ISSUE 014

Engineering in KENYA

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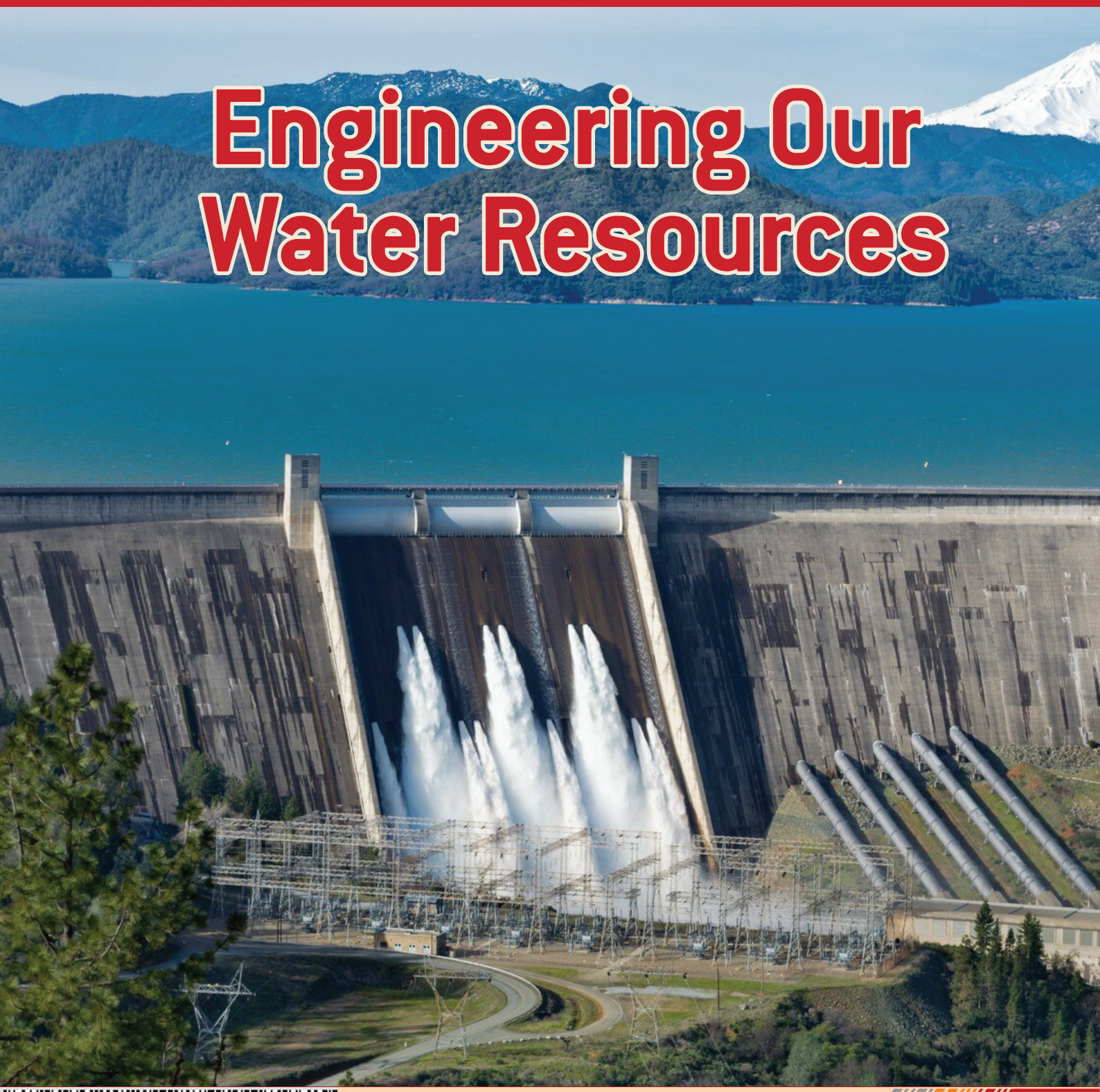
Engineering Our Water Resources



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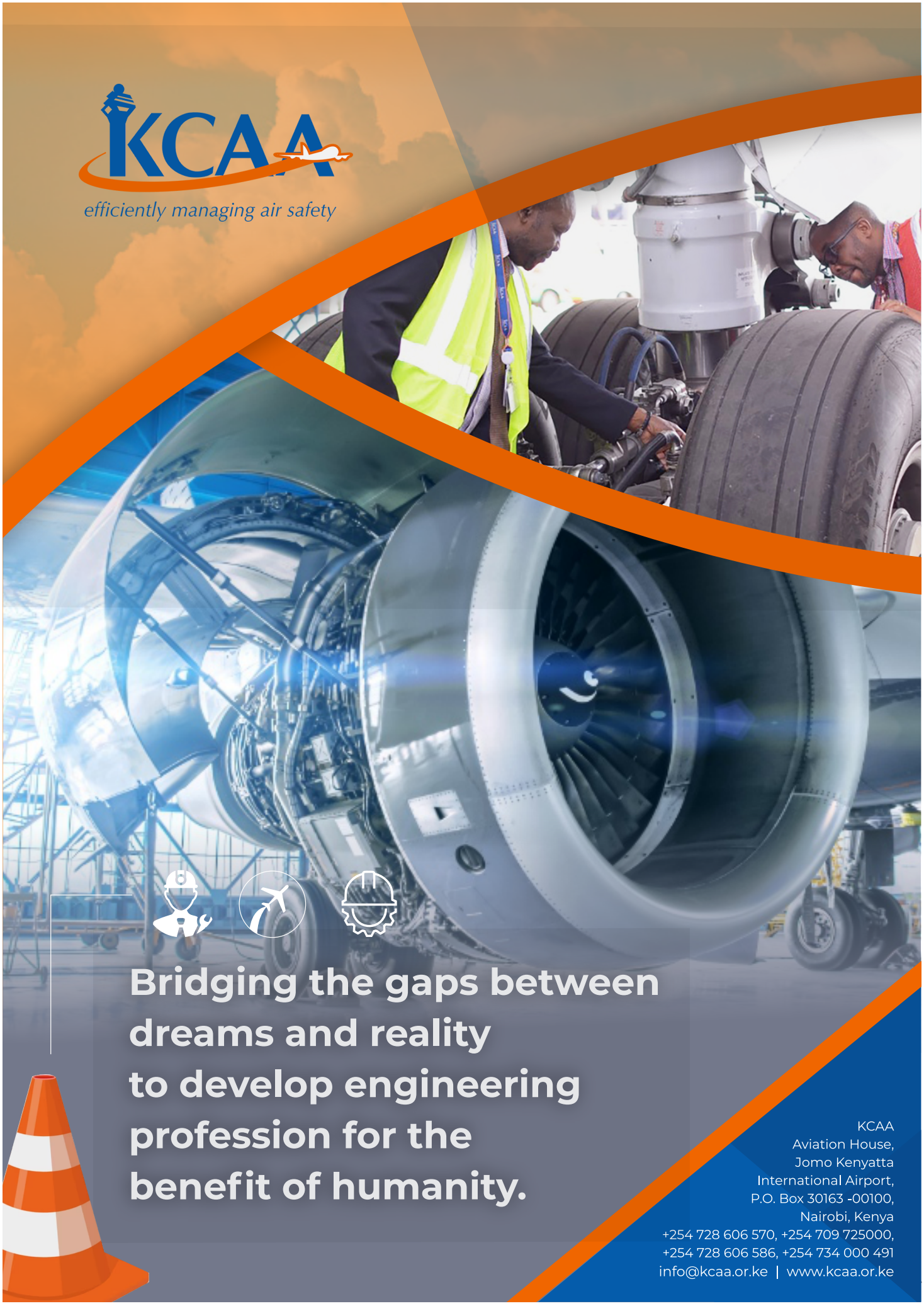
efficiently managing air safety



Bridging the gaps between dreams and reality to develop engineering profession for the benefit of humanity.

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In this Issue

Engineering in KENYA

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Call for Papers

Engineering in Kenya Magazine - Issue 015

The Institution of Engineers of Kenya (IEK) publishes Engineering in Kenya magazine, whose target audience includes engineering professionals, practitioners, policymakers, researchers, educators and other stakeholders in engineering and related fields. The publication is distributed to its target readers free of charge through hard and soft copies.

IEK invites you to contribute articles for our next and future editions. Articles should reach the Editor not later than 20th December, 2023 for our next issue, whose theme shall be "Nuclear Engineering" and related sub-themes, across all engineering disciplines. An article can range from engineering projects to processes, machinery, management, innovation, news and academic research.

The articles must be well researched and written to appeal to our high-end readers in Kenya and beyond. The IEK Editorial Board reserves the right to edit and publish all articles submitted, in line with standing editorial policy. All articles should be in Word document format, 500-700 words, font type Times New Roman and font size 12.

Send your article today, and get a chance to feature in the magazine!

Send your article to:
editor@iekenya.org

Message from the Editor

Eng. Prof. Lawrence Gumbe

The United Nations has stated that Water is at the core of sustainable development and is critical for socio-economic development, energy and food production, healthy ecosystems and for human survival itself. Water is also at the heart of adaptation to climate change, serving as the crucial link between society and the environment.

The objectives of Vison 2030 with respect to water can be summarized as: To ensure that improved water and sanitation are available and accessible to all, to increase both access to safe water and sanitation in both rural and urban areas beyond the present levels; to promote agricultural productivity the area under irrigation and drainage will increase from 140,000 to 300,000 hectares; and to introduce specific strategies to raise the standards of the country's overall water resource management, storage and harvesting capability.

Kenya is a water scarce country, demand outstrips the stock of renewable freshwater with a minority of households using water form safe sources. Available water is often inadequate for industrial, commercial, domestic as well as livestock and wildlife use leading to intensified competition among various users and often resulting to conflicts. Water is a vital requirement in hydro-power generation as hydro-power accounts for a significant part of the country's electrical power generation.

Before 1974 the Ministry of Water, Sanitation and Irrigation was a department in the Ministry of Agriculture. After this year, the Ministry was constituted. It has seen several movements and changes from the time of constitution to date. The vision of the ministry is: To ensure water resources availability and accessibility by all. The mission of the ministry is: To contribute to national development by promoting and supporting integrated water resource management to enhance water availability and accessibility.

The strategic objectives of the ministry are to: to accelerate the implementation of water sector reforms; improving the sustainable management of water resources; Improving the provision of water and sewerage services; improving utilization of land through irrigation and land reclamation; strengthening institutions in the Ministry and the water sector; mobilizing resources and promoting efficiency in their utilization; and to improve the management and access to water resources information.

Achieving water security and sustainable sanitation for all in Africa is possible by 2030 and is within the power of African leaders. This is the key message from the International High-Level Panel on Water Investments for Africa, which released a landmark report, Africa's Rising Investment Tide, on World Water Day 22 March 2023 during the United Nations 2023 Water Conference in New York. Sixteen Heads of State and development leaders sit on the Panel.

The Panel's report outlines three pathways to secure an additional US$30 billion achieve water security and sustainable sanitation in Africa by 2030 on the continent:

- Pathway 1. Achieve more impactful water spending and financial leveraging
- Pathway 2. Mobilise Domestic Resources
- Pathway 3. Secure Global and Continental Investment and Finance

Approximately US$50 billion annually, or US$40 per African per year is required, to achieve water security and sustainable sanitation in Africa by 2030. Currently, US$10-US$19 billion is invested each year.

The Panel's report signals an opportunity for a watershed investment partnership between African governments and institutional investors in Africa and abroad. The three proposed pathways outline how to unlock and scale an unprecedented pipeline of investable water projects through greater risk sharing between public and private finance. This would result in an unprecedented acceleration in both the pace and scale of financing that responds to the current global water and climate emergency.

Every US$1 invested in climate-resilient water and sanitation returns at least US$7 in societal and economic gains through improvements in health, education, energy, food security, a healthy environment, gender equality, and sustainable development goals.

African countries are currently losing up to US$200 billion/year due to insufficient investment, coupled with the impacts of climate change and inefficiencies. Over 300 million Africans do not have access to clean drinking water and over 700 million

live without access to good sanitation. Without action, climate change will make water shortages worse and lead to more food insecurity, disease burden, human displacement, conflict, and obstruct the continent's economic development.

The Panel proposes a 5-point Action Plan for Heads of State and governments, business and global leaders, to support the implementation of the three actionable pathways.

1. Establish cross-sectoral political leadership at the highest level, with commitment to substantially increase public budgets and investments for water security and sustainable sanitation.

2. Track progress and enhance mutual accountability for results in the mobilisation of water investments and in peer review mechanisms at all governance levels. Recommit to allocation of at least 5% of national budgets for the water and sanitation sector and 0.5% of GDP per annum for sanitation and hygiene programmes.

3. Mobilise new sources of funding and innovative finance by supporting matchmaking with a special focus on climate resilient, blended public-private finance, and gender transformative approaches.

4. Strengthen institutional regulation for water investments, create incentives and penalties for increased water efficiency across multiple industries to lead water stewardship efforts, biodiversity, and ecosystem protection.

5. Use official development assistance to de-risk water investments and leverage larger funding streams.

The theme of this issue of Engineering in Kenya is Engineering Our Water Resources. It has many interesting article in this area. We hope that you will be informed, educated and entertained by the articles.

The 30th IEK Convention will be held on 14 to 17 November 2023 at the Pride Inn Beach Resort Convention Centre and Spa, Mombasa. The convention is being organised jointly with the World Council of Civil Engineers, WCCE. Engineers from the private and public sectors from Africa, Asia, Europe, Oceania and the Americas will be in attendance. World class papers and panel discussions on cutting edge technologies and pertinent directions for world engineering will be presented at the convention.

Please visit the IEK website and register to attend the convention.

Picture Courtesy: Hydroelectric Power Station

Message from the President

Eng. Erick Ohaga, CE, FIEK, MKIM, AMCIARB (UK)

This edition, centered around the theme "Engineering Our Water Services," couldn't be timelier and more critical. Water, the lifeblood of our existence, underpins our agriculture, industry, and, most importantly, our overall well-being. It's no exaggeration to assert that the prudent management and equitable distribution of water form the core of sustainable development and prosperity. As engineers, we are at the forefront of this essential mission, and this magazine edition spotlights the exceptional contributions we're making to ensure clean, accessible, and sustainable water services for all.

