Transactions, a case for the Kenyan Context	1,500,000.00
FY 2015/2016					
Raspberry pi	Dr. Ciira Maina	Dedan Kimathi University of Science and Technology		Re-imagining electrical engineering education using Raspberry PiScience and Technology	1,000,000.00
	Mr. Daniel Maitethia	Meru University of Science and Technology		Use of Raspberry Pi in teaching ICT courses at Meru University of Science and Technology	1,000,000.00
	Dr. Sylvester Namuye	United States International University (USIU) – Africa		Leveraging the Raspberry Pi kit for laboratory experiments	1,000,000.00
	Prof. Ouma Absalom	University of Nairobi		Integration of the Raspberry Pi or equivalent low cost computers as student-owned teaching labs for engineering	1,000,000.00
	TOTAL				59,500,000.00

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