In a world where water-related challenges are on the rise, the collaborative spirit exhibited by experts, organizations, and stakeholders in our pursuit of sustainable water resources is genuinely inspiring. This edition captures the essence of our collective endeavors to address issues such as water scarcity, pollution, and the creation of resilient water infrastructure. The shared commitment to engineering solutions that enhance our citizens' quality of life is both laudable and indispensable.

Engineers have long recognized that water is the solution of life, a resource demanding careful management, protection, and harnessing for the betterment of our nation. Water, in its diverse forms and applications, plays a pivotal role in Kenya's journey toward achieving its development goals, spanning from public health to agriculture, industrialization, energy generation, and environmental conservation.

Kenya is endowed with abundant natural water resources, from its lakes and rivers to underground aquifers. However, this blessing comes with the responsibility of ensuring their sustainable use. As engineers, we must continually adapt to changing environmental conditions, population growth, and technological advancements to ensure a clean and reliable water supply for all. Our engineers are at the forefront of addressing challenges related to water quality, scarcity, and infrastructure development, which are essential for public health and the growth of our industries.

Furthermore, we must embrace the principles of environmental stewardship in our water engineering practices. Prioritizing sustainability ensures that our water services are in harmony with the ecological balance, preserving our precious natural heritage for future generations. In this magazine, we will delve into these environmental considerations and explore the role of engineers in safeguarding our water ecosystems.

Moreover, we will delve into the critical topic of water access and equity. While Kenya has made significant strides in improving access to clean water in urban areas, challenges persist in rural and underserved regions. Engineers have a pivotal role to play in bridging these gaps, making clean water accessible to every Kenyan, regardless of their location or economic status. We will share insights and stories of engineers who are working tirelessly to enhance water access and affordability.

Water engineering, with its intricate challenges and transformative potential, is a field where our members have demonstrated remarkable ingenuity and resilience. In the pages that follow, you will encounter a series of thought-provoking articles that shed light on the multifaceted world of water engineering. From innovative technologies to eco-conscious practices, our engineering community is leading the charge in addressing the complex and pressing issues surrounding water. The stories contained herein are testaments to the dedication and unwavering commitment of our engineers who work tirelessly to create a future where every Kenyan has access to safe, clean water.

Eng. Shammah Kiteme, CE, MIEK

Message from the Honorary Secretary

In Genesis 26, it is recorded that Isaac the son of Abraham quarreled with Philistines about water wells. Interestingly, the wells were done by his father Abraham and filled up by the Philistines. So he kept opening one well after another and getting problems from the Philistines until he opened one that was not disputed. This captures events of circa. 1100 BC. More recently, Ethiopia has been in conflict with Egypt and Sudan about the Grand Ethiopian Renaissance Dam. The two countries downstream complained that the dam construction will disadvantage them by reducing the water they get from River Nile. This water is a lifeline to Sudan and Egypt. This is a demonstration that individuals as well as nations do actually fight over water resources. This has been happening as long as humans have inhabited the earth.

About two months ago I was approached by a client to advice on the water situation that had been getting worse and he wanted to consider options to address the problem now and in the future. I work a lot in healthcare infrastructure and in this sector – as well everywhere else - water is basically life as it literally saves lives. This is an ongoing conversation but I witnessed residents going days without water in an environment where water was plenty a few years ago. In this particular instance, the facility has grown and so increasing in its water demand. Interestingly, a key main source of supply for the facility has also drained and so really affecting their supply quantities.

I reflected on this scenario and well aware that there are estates in Nairobi that go days and days without receiving water supply I appreciate the water problem we face as a country. Now, we have a way of adjusting to this through increasing storage, reducing wastage etc. In this case, residents receive water once in a week or once in two weeks. They then store it in various storage containers they have acquired for this purpose. This is a survival strategy because they will not get running water in the taps any day of the week. It has to be periodic. While this can be regarded as a survival strategy, it just communicates the water scarce country that we have become.

The problem is becoming more pronounced because of the climate change. One of the reasons for decrease in supply identified for one of my clients is that a stream that was feeding a dam has since dried. This means that dam without supply now is as good as dead. The main cause of this is climate change. Weather changes are causing rivers to dry and affecting life on earth. We have had reports of how reduction in water levels in Mara river have affected the wildebeest migration in this part of the country. We have witnessed flamingo migration patterns affected in some of our lakes because of the drop in water levels that could no longer support life. Water has also caused human-wildlife conflicts in some of our counties.

We are also aware of the problem of dropping ground water table. This means that in places where boreholes were done and were supplying water, they no longer supply. The reason for this is that there is a drop in ground water table due to over extraction or reduced aquifer recharge. Even in instances where new wells have to be done, the drilling goes hundreds of meters deep compared to previous drilling which could yield sufficient flow for fewer meters for the same aquifer.

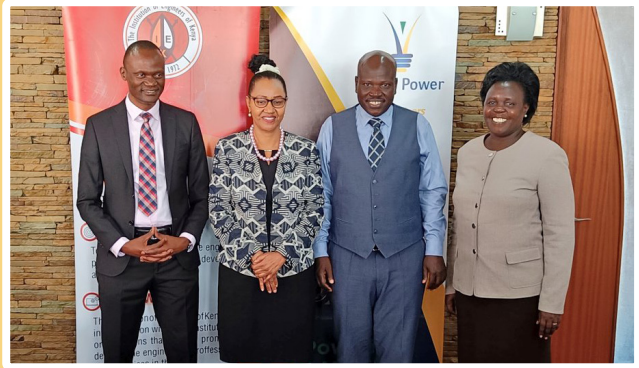
As Engineers we are supposed to be creative problem solvers. This is where our value comes in. We are wired to solve problems. The water sector is mired with many problems. Engineers must come in handy and devise ways to solve these problems. The first step is guaranteeing supply that will meet water demand of our populations. This is important. We must look at multiple sources and ensure that we supply every family, institution, facility with adequate water to support their normal operations. We must not make water rationing an acceptable norm. We must plan, design and construct ourselves out of this problem.

We must propose solutions to ensure the amount of water we receive during rainy season is fully utilized to guarantee consistent supply all the year round. This is achievable. There are countries who receive less than a tenth of rainfall we receive as a country yet because of proper planning and good engineering they are able to conserve even that little they get to support their lives. We certainly can do better in this area. We must construct dams, water pans all over the country to store enough water for our people. Only Engineers are best placed to address this both from a policy perspective but also at a technical level.

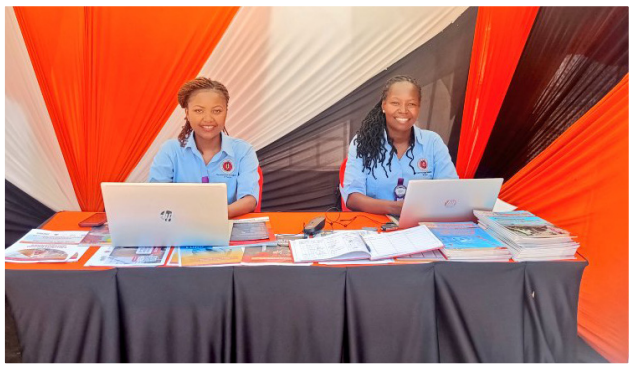
Another approach of course is distribution through reticulation to ensure resources reach everyone, this includes building intake works and pipe networks as well as storage tanks to ensure water is delivered to all the citizens. This is where our engineering is required.

Water treatment, storage and maintenance and operations of the water infrastructure is also a key part of the water sector supply chain that Engineers must focus on in ensuring that we help solve the problems in water sector. Water being a public good must be approached from the angle of human rights and so a basic right that should be guaranteed for every citizen.

I now invite our readers to this issue 14 that focuses on water resources engineering.



From L-R Eng. President Erick Ohaga, 1st VP Eng. Grace Kagondu, KPLC Managing Director Eng. Dr. Joseph Siror and KPLC Eng. Rosemary Oduor



The Institution of Engineers of Kenya Proudly Participated in the 2023 Nairobi International Trade Fair.

IEK Members during the Ordinary meeting on 21st September 2023 at the Daystar University in Nairobi

IEK President Eng. Erick Ohaga, Council member Eng. Paul Ochola and CEO Eng. Dr. Victor Mwongera during a courtesy visit to the KURA DG. Eng. Silas Kinoti held on 4th October, 2023

IEK President handing a copy of the Engineering in Kenya magazine to Mr. Paul Ngugi, the Director General of Geothermal Development Company

IEK President Eng. Erick Ohaga at a Stakeholders' Meeting convened by the Public Service Commission

IEK President Eng. Erick Ohaga, IEK Honorary Treasurer Eng. Justus Otwani, Council member Eng. Paul Ochola during a courtesy visit to the GDC DG. Mr. Paul Ngugi on 4th October, 2023

EBK Strategic Plan 2023-2028

The Board has continued to set and execute critical strategic milestones towards the implementation of the engineering education, training and practice as mandated by the Act and as guided by the Strategic Plan 2022-2023. To ensure strategic organizational and mandate delivery, EBK recognizes the need to develop a new Strategic Plan to succeed the just concluded strategic period. The Strategic period saw tremendous achievements of the set targets. The Board successfully developed the Engineers Rules 2022, which provide a clear framework for the scale of fees applicable to professional engineering services, registered 8,730 engineers in all categories, engaged with stakeholders through 20No. outreach events to foster awareness and compliance with the Engineers Act and Rules, undertook over 70 site inspection visits.

The Board conducted 25 independent reviews of engineering programs in local universities, developed a graduate engineers' internship programme (GEIP) which is a 36-month training program designed to enable graduate engineers acquire requisite skills and develop specific competencies to prepare them for professional practices. Furthermore, the Board coordinated the training of 365 graduate engineers under the agency-based model, provided professional training to 119 graduate engineers under the Board's GEIP and implemented 37 CPD programs for engineers and engineering firms, with a total participation of 6,451 members.

The new strategic plan 2023-2028 has been aligned with the Constitution of Kenya 2010, the national development agenda and other key aspirations as contained in various policy documents including the Bottom-up Economic Transformation Agenda (BeTA), the Medium-term Plan IV of Vision 2030, Vision 2030, African Union's agenda 2063 and the Sustainable Development Goals (SDGs), among other blueprint documents.

This Strategic Plan will guide EBK's actions and decisions in the upcoming planning period. EBK's vision is to create ***"Safe and sustainable engineering infrastructure,"*** while the mission is ***"To ensure production of globally competent engineers and quality engineering services through regulation, capacity building, and enforcing compliance with set engineering standards to meet the current and future needs of society."*** These goals are anchored in EBK's core values of integrity, professionalism, customer focus, teamwork, inclusivity, diversity, and innovation.

The Strategic Plan focuses on key result areas (KRAs): regulation of engineering services, development of capacity for general practice of engineering, strategic partnerships and collaborations, and institutional development. These KRAs align with our strategic objectives and will be brought to life through a detailed implementation plan, which includes strategies, activities, expected outputs, output indicators, targets, budget, and implementing actors. Additionally, the organization's governance structure has been assessed and documented to enhance successful plan implementation.

A comprehensive monitoring, evaluation, and reporting framework has been developed, along with annual key performance indicators. This framework track achievements and ensure that EBK is on track to meet its objectives. To ensure effective implementation, a coordination and risk management framework has also been incorporated into the plan. This will guide EBK in managing potential risks and challenges that may arise during the execution of the Strategic Plan.

Stakeholder engagement sessions for EBK Strategic Plan 2023- 2027

Kenya power

Kenya Power's Smart Grid Journey

An interview with the General Manager, Commercial Sales & Services

Eng. Rosemary Oduor

During an interview with Engineering in Kenya Magazine

To begin, could you provide a brief overview of Kenya Power's smart grid initiatives and their significance in the context of the country's energy sector?

Kenya Power's grid covers a large part of the country. It consists of over 7,000 kilometers of transmission lines and over 200,000 kilometers of distribution lines, with more than 70,000 transformers standing on poles and over 300 underground transformers. In the past, we managed the network manually, but it became apparent that we needed to have an automated grid for better management of our vast power distribution network. Kenya Power has since digitised parts of its grid with Supervisory Control and Data Acquisition (SCADA) being used to manage the transmission lines and the sub-transmission lines alongside automated distribution management that is used to manage the network. At the customer level, we are rolling out smart meters to improve efficiency for our customers.

What are the motivations that led to the transition from the conventional grid to the smart grid system?

With the country's commercial activities now being centered in the counties, the national grid has grown much larger. The SCADA system gives us the possibility of remotely managing the network thus reducing response time to customer issues. The smart meter management system – which includes the reading, operation, disconnection, and reconnection of individual meters - makes the service to our customers better in addition to increasing our sales.

What are the key technological components of Kenya Power's smart grid system, and how do they contribute to improved energy distribution and management?

With SCADA and Advanced Distribution Management System (ADMS), we can see a part of the network that is off. The whole automated environment has the servers and back-end servers where we store the data and the information. Additionally, we have the communication which is very critical in any smart system.

Security and reliability are paramount in energy distribution. How does Kenya Power ensure the cybersecurity and resilience of its smart grid infrastructure?

ICT now plays a key role in the whole ecosystem. This is because it sits at the core of the ecosystem enabling 24-7 surveillance and systems security backed by multi-layered firewalls.

Could you elaborate on the role of data analytics and AI in optimising the smart grid's performance and enhancing energy efficiency?

One good thing with the digitisation and AI facilities that we have in the world now is you're able to have very big data analytics. We have our meters and equipment communicating constantly which is one of the great things we've achieved with ADMS and SCADA. We're able to see the strains as they come and plan corrective action. Previously, we depended on manual inspections and manual reports that would take time which led to losses over time. Data analytics helps us see trends in increased or decreased consumption enabling time adjustment advisory and response. So AI is very critical to us.

What are some of the setbacks you have undergone in the implementation of the smart grid project?

One of the biggest issues is a culture change issue. As you move away from the old way of doing things to the new, you have to change the culture of the organisation so that takes time. Another challenge is that some things work very well in Europe but not locally.

We started the digitization of our network with Radio Frequency communication. However, it could not work in some of our environments because of the terrain and the way the Line of Sight (LoS) communication network works. So we had to adjust the technologies we had to work and leave some technologies since they never worked for us.

Are you planning to do a complete phase-out of the conventional or traditional power grid system, and completely adopt the new smart grid system?

Smartening the grid is a very capital-intensive venture. It is getting better because the costs of some of the communication components are gradually coming down. I'll give you an example: we have nine million customers and communication per meter currently is about 100 shillings per month so smartening the 9 million meters would mean that you have to have a budget of 900 million per month. You can do the math on how much that is per year. Due to this, we have to be strategic and gradual in our digitisation. The other reason is that technology changes. If you rush and do the 9 million today, five years from now you might find all the 9 million requiring a change hence we have to move strategically. Starting with the SCADA system, we have done about 60% of our primary substations making it the bigger communication system on our transmission lines and the sub-transmission lines.

We may not go to 100% quickly because of the cost-benefit analysis. We have some substations that are in remote locations and it doesn't make sense to invest in automation in these locations. We will gradually onboard these locations as our sales increase and as the cost of technology also reduces. On ADMS, we are at about 30% of the entire population, mainly in Nairobi and Mombasa. For the rest of the country, we are strategically moving to the other cities and then on to the rural areas.

How do we adapt the smart grid to accommodate renewable energy generation, and what benefits does this bring?

One of our sustainability focus areas is energy efficiency. When we consume energy efficiently, it becomes affordable. Data shows energy savings can be re-invested into the business driving up further energy consumption. We are positioning ourselves as a super energy-saving company that can support energy efficiency programmes. One area we are thinking about is sustainability and we are keen on reduction of global warming.

I am proud to say that Kenya is among the countries that have a high component of renewable energy in its energy mix. 90% of the energy that we put on the grid is renewable and 10% is thermal but there are strategies to reduce the same so that we get to a very high level, probably above 95% renewable in the long run. This helps in reduction of carbon emissions and in reducing global warming. Consequently, we will be able to have longevity and a better environment.

What plans and innovations does Kenya Power envision for its smart grid journey, and how do these align with the broader energy and sustainability goals for Kenya?

Currently in network surveillance, inspections of the network are manual. We are moving toward smart surveillance of the network using drone technologies and data analytics. This will deter theft and put preventive maintenance side by side with predictive maintenance. Currently, we have preventive maintenance schedules for our substations and some of our transmission lines.

We also want to enhance our self-service tools and outbound communication to customers. In addition, we are moving to support services in equipment monitoring, which will be on a higher level of AI compared to what we have now which will improve the network and the efficiency of the network.

WFEO Approved as UN Water and ITU Member: Strengthening Global Impact

By EiK Correspondent

The World Federation of Engineering Organizations (WFEO) is proud to announce its recent approval as a member of two prestigious United Nations bodies, UN Water and the International Telecommunication Union (ITU). These milestones mark a significant achievement for WFEO and underscore its commitment to contributing to the global community in critical areas.

This remarkable news reflects the dedication and hard work of the Executive Board and Water Committee. The journey towards becoming a member of UN Water began with an application submitted in December, demonstrating WFEO's unwavering commitment to addressing the world's water challenges. It is also a testament to the strategic decision made in 2019 to establish a Working Group on Water, which was subsequently promoted to the STC (Standing Technical Committee) in 2021. WFEO expresses its gratitude to our national members in Spain and Portugal for their invaluable support of the Water Committee.

In addition to this achievement, WFEO has received confirmation of its approval as a member of the International Telecommunication Union (ITU). This momentous development is the result of diligent efforts by the WFEO Secretariat, who prepared the application in March. A key turning point in this process was a WFEO delegation's visit to the ITU Director General in Geneva in October, underscoring WFEO's commitment to fostering collaboration in the field of telecommunications.

These dual approvals represent significant additions to WFEO's portfolio of official statuses and cooperation frameworks with various UN agencies and programs. By becoming members of UN Water and the ITU, WFEO is poised to make an even greater impact on the global stage, particularly in two crucial areas of action.

UN Water Membership: Promoting Sustainable Water Management

WFEO's membership in UN Water is a testament to its dedication to addressing one of the most pressing global challenges: water management. With increasing water scarcity and environmental degradation, sustainable water management has never been more critical. WFEO's involvement in UN Water will enable it to contribute its expertise in engineering to finding innovative solutions for water-related issues. This collaboration aligns perfectly with the United Nations' Sustainable Development Goals (SDGs), particularly Goal 6, which focuses on ensuring the availability and sustainable management of water and sanitation for all.

WFEO's global network of engineers and experts is well-positioned to address the complex and interconnected challenges related to water resources. By joining UN Water, WFEO can facilitate knowledge sharing, promote best practices, and foster international cooperation in tackling water-related issues. This membership opens doors to collaborative initiatives that will contribute to a more sustainable and equitable future for all, where access to clean water is not a privilege but a fundamental human right.

ITU Membership: Advancing Telecommunications for All

WFEO's approval as a member of the International Telecommunication Union (ITU) signifies its commitment to the advancement of telecommunications on a global scale. In an increasingly interconnected world, telecommunications play a pivotal role in ensuring connectivity, access to information, and digital inclusion. By joining the ITU, WFEO can leverage its engineering expertise to support the development of robust and inclusive telecommunications networks worldwide.

This membership provides WFEO with a platform to advocate for accessible and affordable telecommunications services for underserved communities, particularly in remote and developing regions. It also enables WFEO to contribute to the development of international standards and regulations that promote innovation, cybersecurity, and digital infrastructure resilience. WFEO's involvement in the ITU reaffirms its commitment to harnessing technology for the benefit of all, in alignment with the SDGs, particularly Goal 9, which emphasizes industry, innovation, and infrastructure development.

In conclusion, WFEO's approval as a member of UN Water and the ITU is a testament to its unwavering commitment to global progress, sustainability, and cooperation. These achievements position WFEO to make an even more substantial impact on the global stage in addressing pressing issues related to water management and telecommunications, aligning perfectly with the United Nations' Sustainable Development Goals. As WFEO continues to engage with these vital UN bodies, it reinforces the idea that engineering, innovation, and collaboration are essential components of building a better future for humanity, leaving no one behind.

REREC

Rural Electrification and Renewable Energy Corporation

Paving the way for better lives with Clean Energy

Key Deliverables of the Strategic Plan *(2023-2027)*

1. *It is envisaged that **1Million** households will be connected through electrification of **15,000** public facilities and installation of **5,000** Constituency transformers in rural areas*
2. *The Corporation plans to connect **14,000** markets with electricity in the next five years.*
3. *The Corporation will promote adoption of modern and clean cooking solutions through training of **4,500** artisans on clean cooking technologies and extension services to communities.*
4. *The Corporation will contribute of an additional **18.372MW** of clean energy through harnessing of solar resources by construction of **60 solar mini-grids**.*
5. *REREC will also install **solar photovoltaic** systems in public institutions.*
6. *The Corporation will electrify the **Galana Kulalu** project that currently on diesel generators, this will reduce the cost of food production and enhance food security in the country.*
7. *The Corporation will solarize **1,000 boreholes** in the underserved counties.*
8. *The Corporation will also acquire **e-vehicles** as aclimate change mitigation measure*
9. *The Corporation plans to increase tree seedlings production by **9 million.***
10. *Under this Plan, the Corporation has mapped its activities to specifically target gender responsive programs and projects, and inculcating an engendered work culture among staff.*

Twazidi Kuangaza

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SYNERGIZING THE RENEWABLE ENERGY TECHNOLOGIES, FOOD, AND WATER NEXUS FOR SUSTAINABLE DEVELOPMENT IN KENYA

By Fred Ishuga,
General Manager, Renewable Energy Research and Development at
Rural Electrification & Renewable Energy Agency (REREC).

Fred Ishuga

Kenya, like the rest of the developing world economies, faces the complex challenge of achieving sustainable development while addressing pressing issues related to affordable energy, sustainable food security, and access to clean water. The true potential for sustainable development lies in the synergy between renewable energy, food production, and water management. Food security, access to clean water, and sustainable and affordable energy are intertwined elements essential for the well-being and prosperity of communities and nations. In the face of climate change and population growth, harmonization of these aspects becomes an overarching need to see any sustainable development in the countries underserved areas.

The Energy Act 2019 mandates Rural Electrification and Renewable Energy Corporation (REREC) with the responsibility of developing and promoting renewable energy in the country among other functions. In the implementation of our programs, REREC endeavors to foster sustainable synergy in renewable energy technologies, food, and water nexus for sustainable development. The Corporation has installed a number of boreholes in rural areas to promote animal and crop farming in rural areas. Irrigation systems and supply of underground water to livestock has shown significantly enhance food production in Kenya. In addition to water supply, the Corporation has been at the forefront of ensuring that under-served rural communities have access to renewable energy installations of higher tier off-grid electrification that can be productive to enhance social and economic status of rural areas. Examples of Productive Use of Renewable Energy (PURE) initiativea done by REREC have enhanced the use of renewable energy-driven cold storage facilities to help reduce food wastage, extending the shelf life of perishable goods and improving food security. Mini-grids installed within Lake Turkana, Lake Victoria and Indian Ocean Islands play a great role in fish preservation. Mini-grids in other arid and semi-arid areas have played a critical role in milk, vegetables and meat preservation. At the moment, the Corporation has 27 installations of solar hybrid mini-grids under operation, 7 under construction and 31 planned for implementation by May 2025.

Even with the above success, a number of bottle necks exist. The first challenge is the huge initial capital outlay in developing renewable energy projects. Recent models on public-private partnerships, international funding, and incentives for investors can help mitigate these costs. Secondly, the lack of a centralized and dynamic data repository with proper management has exacerbated the lack of synergy in this nexus. For the effective synergizing of the nexus, data informed planning and decision making is paramount. Thirdly, adapting and scaling up some of these renewable energy solutions to meet Kenya's specific water needs require technological expertise and training. Investment in research and development is essential and should be more emphasized right from the top of the government. Lastly, the country owns weak infrastructure to efficiently integrate in renewable energy projects, such as transmission lines and water pipelines that require careful planning and investment.

Kenya's general status of water scarcity, food insecurity and energy challenges are complex, but they can be addressed with innovative multi-sectoral integrated solutions that leverage renewable energy sources. REREC focuses on solutions integrating solar, wind, and hydropower and other renewables into food and water engineering projects can secure a sustainable and resilient nexus ensuring supply for its growing population while abating its carbon footprint. By effectively synergizing this, the Corporation is keen to simultaneously address its energy supply mandate to enhance the country potential to improve food security, and ensure access to clean water resources.

Picture Courtesy: Clean Energy Equipment

Assessment of Impacts of Land Use/ Land Cover Changes in Sondu Catchment on Streamflow Variability and Implication for Hydropower Potential at Sondu Hydropower Station

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1. Introduction

The land covered by forests in Kenya is only about 3%. Forests are necessary for managing local climate conditions, restoring groundwater tables, enhancing soil fertility, minimizing soil erosion, and eventually, sediment loads in stream and river water. They also act as carbon sinks and reservoirs. As a result of economic pressures pushing people into protected forest regions, there has been a progressive decline in forest cover over time. This has happened in the Mau Forest, which has consequently affected the flow of River Sondu and the power generation at Sondu Station.

In order to evaluate the magnitude of ground cover changes in the Sondu River watershed and examine how these changes have affected river flows over the past three decades, this study makes use of the SWAT hydrological model, a distributed deterministic model for stream flow simulation, and geographic information system (GIS).

2. Methodology

The Shutter Radar Topography Mission (SRTM) Downloader, a QGIS plug-in, was used to download a Digital Elevation Model with a 30-m resolution. Afterwards, the DEM was combined into a mosaic, reprojected, preprocessed to fill any available sinks, clipped, and utilized to determine the direction of the flow and stream network. This delineated the watershed.

Landsat images from 1992, 2002, 2012, and 2022 were downloaded using the USGS Earth Explorer website. Supervised classification of the Landsat images was then done to determine various land uses and land cover. The land use images were projected, clipped, and overlaid on the catchment. Three major land uses were identified; agricultural lands, forests, and bushland.

The Food and Agricultural Organization (FAO) website of the United Nations was used to download the soil map. The map was then reprojected, clipped, and overlayed over the catchment. A database on Microsoft Access was then developed to define the soil parameters required to run the SWAT model, such as texture, hydrologic soil group, available water content, and soil depth.

Precipitation and temperature data was acquired from the Kenya Meteorological Department (KMD) in Nairobi. The daily rainfall and temperature data was acquired from 1992 to 2022. The meteorological data provided by the Kenya Meteorological Department is gridded data, which is interpolated station and satellite data.

Model calibration and validation were done by adjusting model inputs to achieve the best simulation match with the observation. For the study, calibration and validation were done manually by adjusting the parameters in Table 1. Sensitivity analysis was used to identify the most influential input parameters on model output. The period 2002- 2004 was used as the warm-up period to mitigate the effects of initial conditions. The years 2011 to 2015 were used as the calibration period. Model validation was done using the data for the period between 2005 and 2010.

Table 1. Parameters for model calibration

Parameter	Description	Calibration Range
CN2	Curve Number	-0.25 to +0.25
Soil_K	Soil hydraulic conductivity (mm/h)	-2 to +2
GWQMN.gw	Threshold depth of water in shallow aquifer required for return flow to occur (mm)	200 to 750
Alpha_BF.gw	Baseflow alpha factor	0 to 1
GW_Revap.gw	Maximum of groundwater that can be returned to the atmosphere through evaporation	0.02 to 0.13
SURLAG	Represents the surface lag time, which is the time it takes for water to travel from the surface to the stream	0 to 1
GW Delay	Time taken by groundwater to reach the stream	0 to 30
ESCO	Soil evaporation compensation factor	0.10 to 0.5
SOIL AWC	The soil available soil capacity	-0.50 to +0.50

3. Results

The study area covered an area of approximately 3470 km2. Three land uses were considered, forest cover, agricultural land, and bushland. The changes were observed for a 30-year period at 10-year intervals. A decrease in forest cover was observed over time. Agricultural land experienced an initial decrease followed by a substantial increase in the final time period. Bushland initially decreased, followed by a slight increase and then a significant decrease in 2022.

Table 2. Summary of Land Use Change (1992- 2002)

Land use	Percentages of Area Covered %			
Year	1992	2002	2012	2022
Forest	17.97	12.72	15.12	7.56
Agricultural land	15.55	14.40	32.14	87.22
Bushland	66.47	72.88	52.74	5.22
Total Percentage Area	100	100	100	100

After performing several iterations with modifications to the parameters in Table 1, the model was observed to have a good fit between the observed and simulated flows. The calibration period was chosen from 2011 to 2015. Although the model had an acceptable fit, the performance of the model was not optimal because of the inconsistencies in observed streamflow data. The observed streamflow data therefore may have not given a good representation of the catchment. The Nash–Sutcliffe model efficiency coefficient (NSE) was used to assess the predictive skill of the SWAT model.

For the calibrated model, the NSE value was found to be 0.82, NNSE of 0.85, and R2 of 0.99 for calibrated monthly flows.

$$NSE = 1 - \frac{\sum(Q_o - Q_m)^2}{\sum(Q_o - \bar{Q}_o)^2}$$

$$\text{NNSE} = \frac{1}{2 - NSE}$$

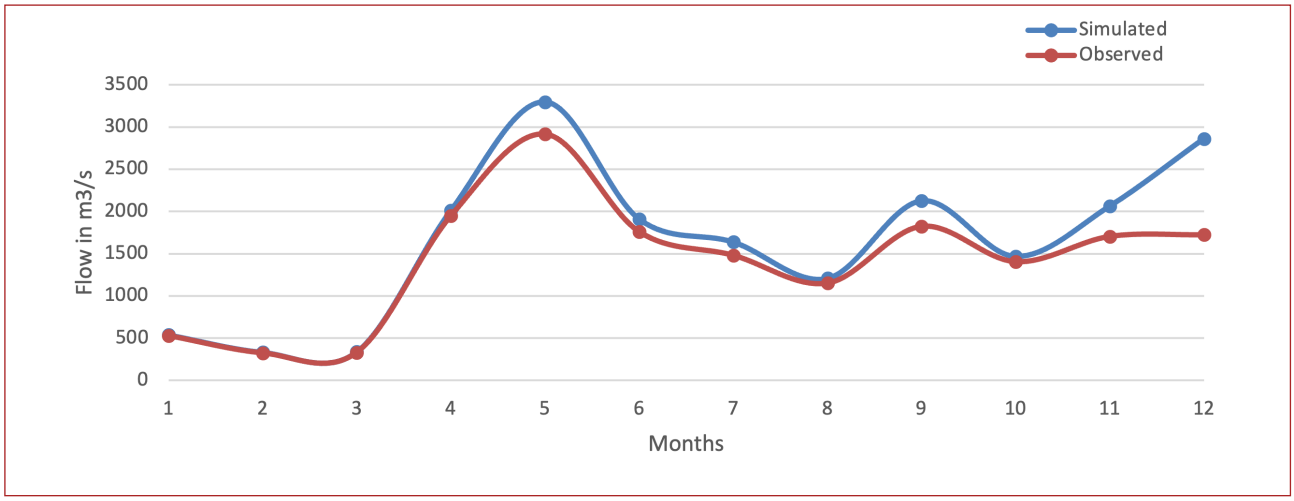

Fig 1. Model Calibration Graph for the period of 2011-2015

Fig 2. shows the outflow graph for the observed and simulated flows during the model validation period of 2005-2010. The validated model gave a good prediction of monthly flow with an NSE value of 0.87.

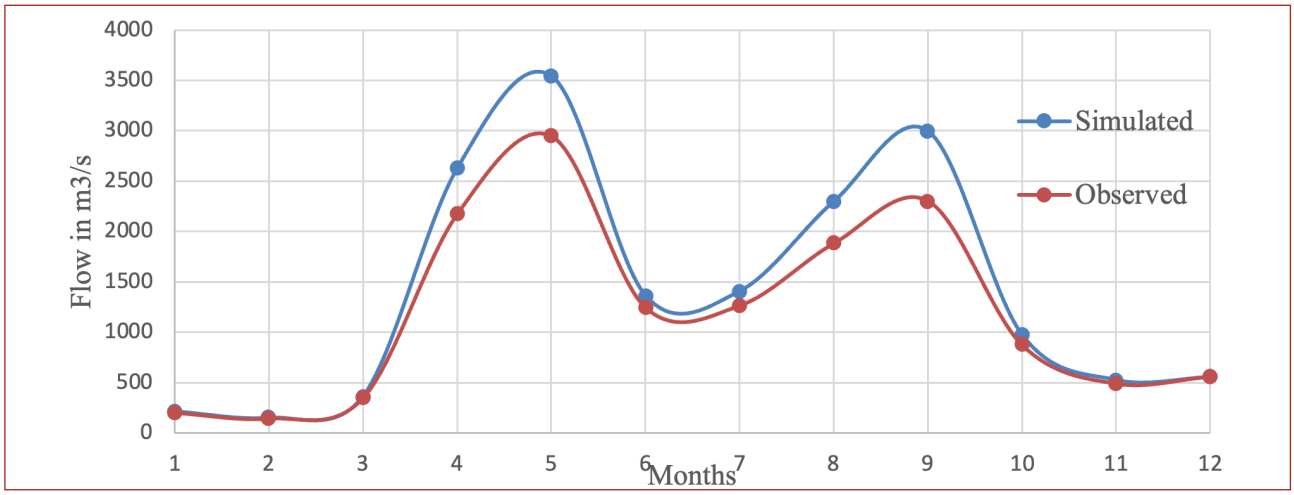

Fig 2. Model Validation Graph for the period of 2005-2010

Table 3. Goodness of fit

Parameter	Optimal Value	Calibration Value	Validation Value
R2	1.0	0.99	0.99
NSE	1.0	0.82	0.87
NNSE	1.0	0.85	0.88

The observed statistical parameters given in Table 3 indicate a very good model performance which gives a corresponding expected streamflow. The parameters aid in showing the consistency between the simulated and observed flow. Upon comparing the values with the expected general performance ratings, the calibrated and validated model was within the expected performance.

Scenario analysis was done based on a gradual increase of forest cover by altering the other land uses in the catchment.

Scenario 1: 15% of bushland converted to forest

Scenario 2: 25% of bushland converted to forest

Scenario 3: 10% of agricultural land converted to forest

Scenario 4: Terracing and the planting of strips of tea plantations on agricultural lands with slopes 10-20%

Baseline yield: 401.73 mm

Table 4. Scenario Analysis Summary

Scenario	Runoff (mm)	Yield (mm)	% increase in yield	% flow change compared to baseline
15% of bushland converted to forest	348.66	412.09	2.5%	6.3%
25% of bushland converted to forest	349.01	413.3	2.8%	7.2%
10% of agricultural land converted to forest	341.62	411.3	2.2%	5.7%
Terracing and the planting of strips of tea plantations on agricultural lands with slopes 10-20%	311.03	402.1	0.09%	1.7 %

As shown in Table 4, the yield increased gradually with increased forest cover. A conversion of 25% of bushland to forest results in a decrease in runoff and an increase in groundwater recharge, producing baseflows that stabilize the streamflow during low flows.

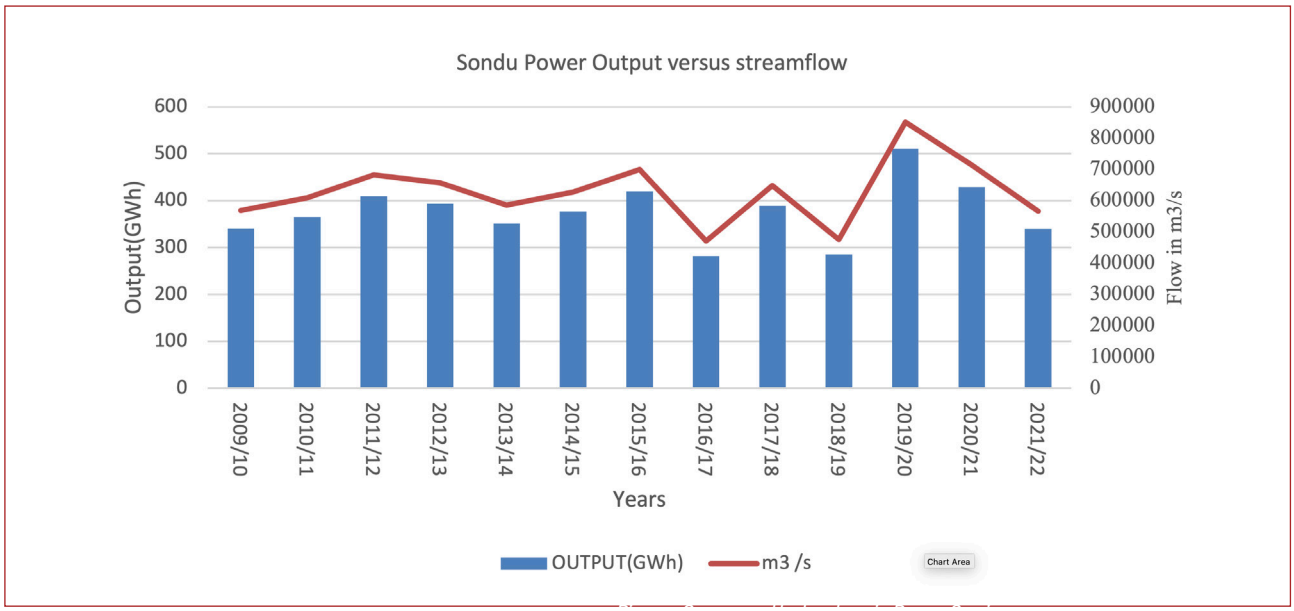

Fig 3. Sondu power output versus streamflow under base scenario

A correlation between power and streamflow was obtained as: y = 0.0006 x

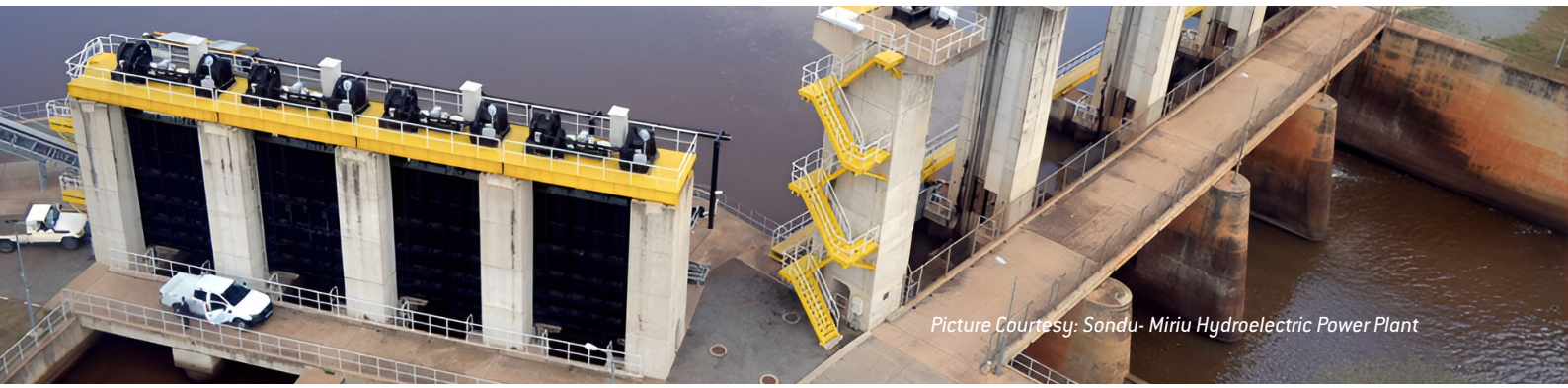

Table 5. Correlation between power and streamflow for different catchment management scenarios

Scenarios		2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	Total
Baseline	Power (GWh)	341.1	365.1	409.6	393.8	351.7	376.4	419.5	282.1	389	285.3	510.7	428.8	4553.1
	Flow (m^3/s)	568500	608500	682666	656333	586167	627333	699167	470167	648333	475500	851167	714667	7588500
Scenario 1	Power (GWh)	361.4	390.2	441.9	420.1	382.9	403.7	456.8	305.3	401.3	311.6	533.9	450.1	4859.2
	Flow (m^3/s)	602333.3	650333.3	736500	700166.7	638166.7	672833.3	761333.3	508833.3	668833.3	519333.3	889833.3	750166.7	8098667
Scenario 2	Power (GWh)	370.2	397.2	451.6	412.9	380.7	389.7	447.9	315.1	427.9	307.6	540.7	464.9	4906.4
	Flow (m^3/s)	617000	662000	752666.7	688166.7	634500	649500	746500	525166.7	713166.7	512666.7	901166.7	774833.3	8177333
Scenario 3	Power (GWh)	367.5	383.2	435.6	409.9	376.8	389.5	446.7	301.2	398.1	301.4	523.8	443.9	4777.6
	Flow (m^3/s)	612500	638666.7	726000	683166.7	628000	649166.7	744500	502000	663500	502333.3	873000	739833.3	7962667
Scenario 4	Power (GWh)	347.7	371.3	421.9	398.8	357.9	381.5	428.8	293.9	393.7	289.7	517.4	429.2	4631.8
	Flow (m^3/s)	579500	618833.3	703166.7	664666.7	596500	635833.3	714666.7	489833.3	656166.7	482833.3	862333.3	715333.3	7719667

4. Discussion

Three land use classifications were considered in this research; forest cover, bushland, and agricultural use. There were some unlikely changes from agricultural areas to bushland that were observed during the study between the years from 1992 to 2002. This may have resulted from a misclassification of bushland in 2002 or a misclassification of agricultural land in 1992. However, this comprises only 1% of the catchment that was changed to bushland as shown in Table 1, and indicates a small acceptable uncertainty of the method. There was an observed decline in forest cover, a decrease in bushland, and an overall increase in agricultural land within the period 1992 to 2022.

The study observed that over time there was increased land use change due to increased population and settlement in the area resulting in a significant decrease in forest cover from approximately 17% in 1992 to 7.5% in 2022, while the proportion of agricultural land increased from 15% to 87% in 1992 and 2022 respectively. This can be attributed to the increased population within the catchment and the need for more food production to cater to the existing food security needs. A decrease in forest cover may have resulted from illegal logging, charcoal burning, settlement, and agricultural activities. This had an effect on the evapotranspiration rates within the catchment therefore affecting the hydrological cycle. Reduced forest cover increases rainfall peaks and reduces the low flows thus reducing the reliability of the river flows required for optimal power production. There was a general declining trend in the streamflow with reducing land use cover and this was coupled with larger variability in streamflow values between minimum and maximum discharges.

The Nash-Sutcliffe coefficient represents the ratio of the residual variance to the variance of the observed streamflow. Its value is 1 when the simulated flows are identical to the observed flows. As the difference between the calculated streamflow increases, the coefficient decreases and can even become negative. The NSE, NNSE, and R^2 values in Table 3 indicate that the SWAT model adequately captured the hydrological processes and the impacts of land management practices on streamflow. These results enhance confidence in the model's performance and support its application for water resource management, land use planning, and decision-making processes in the study area.

Hydropower generation is closely tied to streamflow, as the flow of water is harnessed to generate electricity. Analyzing the relationship between streamflow and hydropower generation under different scenarios provided insights into how changes in water availability may impact energy production. It was observed that converting 25% of bushland to forest improved stream flows resulted in increased HEP generation. The increase in forest cover improved the stream flows. From the analysis, forests have a complex root system that promotes the absorption of rainfall into the soil, reducing surface runoff. This increased water infiltration helps to replenish groundwater reserves and maintain baseflow in streams, resulting in more consistent streamflow throughout the year.

Forests play a crucial role in regulating streamflow patterns by acting as natural sponges. They can intercept rainfall, allowing water to evaporate from the leaves and reducing the volume of water that reaches the ground. This interception process helps to regulate the timing and magnitude of streamflow, preventing sudden increases or decreases in water levels. Consequently, increasing forest cover can contribute to more stable streamflow regimes, which is beneficial for hydropower generation.

5. Conclusions

The ability to model and comprehend the altering hydrologic response of the Sondu catchment over time was made possible by the availability of land use, climate, and streamflow data. The model's ability to be applied to day-to-day management decisions is, however, constrained by the observed bias between the observed data and the model output, which is attributed to insufficient observed data. These findings highlight the significance of streamflow as a crucial factor in determining the potential for hydropower generation. The study confirms the hydrological link between water availability and renewable energy production, underscoring the importance of sustainable water resource management for meeting energy demands. Therefore, the necessary land management practices should be adopted.

Acknowledgement

We wish to express utmost gratitude to our supervisor, Prof. Eng. Emmanuel C. Kipkorir, for his dedicated commitment to ensure the success of this research project through his guidance, intense consultations, encouragement, and his all-time availability. We extend our appreciation to Mr. Gilbert Nyandwaro, lecturer in the Department of Civil and Structural Engineering, Moi University, and Mr. Joshua Kibiiy, former student Moi University, for the technical support that they offered in setting up of SWAT model. To the entire teaching staff of the Moi University, Civil and Structural Engineering Department, we're grateful for the invaluable feedback and guidance provided throughout the period of undertaking this research project.

We would also like to acknowledge the assistance offered to us by the Kenya Meteorological Department with meteorological data of the study area, KenGen for providing power generation data for Sondu power station and the Water Resources Authorities for providing streamflow data that we needed for our project.

Our special appreciation goes to our parents and entire family for their prayers, love, financial and moral support that facilitated the completion of this project.

This has been more than a learning experience.

May God bless you all.

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Investigation on the Use Turbidity to Estimate Suspended Sediment Load in Surface Water

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Introduction

SSC was identified by The U.S. Environmental Protection Agency (2000) as the most widespread water pollutant, inhibiting the drinking water quality, interfering with aquatic habitat and water related recreation activities. These sediments remain suspended on water bodies and settle with time, thereby contributing to settled sediment load in the long run.

Turbidity provides a visual method of determining SSC levels in water. Continuous turbidity record can reveal sediment pulses, providing information about the timing and magnitude of sediment inputs. Turbidity is used in an automated Turbidity Threshold Sampling system (TTS) to make real-time sampling decisions to facilitate Suspended Sediment Load (SSL) estimation. TTS system has been used at gaging stations in northern California, USA, since 1996 (Lewis, 2001)

This study aims at providing a simpler and cost-effective way for determining SSL in surface water using the Turbidity level approach, as compared to the conventional time-consuming methods that cannot determine SSC for particles that are less than two micrometers.

A relationship between turbidity and SSL can help in monitoring sedimentation levels in surface water bodies. A real time automatic turbidity measurement can be used to give sedimentation progress, and provide threshold alerts. This can solve the sedimentation problem, reveal the timing of erosion events and enforcing water quality regulations.

To verify the effectiveness of Turbidity-SSC relationship, this research aimed at developing a mathematical model that relates turbidity to SSL.

The study established an adequate number and distribution of laboratory manipulated samples to calibrate every significant rise in turbidity and validate turbidity against SSC. The results were analyzed statistically to develop models that relate turbidity to SSL for different soil types. Water samples from a number of water resources in Uasin Gishu county were tested for turbidity and SSC, and the results compared to those generated by the established models.

Methodology

Locations for various soil types were mapped out using remote sensing techniques. Five soil types were identified, sampled and their particle distributions established through wet sieving.

A flume simulation (Figure 1) in the laboratory to represent an artificial water course. It was inclined at a slope of 3%, to achieve threshold velocity for sediment transport, and low enough to limit scouring of bed.

Figure 1;1.2m long circulating flume simulating sediment transport

Each soil type was placed at varying depths and steady flows. Water samples were collected at intervals of 20 minutes. Samples were tested for turbidity using a portable turbidimeter. SSC were measured by determining the weight of sediments trapped in a 7µm filter paper. Turbidity (NTU) was plotted against SSC (mg/L) to establish regression models.

The research procedure is illustrated in Figure 1.

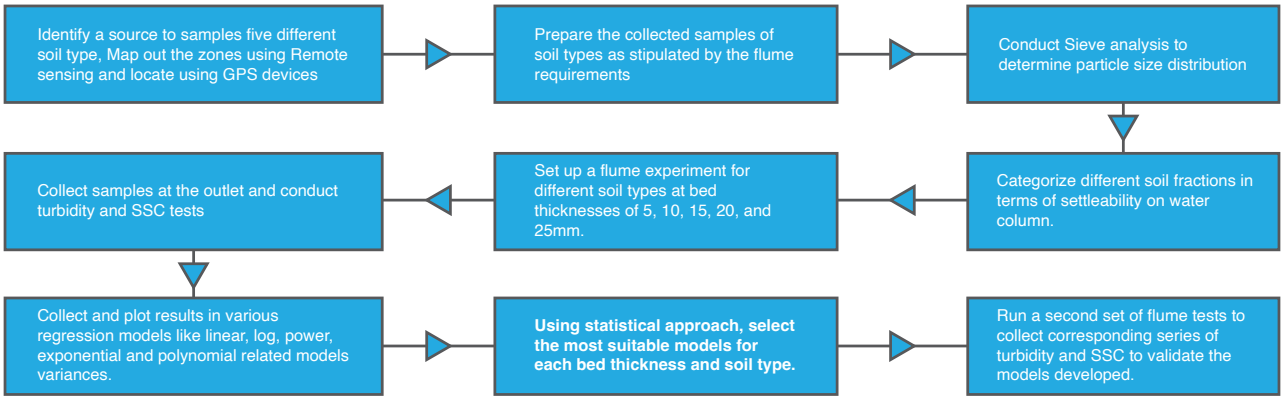


Figure 2; Research procedure flowchart

Results And Analysis

Data Analysis

Best-fit regression lines represent the relation between SSC and turbidity, and can be used to evaluate how SSC responds to changes in turbidity within and among sites. Strength of each model was established by R2. The strength of the SSC-turbidity relationship is also shown by how closely the observed data fall along the regression line.

Test results were analysed to obtain summary statistics, nonparametric match-pair tests, forms of regression models using Excel spreadsheet statistical analysis software. Summary statistics included the minimum, maximum, mean, median, total numbers of samples, and standard deviation.

Findings and discussions

Particle size distribution and bed thickness

Soils such as clayey and loamy soils with higher percentages of finer particles recorded higher Turbidity and SSC levels compared to their counterparts with lower percentages of fines. Likewise, higher turbities and SSCs were recorded at thicker water course beds. Finer particles have higher scour velocities making them easy to suspend. Mean results for Turbidity and SSC are illustrated in Table 1.

Table 1: Summary statistics for suspended-sediment concentrations and turbidity

Depth	LOAMY SAND		SANDY SOIL		LOAMY SOIL		CLAYEY SOIL		COMPOSITE	
(mm)	mg/L	NTU	Mg/L	NTU	mg/L	NTU	mg/L	NTU	mg/L	NTU
5	27.0	13.1	25.0	23.4	31.8	31.26	27.3	46.69	10.0	45.78
10	41.5	15.5	13.6	17.3	26.3	27.48	172	98.61	60.0	100.5
15	87.8	26.9	52.1	22.5	51.1	52.76	53.6	59.65	20.0	60.5
20	133	49.9	61.5	24.8	28.5	28.99	50	58.55	28.9	32.28
25	27.0	13.1	25.0	23.4	24.5	25.28	42	56.11	30.0	34.11

Regression models

Relationship models giving the most suitable line of best fit were selected as illustrated in Table 2. Selection was based on the models that produced the highest R2.

Table 2: Best fitting regression models for strongest relationship

SOIL TYPE	FUNCTION	R^2
Loamy sand	SSC = 80.603ln(Tur) - 162.65	0.834
Sandy	$SSC = 4.8691e^{0.0681*Tur}$	0.644
Clayey	$SSC=0.0033*Tur^2+0.7415*Tur-0.91599$	0.805
Loamy	$SSC = 0.7934*Tur^{1.0511}$	0.955
Composite	**$SSC=0.008*Tur^2-0.4202*Tur + 30.391$**	**0.459**

Composite soil had the poorest correlation with the lowest R2 of 0.459. This indicates that the models shall be relevant to individual soils.

Analysis of Variance (ANOVA)

Significance of the variances obtained between the actual test values, and those that were projected by the models are discussed by relevant statistical analysis tools and summarized in Table 3.

Sum of squares

Sum of squares (SS) was used to determine dispersal of independent data around the mean. It gives the difference between the actual data and the values approximated by the model. Total SS (Equation 1)

$SS = \sum(y-Y)^2$ ---- Equation 1

Where **y** is the actual while **Y** is the predicted y-variable.

Total SS = Explained SS + Residual SS where residual SS is that SS that was not explained by the model. A zero Residual SS shows a perfect fit of data in to the model, i.e. the bigger the Residual SS, the less accurate the model relates to the data and a zero residual SS show a perfect fit.

Root mean square

Root mean square (RMS) used to determine the line of best fit when the plotted data is scattered widely around the regression line. The smaller the mean squared error, the closer it is to finding the line of the best fit.

$$MS = \sqrt[2]{\frac{(\sum_{i=1}^{n} ai)}{N}} - - - \text{Equation}$$

Where; **n** = number of samples

a = Square of the difference of mean and the estimated value of SSC.

Standard error

Standard error represents the typical deviation from the actual data and that value predicted by the model. It uses the statistical data to measure the spread. For instance, a standard error of 18.0999 for the 5 mm thick loamy sand soil indicates 0.1809% error on the model in relation to the actual data.

Tests for significance

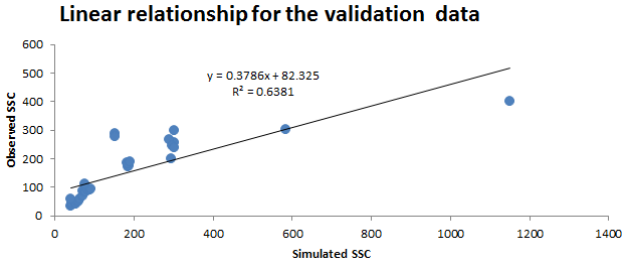
The relation between SSC and turbidity was significant statistically (p-value < 0.05) at 19 of the 21 tests. For model development, mathematical models were used to calculate SSC based on corresponding turbidity measurements. For these models, p-values were used to evaluate the model's null hypothesis for statistical significance [p-values less than (<) 0.05 indicated statistical significance] because the confidence limit was set at 95%. All the models recorded a p-value of less than 0.05, hence the null hypothesis is correct (There is a relationship between Turbidity and SSC).

Table 3: Summary for analysis of variance

Soil type	RESIDUAL SS	RMS	Std. Error	p-value	Turbidity Coefficient
Loamy sand Soil	0.3514	18.54	21.6	0	5.61
Sandy	0.360.15	9.98	5.57	0	1.46
Loamy	0.232.76	3.64	3.8	0	0.985
Clayey	4.292.6	11.58	13.74	0	1.301
Composite	6.469.4	44.44	18.29	0.0046	1.385

Validation of the developed models

Streams running though areas of different soil type covers were identified, and water samples collected for verification tests. Actual SSC test results were compared against those that were simulated by the regression models for individual soil types. Linear graph of observed SSC against simulated SSC was plotted. The strength of the correlations was above average with an R2 of 63.8% as shown in Figure 3.



Two sample t-test

Two-sample t-test uses means and standard deviations of two populations to determine if their means have a statistically significant difference. This analysis utilized the 1-tailed t-test criteria.

t is the calculated test statistic of the populations given by;

$$\text{Test statistic(t)} = \frac{(m1-m2)}{standard\ Err}$$

where m1 and m2 are the population means
$\mathbf{t_{cr}}$ is the critical t value established from distribution table.

Table3; t-tests for the selected soil types

Soil Type	t	t_{cr}	Comment
Loamy sand	1.712	1.812	**Insignificant**
Sandy	1.716	1.717	**Insignificant**
Clayey	2.397	1.746	**Significant**
Loamy	1.737	1.782	**Insignificant**

Insignificant differences in mean for the simulated and observed SSC data sets shows that the models for sandy soil, loamy sand and loamy soil beds relate to the actual river beds or watersheds made up of those particular soil types. Regression models for clayey soil proved unreliable in correlating turbidity and SSC.

Conclusion

The tests results and statistical analyses showed a positive relationship between SSC and Turbidity. For every test, there was a corresponding change of SSC for every change in turbidity of a water sample. The sample size provided reliable relationships between turbidity and SSC. These relationships generated models that were sufficient in determining the SSL based on turbidity values.

In the statistical analysis bit, the statistical significance and ANOVA interpretations clearly indicate that the SSC-Turbidity Relationship can be used to create reliable models to calibrate either of the variables from a data set of only one of the variables.

The field data sets that were used to validate the models gave a 75% confidence in these laboratory-generated models, i.e., three out of the four tests showed insignificant difference in the means of the two sets of data. This indicates some chances that the models are reliable to determine turbidity and SSC in the natural systems.

For further studies, it is advisable that the circulating flume runs for longer periods to allow the flow to stabilise before sampling starts. Moreover, considerations shall be placed on more variables like gradient and discharge, velocity, particle size and resistance among others. Thus, establish the impact of every sediment transport variable to our regression models.

Consider absorbing the most suitable regression models in to software applications that automatically determine turbidity of water. This would easily solve the cumbersome processes of determining turbidity and SSC in the laboratory.

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IEK Council led by Eng. Erick Ohaga during a courtesy visit to the Kenya Civil Aviation Authority on 4th October, 2023

IEK CEO Induction meeting at the Nairobi Club in September 2023

IEK President Eng. Erick Ohaga hands over an Engineering in Kenya Magazine to the KCAA Director General Mr. Emile N. Arao

The outgoing President of the EAFEO, Eng. Vincent Ochwo, hands over the Presidential Chain of leadership to the current President, Eng. Collins Juma of Kenya

A client visits the IEK stand during the Nairobi International Trade Fair in September 2023

IEK President Eng.Erick Ohaga gives a Keynote address at the Architectural Association of Kenya Annual Conference 2023

A team from IEK led by President Eng. Eric Ohaga, 1st Vice President Eng. Grace Kagondu, Council Member Eng. Paul Ochola and CEO Eng. Dr. Victor Mwongera at a Courtesy Visit to Kenya Power and Lighting Company (KPLC) in September 2023

Kenya National Highways Authority

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KeNHA... Engineering a New World in Road Construction

The Kenya National Highways Authority (KeNHA) is committed to develop, maintain, and manage resilient, safe, and adequate National Trunk Roads. The Authority, in delivering on this mandate, is driven by innovation and optimal utilization of resources for sustainable road development. In order to achieve this goal, KeNHA has continuously improved the road network under our jurisdiction, comprising classes S, A, and B roads countrywide. In the coast region, the Authority has revitalized the road network thus creating a seamless transport network that has led to improved sustainable development across the country and the East Africa Region. The completion of the following key projects will revolutionize economic growth in the region.

CONSTRUCTION OF MOMBASA - MTWAPA - KILIFI (A7) ROAD

The Road project is located in Mombasa and Kilifi counties. The Project, which is currently ongoing, involves the dualling of the existing highway into four-lane carriageway, is an internaitional truck road classified as A7 Road.

It starts just at the end of Nyali Bridge in Mombasa County and runs adjacent to the coastline in a north easterly direction, through Mtwapa and terminates at Kilifi town, a total of 54.1 Kilometres. The Road, once complete, will improve transport efficiency thus projecting a positive economic growth in the region. It is implemented in two lots.

Lot I: Mombasa - Mtwapa (A7) Road, an approximate length of 13.7Km, the project is currently ongoing.

Lot II: Mtwapa - Kwa Kadzengo - Kilifi (A7) Road, an approximate length of 40.4Km, the project is currently ongoing.

Kilifi Bridge

DONGO KUNDU BYPASS - MOMBASA PORT AREA ROAD DEVELOPMENT (MPARD) - PACKAGE II & III

This Road project is located in Mombasa and Kwale counties. The Project, which is projected to be fully complete in early 2024, promises to be a game changer in fostering economic growth and facilitating effective regional and international trade along the coast as the Project effectively links North Coast and South Coast border of Tanzania to the Kenyan hinterland roads.

The Project is packaged in three lots namely: MPARD Package I: Miritini - Mwache - Kipevu Link which is 10 Kilometres and was completed in 2018.

The remaining two lots are at an advanced stage of completion with MPARD Package II: Mwache - Tsunza - Mteza (Dongo Kundu) Road, with a length of 9KMs being 96% complete and MPARD Package III: Mteza (Dongo Kundu) - Kibundani Road, with a length of 7Km at 98% complete.

Mteza Bridge

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Evolution of Axle Load Control

Determination to Safeguard All Regional Roads for the Future

By Valentine Brenda

Roads are the lifeblood of economies. They connect producers to markets, employees to workplaces, students to schools, and bridges the gap between maritime, aviation, and terrestrial transport. Roads are built to design specifications commensurate to their intended usage.

This means that overloaded vehicles using roads, they are supposed to, are dangerous from a road safety standpoint. Such vehicles cause premature damage to the road infrastructure including bridges. Unfortunately, all road users suffer the consequences of damaged pavements resulting from such motorist behaviours. This leads to slower speeds and higher vehicle operating costs (VOC).

Indeed, overloading has been estimated to cause an average additional road maintenance cost of US$7,652.5 (Ksh.1,178408 at the current exchange rate) per kilometre per year. This amounts to an astounding US$43 million (Ksh.6.622 billion) as the total annual additional maintenance costs (Ochola & Odoki, 2022).

Informatively, a national network of over 161451KMs with a net worth of over KSh.3 trillion is at risk of deterioration with attendant heavy maintenance costs if strategies for protection of the same are not put in place. The strategy is the Axle Load Control.

The Kenya National Highways Authority (KeNHA) is mandated - under Section 4 (2) (d) of the Kenya Roads Act, 2007 - to ensure adherence to rules and guidelines on Axle Load Control.

KeNHA, therefore, monitors axle compliance by weighing vehicles and enforcing relevant provisions of the Kenya Roads Act, 2007, Traffic Act Cap 403, and the East Africa Community Vehicle Load Control (EACVLC) Act, 2016 to deter transporters from breaking axle load control rules, control transportation of abnormal and special loads as well as sensitize the public and other stakeholders on axle load control.

The aforementioned Acts stipulate the permissible axle load limits and maximum gross vehicle weights for different categories of automobiles. To ensure proper enforcement of these laws, KeNHA entered into a Memorandum of Understanding with the National Police Service and established the Axle Load Enforcement and Highways Unit (ALEHU).

It is this unit - Alehu - that aids the Authority to monitor axle weights through eleven (11) static weighbridge stations, twenty three (23) virtual weighbridge stations, and twenty two (22) mobile weighbridge surveillance teams.

Static weighbridges have often been perceived as Non-Tariff Barriers to faster movement of goods within the country and region. To mitigate this, KeNHA has introduced weigh-in-motion (WIM) technology that has evolved from, slow-speed WIM systems to High-Speed-Weigh-in-Motion HSWIM systems.

The HSWIM systems filter trucks at high speeds on dedicated auxiliary lanes adjacent to static weighbridges where only vehicles suspected to be overloaded are called in for weight confirmations. The compliant vehicles are cleared to proceed at maximum high speeds, although the system have the capacity to clears vehicles up to speeds of 140 km/hr.

Virtual weighbridges also supplement static weigh stations by weighing vehicles in motion without the need to stop. Other innovations for seamless Axle Load Control (ALC) include the adoption digital mobile scales that have enhanced integrity and reduced human error by digitizing mobile vehicle weighing operations.

In 2021, KeNHA rolled out KenLoad Version Two (2), an improved web-based software for collecting and managing data from weighbridge stations. These concerted effort in axle load control, through infrastructure investment and enforcement, has culminated in KeNHA recording a commendable over 98 per cent compliance with axle load limits in FY 2022/2023.

The Authority is fully implementing the regional Axle Load Control laws, which seeks harmonization of weighing standards and equipment in the region. To achieve this, KeNHA is leveraging on Kenya's membership to the 26-member Tripartite Transport and Transit Facilitation Program (TTTFP). The seminal objective of this Program is the development of the Vehicle Load Management Agreement (VLMA). This is geared towards standardizing axle load and vehicle dimension limits, mobility restrictions, and demerit points systems related to non-compliance across the region all while providing the necessary technical assistance to member countries.

Notably, KeNHA installed weighbridge stations are enforcing harmonized axle load limits in accordance with TTTFP's Technical Assistance. This has solidified KeNHA's commitment to smooth cross-border transport and safeguarding the structural integrity of the country's roads.

Circularity in the Fashion Industry

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1. Introduction

It is estimated that 92 billion tons of textile waste is created by the fashion industry and this is set to increase by 60% by 2030 (Rauturier, 2022). The Textile and Apparel (T&A) sector being the third most polluting industry, preceded by the construction and food industry, with only about 12% of the collected fashion waste being recycled and about 73% being burned or sent to landfills (World Economic Forum, 2019). A cost to the environment of 10% in green-house gases and a cost to the industry of $560 billion in unused recycling opportunities is also sustained. With the rising concerns of climate change, the T&A sector continues to receive pressure from various stakeholders to embrace circular solutions which will have the economy enjoy approximately USD 192 billion of benefit by 2030 (Ellen MacArthur Foundation, 2017). Besides, the Intergovernmental Panel on Climate Change emphasizes on the need to reduce the global carbon emissions by approximately 45% from the 2010 levels. This will aid in the attainment of net zero carbon emission by 2050 and limit global warming to an increase of 1.5- (IPCC, 2019). In addition, there is so much social, economic and environmental benefit across the T&A value chain that comes with adopting circular business models.

2. Methods and Materials

The T&A value chain is complex as it consists of various stakeholders who influence the fashion industry at different capacities. To better understand this value chain and the applicability of circular business models, the study focuses on the journeys of raw materials, finished goods and that of fashion waste, with the main destinations being termed as the global north (Europe) and global south (mainly Africa). Within the context of potential circular solutions, this paper focuses on two principal areas of availability and access to the industry's waste materials. Firstly, the pre-consumer waste of manufacturers and brands that is currently being destroyed in Kenyan garment manufacturing facilities, mainly located at the Export Processing Zones (EPZS). Secondly, the post-consumer waste that is collected in Kenya and that shipped in from overseas. For each source, their availability, access, quality and overall suitability for circular economies are assessed. This study focuses on waste produced as a result of the trade engagements between the global south and global north. A combination of review of literature, observation and discussions with experts in the T&A industry was used to collect and analyse data.

3. Fashion Waste

Classification of Fashion Waste

Fashion waste is categorized into two: Pre-consumer waste, also known as post-industrial waste, which includes waste from all points in fashion's value chain up to the purchase of the products and which is responsible for roughly 30% of fashion's waste; and the post-consumer waste which is the waste generated after the T&A product has been purchased for use and makes up the balance of about 70% of the industry's waste (Son of a tailor, 2019). Pre-consumer waste mainly includes the waste produced from the production and processing of fiber into fabric and fabric into garments (Dissanayake D. & Dakshitha W., 2021), and unsold stock/deadstock, which refers to garments not sold by brands or those returned to retailing stores, mainly after online purchases (Niinimaki et al, 2020). Post-consumer waste is the industry's worn/used and discarded clothing. Figure 1 summarizes the types of waste along the T&A value chain.

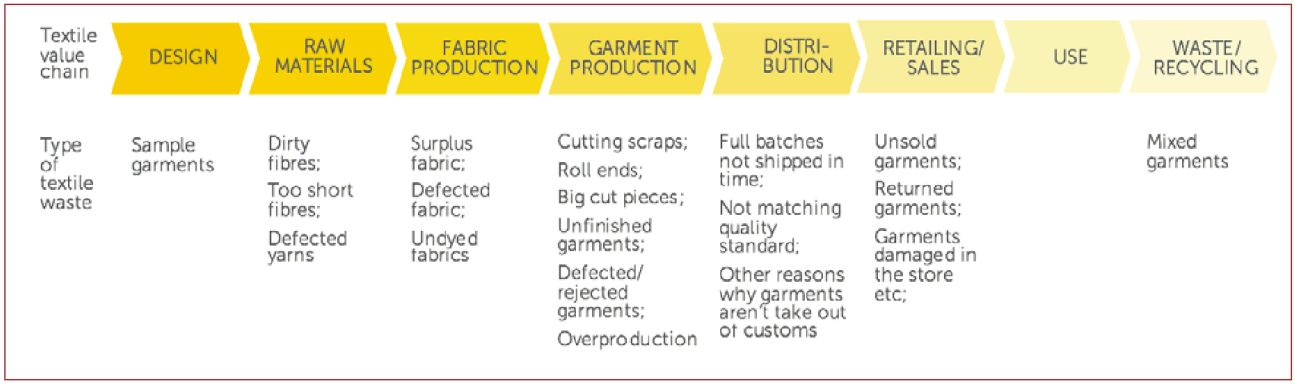

Figure 1: Simplified Textile & Apparel Value Chain and Examples of Waste at Various Phases

Source: Reverse Resources (Reverse Resources, 2017)

Availability of Fashion Waste

Fashion waste arising from the manufacturing processes is determined by variables such as the garment type, garment design, fabric width and the design of the fabric surface, for example, one-directional prints that result in more waste (Niinimaki et al, 2020). Studies show that about 15%-25% of all fabric used to make a garment is wasted (Cooklin, 1997) (Kasemset, 2015) (McQuillan, 2019). The overproduction practice by major manufacturers and retailers is systemic and global. This is done to catch the high and dynamic demands of the market. This adds to the volume of unsold stock that is disposed with the fast-changing fashion trends.

Manufacturing products are predominant in developing countries where manufacturing facilities are mainly located, whereas unsold stock is mainly found in developed countries where they are exported for sale. A study done by Reverse Resources on the Undiscovered Business Potential of Production Leftovers within Global Fashion Supply Chain shows that the amount of waste produced is underreported and therefore its value is underestimated (Reverse Resources, 2017). As many apparel manufacturers and suppliers do not offer digital transparency of waste produced, it is difficult to trace this waste and to create sustainable interconnections in the T & A industry.

There has been an increase in the generation of post-consumer waste due to the increase in production as fast fashion brands are now producing a variety and twice the number of textiles produced in 2000 (Martina, 2023). This has equally influenced consumerism which results to overconsumption and underutilization of purchased garments. Annually, the average consumer now buys 60% more clothing than they did 15 years ago, but only keep the clothes for half as long as they used to (McKinsey, 2019). About 56 million tonnes of clothing are bought each year globally (Beall, 2020). This is expected to rise to 93 million tonnes by 2030 and 160 million tonnes by 2050. With low rates of wear times and recycling, clothing (post-consumer waste) ends up in dumpsites and incinerators, and cause adverse effects to the environment. Just as the pre-consumer fashion waste, it is difficult to quantify the volumes of post-consumer waste collected globally, due to lack of efficient waste collection and disposal systems.

Quality of Fashion Waste

The nature and quality of pre-consumer waste can be discussed in regards to the types of waste produced at different stages of the value chain. Fibre and yarn waste are produced at the first stages of the value chain and are of a lower quality as they cannot be incorporated in the next manufacturing stages. Excess fabric in the form of leftovers and those with no defects are of high quality as the fabric has already undergone more value addition and it can therefore be used to produce new products if the fabric is suitable. Therefore, companies keep them for future use, but if not used in the short-term, they discard them. Rejected garments that are returned to the manufacturers by retailing brands due to quality issues such as colour shading are of a lower quality compared to deadstock, but are of a greater quality compared to production waste such as the cutting waste. Deadstock which remains unsold by manufacturers and retailing brands is of high quality as the garments are new and unworn. The quality of post-consumer waste varies with period of use and the care given to the product before disposal, and this determines its end application in the context of reuse.

The Journey of Fashion Waste

According to a Green Peace Germany Report (Greenpeace, 2022), the Global North has a waste problem as their fast fashion business models largely relies on the Global South for disposal of their textile waste. Textile waste disguised as second-hand clothing, commonly referred to as “Mitumba”, is exported to developing countries, with developed countries claiming that this is a way to help the less privileged nations such as Kenya. In 2020, Green Peace International reported that Kenya ($122M worth clothing), was one of the leading importers of second-hand clothing. However, this is a tactic to avoid the cost and responsibility that comes with the problem of waste management. As it is not mandatory for brands to report on the amounts of pre-consumer waste produced and for countries to report on where their post-consumer waste ends up, there is no consistent data on the journeys of textile waste.

Stakeholders in the global trade of second-hand clothing consists of fashion brands, manufacturers, consumers, charitable organizations, recyclers, rag traders, international shippers, local importers and other institutions. All stakeholders play various roles in the journey of textiles. Prior to export charities such as Planet Aid (Planet Aid, 2023), Traid and Goodwill Industries International, sort the best fits for sale in their shops, while recyclers such as the Secondary Recycled Textiles Association (ABC News, 2006) and other commercial clothing sorters sort what they can recycle and down-cycle (e.g., used as cloths and rags for industrial use), while some amount is landfilled or incinerated. Recyclers then sell to international shippers who bale the remainder and export it to developing countries as second-hand clothes.

Approximately, 25-50% is down-cycled in the country of origin, 45-60% is exported for re-use as clothing, and 5-10% is disposed as waste before export. A small percentage of post-consumer waste (clothes) is re-sold in the countries of collection, with the rest being exported overseas (Brooks,2015). On arrival at the ports such as the East African ports, containers of second-hand clothing are shipped to other inland African countries in trucks and delivered to the inland container depots. Local importers purchase bales in warehouses and supply big markets such as Gikomba in Kenya and Kamanto in Ghana. Big Mitumba markets such as open the imported bales of clothing and redistribute to other consumer markets such as Toi market in Kenya. From here, other retailers such as street sellers, up-cyclers and those who sell in shops and through social media get to purchase their best fits.

Textile waste management in Kenya

With the aim of achieving circular economies, the European Union gives options of waste management as in figure 2, with prevention being a key strategy (EC, 2023). However, fashion waste management techniques in the present day include incineration, landfilling, reusing, upcycling and recycling.

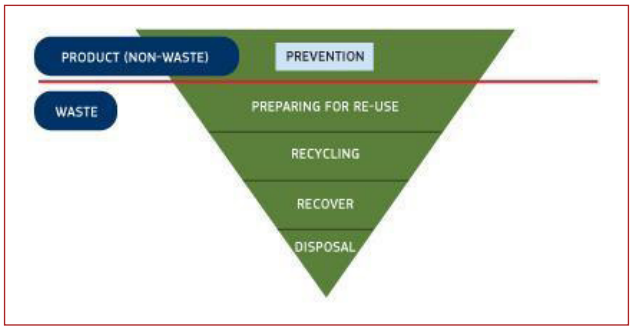

Figure 2: The EU Waste Hierarchy

Source: The European Commission

Just in like most developing countries, little to no recycling of fashion waste is being done in Kenya. This can be attributed to several factors. Firstly, manufacturers and retailing brands of T & A products are the greatest influencers of pre-consumer fashion waste management and therefore, the methods of textile waste management are largely determined by brands who manufacture in developing countries, with most opting for incineration or landfilling, as they deem recycling to be costly due to the complexity of raw materials used and the unreliable recycling technologies (Dissanayake D. & Dakshitha W., 2021). Besides, some term these techniques as safer, in terms of

protecting their brand identities, as waste is shredded before landfilling or completely burnt. Some of the waste collected is however down-cycled for use in applications of lower value such as in industries for wiping or in filling of furniture. When down-cycled, it is hard to recover this value a second time and so most of the waste ends up in incinerators and landfills.

In the context of post-consumer fashion waste, second-hand clothes are in high demand due to their affordability, better quality and style compared to new clothing which is deemed expensive and which does not guarantee better quality. Mitumba undoubtedly contributes to the economy of African Countries such as Kenya and Tanzania. However, assessing quality second-hand clothes is a challenge as a large percentage of the imported clothes are of poor quality and are landfilled or incinerated in open air and disposed in waterways, immediately on arrival from the ports. This is an addition to what is directly disposed or burnt by consumers. Kenya imported 185,000 tonnes (UNEP, 2021) of second-hand clothing in 2019 and according to local sources such as Afrika Collect Textiles, about 30-40% of imported clothing is usually of bad quality and cannot be sold in the local markets (Greenpeace, 2022).

Overall suitability of upcycling as a circular textile waste management strategy

The value of both pre-consumer and post-consumer fashion waste is undermined and the volumes upcycled globally are undetermined, in spite of its use being a vital technique that extends the lifecycle of textiles. Its major benefit is the retarding of unnecessary production which consequently improves natural resource management. Waste, in the form of swatches, cuttings, headers, yarns, scrap from production, trims, unsold and rejected stock, is converted to products of better quality and more value, unlike recycling where products produced are of a lower quality and value compared to the waste material despite of it undergoing major alterations which are resource and energy intensive (Textile Value Chain, 2020). Basically, upcycling only requires minor adjustments such as ripping seams and sewing back the fabric pieces to create garments of different designs and higher value. In Kenya, Institutions such as Africa Collect Textiles are in the forefront of utilizing post-consumer waste to manufacture textile products such as bags, mats and bags for both the local and international markets.

Remanufacturing (Ellen MacArthur Foundation, 2017) is another aspect of upcycling, with the only difference being that the garment is not produced from 100% recycled fabric and is often practiced in the company where the waste is produced. A study conducted by Reverse Resources on The Undiscovered Business Potential of Production Leftovers within Global Fashion Supply Chain (Reverse Resources, 2017), reported that more than a quarter of pre-consumer waste fabrics collected are bigger than 18 inches and would be best remanufactured before recycling. Small pieces of fabric should be recycled as they cannot be reused in upcycled or remanufactured garments. Remanufacturing is further classified as visible, invisible or design-led, depending where the waste material is incorporated in the garment manufacturing process.

Upcycling avail opportunities of reducing environmental impact as much waste is diverted from landfills and is prevented from incineration by fashion designers who make outstanding upcycled products. Application of remanufacturing in production has the potential to reduce the amount of pre-consumer production waste disposed and to save up on virgin fibre used. Unlike recycling, upcycling does not require huge investments in technology. The latter entail making slight changes and improvements in regards to waste collection, segregation and storage for ease in assess and retrieval. This can be achieved by enhancing transparency and visibility along the T&A value chain, especially between designers and the factory, both internally for remanufacturing and externally for upcycling.

As upcycling entails the design and assemble of new textile products using excess fabric or fabric from disassembled garments, much time and cost is not needed to understand the composition of individual materials and additional materials needed for the process, as in recycling. For example, virgin fibres are often added to improve the quality of recycled fibres, and minimal resources such as chemicals, water and dyes are used as there is often need to re-dye and bleach. Both upcycling and remanufacturing processes eliminate the cost incurred to access materials through intermediaries. Small scale fashion designers can easily access these materials by upcycling their personal clothes, acquiring from friends, family and charities, or by purchasing affordably in thrift shops. Remanufacturing is often done internally by the initial manufacturing company.

Opportunities for upcycling and stakeholder responsibility

To improve on the performance and availability of sustainable recycled materials and products, brands, consumers, retailers, recyclers, designers and the government need to co-operate to establish optimal solutions to scale up upcycling activities. This will allow the industry to capture the value of disposed material and ensure fair competition of upcycled materials against virgin materials on speed, price and choice, thus availing sustainable fashion to all. The industry will enjoy much value in terms of social, economic and environmental sustainability with adoption of upcycling initiatives.

This can be achieved by bridging of the gap between apparel manufacturing and upcycling companies to provide ease assess of fashion waste; and improving the quality and economics of upcycling through innovation of technology, for example by investing in infrastructure to better textile waste collection, sorting, closed-loop recycling and up-cycling practices and providing training and upskilling support for collectors, sorters, recyclers and up-cyclers to explore the alternatives of re-purposing collected pre-consumer and post-consumer waste. In addition, spiking demand for upcycled materials and products through policy making and establishment transparent and visible channels between recyclers, up-cyclers and factories. This can be coupled with consumer awareness to change their perception towards upcycled products and drive them towards responsible and ethical consumerism.

Lastly, the government and policy formulation bodies such as the European Union and Kenya Bureau of Standards should implement policies and regulations to further the agenda of circularity. Other potential legislative and policy strategies include the establishment of Extended Producer Responsibility schemes that mandate firms to invest in upcycling services; offering grants to circular small and medium enterprises to promote upcycling; and incorporation of sustainable solutions when making and renewing trade agreements.

4. Conclusion

Review of many years of research has proven that the current linear fashion business model is extremely wasteful and polluting, and the impacts on the economy, people and the

environment continue to rise with the "fast fashion" phenomena. It is also evident that the volumes of both pre-consumer and post-consumer waste are underreported and therefore, their value and the alternatives available to manage this waste are underestimated. Besides the much fashion waste landfilled and incinerated, there is a huge percentage available in good quality and can be readily used in upcycling designs that utilizes waste of all sizes.

From this study, the upcycling alternative is a viable and feasible opportunity where greater value of waste can be recovered at relatively low costs compared to recycling. In the context of environmental sustainability, negative impacts such as the release of toxic emissions, depletion of resources and negative impacts to human life still result from recycling, but at a lower rate compared to processing of virgin fibres, and much lesser one when upcycling. Economically, upcycling companies enjoy more revenue compared to recycling and create more job opportunities in the fashion industry. However, the complexity of the textile value chain, lack of visibility and transparency and inefficient collection and distribution systems, render the access of up-cyclable waste difficult. It is therefore important that all stakeholders understand and take on their responsibilities diligently, to drive circularity in the T&A industry.

Acknowledgement

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THE INSTITUTION OF ENGINEERS OF KENYA COURTESY CALL TO KENYA CIVIL AVIATION AUTHORITY

By Jebet Faith

In the world of engineering, collaboration and continuous learning are the driving forces that propel industries forward. A recent courtesy call by the Institution of Engineers of Kenya (IEK) to the Kenya Civil Aviation Authority (KCAA) Headquarters on 4th October exemplified these principles, setting the stage for a promising partnership. Led by IEK President Engineer Erick Ohaga, this meeting marked by gratitude, collaboration, and shared vision, illuminated the path towards further advancements in the aviation and engineering sectors in Kenya.

From right, KCAA DG Mr. Emile N. Arao, IEK President Eng. Erick Ohaga and Eng. Paul Ochola.

IEK, the learned society of the engineering profession, has always stood at the forefront of engineering development in Kenya. In alignment with its mission, IEK seeks to cooperate with both national and international institutions, with the shared goal of applying engineering for the benefit of humanity.

IEK's vision extends beyond its own community; it encompasses the broader engineering landscape of Kenya. In this spirit, IEK expressed its interest in sponsoring the upcoming 30th IEK Convention and extending this sponsorship to KCAA engineers. This request also extends to logistical support, including airport transfers, ensuring a seamless experience for convention delegates This support not only signifies IEK's commitment to knowledge sharing and innovation but also positions KCAA engineers at the forefront of cutting-edge developments in the field.

IEK's recognition of KCAA's efforts in training and mentoring its engineering staff, leading to the registration of eight professional engineers, is commendable. The proposal to collaborate in fast-tracking the registration of interested KCAA engineering staff through mentorship programs demonstrates the commitment of both organizations to continuous development.

Members present during the discussion presented by Eng. Paul Ochola.

IEK's commitment to advocacy aligns with KCAA's vision for a robust aviation sector. IEK's interest in working with KCAA to develop focus areas for advocacy underscores the collective responsibility of both organizations in addressing critical issues affecting engineers and engineering in Kenya. The advocacy efforts aim to enhance the aviation and engineering landscape, ensuring that the concerns and interests of professionals are championed in both public and industry forums.

The courtesy call by IEK to KCAA exemplifies the spirit of collaboration and shared goals between professional institutions and regulatory bodies. The proposals and remarks made during this interaction pave the way for a promising partnership that can drive advancements in the engineering and aviation sectors in Kenya. As these two entities join forces, the future holds the promise of innovation, growth, and excellence for the professionals and industries they represent.

KCAA and IEK'S Group photo session at KCAA HQ

Climate Change Against National Commitment for Developing Countries - Adaptation by Power Utilities: A Case Study for Kenya

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1. Introduction

Kenya's ministry of energy and petroleum makes and articulates energy policies to create an enabling environment for efficient operation and growth of the sector.

The energy and petroleum regulatory authority (EPRA) regulates and licenses players in the entire energy sector. Its other functions include tariff setting and oversight, coordination of the development of the integrated energy plan monitoring and enforcement of sector regulations e.g. the energy management regulations.

Kenya's energy act 2019 sets up other agencies, namely:

- Nuclear Power and Energy Agency (NUPEA) to handle nuclear energy programme.
- Rural Electrification and Renewable Energy (REREC) to manage the rural electrification projects.
- Kenya Electricity Transmission Company (KETRACO) to manage the electricity transmission assets.

Other key energy sector players are Kenya electricity generating company (KenGen) that generates the bulk of energy consumed in Kenya and the Kenya power and lighting company (KPLC) that does the power distribution and retail functions in the country.

In 2020, the Ministry of Energy released the Kenya National Energy Efficiency and Conservation Strategy [4]. It establishes energy efficiency targets in the buildings, industry, agriculture, transport, and power sectors to meet the goal of reducing the national energy intensity by 2.8% per year. The strategy also aims to ensure that energy efficiency measures contribute to the achievement of the nationally determined targets (NDC) by keeping Green House Gas (GHG) emissions as per the targets in table 1 below.

2. Methods

In Kenya, climate change action is guided by the climate change act 2016 which provides the framework for mainstreaming climate change across all sectors of the economy. The law has been applied to the development, management, implementation and regulation of mechanism to enhance climate change resilience and low carbon development for sustainable development in the country.

The act obligates the cabinet secretary responsible for climate change affairs to formulate a five-year national climate change action plan (NCCAP) that addresses all sectors of the economy. The plan covers thematic areas of agriculture, forestry, industry, energy, transport and waste. The first NCCAP ran from 2013-2017 and the second from 2018-2022.

Table 1 below shows Kenya's emission reduction potential and the nationally determined contribution (NDC) targets by sectors (in $MtCO_2e$ per year) projected to 2030:

Table 1: Kenya's emission reduction potential and the NDC targets by sector (in $MtCO_2e$ per year [3])

	GHG Emission reduction potential(MtCO2e)				NDC Target
Sector	2015	2020	2025	2030	2030
Forestry	2.71	16.24	29.76	40.2	20.1
Electricity generation	0.28	2.24	8.61	18.63	9.32
Energy demand	2.74	5.16	7.92	12.17	6.09
transport	1.54	3.52	5.13	6.92	3.46
Agriculture	0.63	2.57	4.41	5.53	2.77
Industrial processes	0.26	0.69	1.03	1.56	0.78
waste	0.05	0.33	0.5	0.78	0.39

Table 2 below is a summary of the various energy mitigation actions for the electricity generation and demand sectors above:

Table 2: Estimated technical potential emission reduction by 2030 [6-7]

		MtCO2e
Electricity Generation	Clean coal	1
	landfill gas generation	0.4
	Solar-grid connected	0.65
	Hydro	1.1
	wind	1.7
	Geothermal	14

Energy demand	Solar thermal water heating	0.2
	Energy efficient light bulbs	1.1
	LPG stove substitution	1.4
	Renewable lamps	1.8
	Cogeneration in agriculture	1.75
	Improved cook stoves	5.7
Total		30.8

The 2018-2022 NCCAP encompasses development of new 2,405MW of grid-connected renewable power generation and retirement of three thermal plant. The highest mitigation opportunity is in geothermal expansion, envisaged to add 2,775MW to the grid by 2030.

Others targeted measures are: 157MW of Biomass and 30MW of distributed solar/mini grids –largely done by REREC in the counties of Wajir, Mandera, Marsabit, Turkana and Garissa.

3. Results

Table 3 below shows the various interventions and the achieved results.

Table 3: 2018-2022 NCCAP Energy mitigation actions [5-6]

Actions	Expected results by June 2023	Results achieved by June 2022
Increased generation of renewable energy.	Develop 2,405MW of new renewables that include geothermal, biomass, hydro, distributed solar and mini-grids, solar and wind. Retire 300MW of thermal plants – 120MW Kipevu, 108MW Iberafrica and 74MW Tsavo.	2,883MW of generation on renewables. 913MW geothermal plants in Olkaria and Menengai 300MW lake Turkana wind among others in Ngong, Meru and Kipeto 442MW solar in Strathmore, Makindu among others 10% of TVET institutions using solar and five solar mini-grids done- 4 in Marsabit and 1 in Kisumu. Tsavo power has been retired
Increased generation capacity for captive renewable energy	Increase captive renewable energy generation capacity by 250MW by 2022 – 50MW of solar, wind and hydro and 200MW of cogeneration. Direct use of geothermal resources to power industrial applications-Naivasha industrial park.	Meru county has 200 solar-powered boreholes under their captive energy goals. 153MW Kwale sugar biomass plant done 93MW KTDA generation done GDC has established geothermal heated milk pasteurizers.
Improved energy efficiency and energy conservation	Reduce transmission and distribution utility losses from 18% to 14%. Distribute 3.3m CFL bulbs to shave 50MW from the peak demand. Energy efficiency in buildings and industry – EPRA regulations.	4.25m CFL bulbs distributed to 1.4m households by KPLC-funded by MoE. Energy management compliance certificates awarded to many factories under the energy management regulations 2012. The Ministry of Energy has worked with the Kenya Association of Manufacturers (KAM) to establish a Centre for Energy Efficiency and Conservation that promotes energy efficiency.
Climate proof energy infrastructure	Concrete poles to replace wooden poles. Optimize existing hydro plants.	20.47% (22,500 poles) now concrete. Kengen has done a feasibility study on how to optimize hydro power plants by increasing dam storage eg Masinga wall has been raised by 1.5m- because of erratic rain patterns. In other instances, the number of turbines is increased to allow excess spill to generate power- Kindaruma added the third turbine.
Enabling actions(technology)	Research on new technologies to reduce GHG emissions. Climate change resilient technologies such as coolers and scrubbers promoted.	Renewable energies research laboratory established. Energy efficiency research and testing facility established at KIRDI.
Enabling actions(capacity development)	Training and public awareness on climate change adaptation and mitigation mechanism. Train 100 students per year at the KPI on renewable energy technologies. Train 60 participants at the UNU Geothermal's training program.	TVET Instructors trained on solar PV and solar water heating installations. Marsabit county trained staff on solar installations. KPLC trained 163 students on solar installation.

Currently 78% (2,266MW) of generation capacity in Kenya is renewable as seen in table 4 below:

Table 4: Kenya's installed generation capacity [8]

	Installed(MW)	Effective/Contracted(MW)
Hydro	838.51	810
Geothermal	904.98	817
Thermal (MSD)	621.89	589
Thermal (GT)	60.00	56
Wind	436.05	426
Biomass	2.00	2
Solar	212.51	212
Imports	200.00	0
Total Capacity MW	3,276	2,911

The country has a peak demand of 2,149MW with 80.1% of the population having access to electric power.

The graphical illustrations below show the above trends:

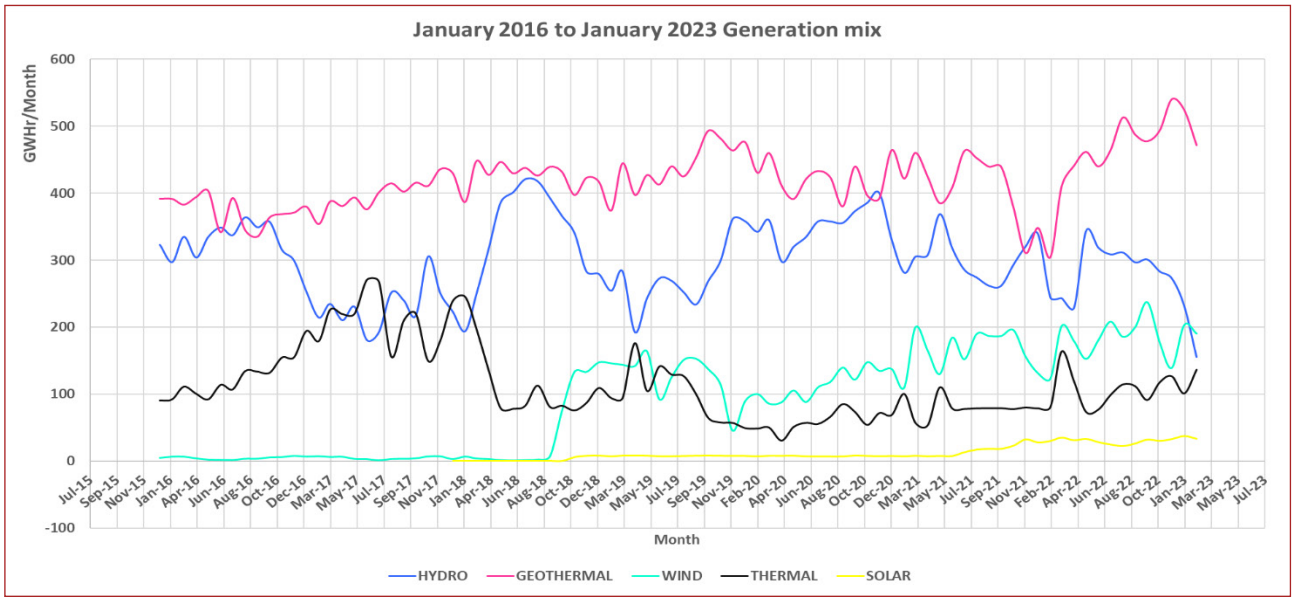

Figure 1: Changes in various sources of energy from January 2016 to January 2023 [8]

4. Discussion

Kenya uses 231/838MW (28% of the total installed capacity, largely to meet peak load demand as compared to the convectional base load) of hydro capacity – due to persistent drought for three years in a row.

Wind power has cut by more than half the gap between it and hydro- now doing 17.8% of the total load against hydro's 14.47%.

Solar energy has a big room for growth- now at 3.11% of the total national load.

Geothermal still takes the lion's share at 44.07% of the total load.

Kenya is on the road to retire all 300MW thermal power plants. Tsavo power 75MW plant already retired, 120MW Kipevu and 108MW Iberafrica pending- Currently contributing 12.72% of the total grid energy.

The draft net metering regulations 2022 are under discussion. These will go a long way in the contribution of the energy sector towards reduction of the targeted GHG emissions.

The electric mobility and time of use tariffs were introduced in April 2023. These will spur more utilization of the generated clean energy. As at the end of 2022, Kenya had well over 400 registered electric vehicles in the country.

5. Conclusion

Kenya is a leader in the generation and utilization of clean energy in Africa [10]. Kenya is number one in the generation of geothermal energy in the continent. The place of the energy sector is well cut out in the 2023-2027 NCCAP and beyond as Kenya seeks to leverage on the above gains and more. The future is bright.

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Picture Courtesy: Clean Energy Equipment

The Uasin Gishu County Governor H.E Hon. Jonathan Bii, CECs, Join the ACEK Council, other dignitaries during opening ceremony of the ACEK Conference 2023 themed 'Engineering Food Security' held between 16th – 19th October, 2023.

The Engineers Board of Kenya and the Institution of Engineers of Kenya pose for a photo after a meeting with the Public Service Commission on 27th September 2023

From L to R-IEK PrAC Manager Eng. Kenneth Amollo, CEO Eng. Dr. Victor Mwongera, Council Member Eng. Paul Ochola,KURA DG. Eng. Silas Kinoti, IEK President Eng. Erick Ohaga and Council Member Eng. Jennifer Korir

IEK President Eng. Erick Ohaga presenting a copy of Engineering in Kenya Magazine to the DG KURA, Eng. Silas Kinoti

(Above and Below) Gakoye Girls High School, Kiambu visits the IEK stand during the Nairobi International Trade Fair 2023

Recognized Engineering Programs at the Technical University of Kenya: Pioneering Excellence in Engineering Education

By EiK Correspondent

In a significant milestone for the Technical University of Kenya (TU-K), the Engineers Board of Kenya (EBK) granted recognition to five engineering programs at the institution. This achievement underscores TU-K's commitment to providing high-quality engineering education that meets both local and international standards.

The decision to grant recognition to TU-K's engineering programs was the result of a rigorous evaluation process conducted by the Engineers Board of Kenya. This evaluation aimed to ensure that the programs offered by TU-K met the highest educational and professional standards in the field of engineering. The Board's recognition of these programs comes as a testament to TU-K's dedication to excellence in engineering education.

The letter, which conveyed EBK's decision following a Board Meeting held on the 8th of August, 2023, recognized the following five programs at TU-K:

1. **Bachelor of Engineering (Electrical and Electronic Engineering):** This program equips students with the knowledge and skills required to excel in the dynamic field of electrical and electronic engineering. Graduates of this program are well-prepared to contribute to the development and innovation of electrical and electronic systems.

2. **Bachelor of Engineering (Civil Engineering):** Civil engineering is at the heart of infrastructure development. This program ensures that students receive a comprehensive education in designing, constructing, and maintaining essential infrastructure such as roads, bridges, and buildings.

3. **Bachelor of Engineering (Mechanical Engineering):** Mechanical engineering is a diverse field with applications ranging from manufacturing to energy production. TU-K's program provides students with a solid foundation in mechanical engineering principles and practices.

4. **Bachelor of Engineering (Biosystems and Environmental Engineering):** In an era of increasing environmental concerns, this program is instrumental in training engineers who can address complex environmental and biosystem challenges. Graduates are well-equipped to contribute to sustainable solutions in agriculture, environmental management, and related fields.

5. **Bachelor of Engineering (Chemical Engineering):** Chemical engineering plays a pivotal role in industries such as manufacturing, pharmaceuticals, and energy. TU-K's program offers students the knowledge and skills needed to excel in this dynamic and essential field.

In the wake of this recognition, TU-K is poised to take further steps to maintain and enhance the quality of its engineering programs. The university is expected to submit various documentation to demonstrate its commitment to ongoing improvement. These documents include:

- **Addressing Identified Gaps:** TU-K will provide a report outlining how it plans to address any gaps identified during the recognition process, ensuring continuous improvement.
- **Staff Recruitment and Development Plan:** The university will outline its strategy for recruiting and developing faculty members to ensure that students receive the best possible education.
- **Staff Mentorship Program for Professional Registration:** TU-K will establish a mentorship program to support staff members seeking professional registration, fostering a culture of expertise and excellence.
- **Student Mentorship Program:** To guide and nurture the next generation of engineers, the university will establish a student mentorship program to provide guidance and support to aspiring engineers.
- **Memoranda of Understanding (MoUs):** TU-K will seek collaboration with other institutions to facilitate practical training and experiences for its students, ensuring they are well-prepared for the field.
- **Equipment Upgrade Plan:** As technology evolves, TU-K will develop a plan to upgrade and maintain its engineering equipment, keeping its programs at the forefront of technological advancements.

This recognition is not just a recognition of TU-K's engineering programs; it is a testament to the university's commitment to producing highly skilled engineers who will drive innovation, infrastructure development, and environmental sustainability in Kenya and beyond. As TU-K continues to meet and exceed rigorous standards, it reaffirms its position as a leading institution for engineering education in the region. This achievement is not only a cause for celebration but also a call to action for TU-K to continue its pursuit of excellence in engineering education.

Chemical Engineering Department at Technical University of Kenya

Dr. Bilha Eshton
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What are the areas in your undergraduate (including diploma) curriculum?

- B.Eng. Chemical Engineering
- B.Tech. Chemical Engineering (Regular and Evening)
- Dip. Tech. Chemical Engineering

Do you have a graduate programme? If yes, please indicate the areas.

We have developed the curriculum for MSc. Chemical Engineering. The Programme will commence immediately after approval by University Senate and CUE.

What are your research areas?

- Process Engineering
- Bioenergy
- Waste Management
- Climate change and mitigation

What are your linkages with industry?

The Department is currently working on cooperation with some industries, especially those based in Nairobi.

What is your view of the chemical engineering industry in Kenya in 2023? What are the prospects for the future?

The future for Chemical Engineering in Kenya is bright, very bright. As the nation works towards industrialization under Vision 2030, we expect many industries to emerge in Kenya. These industries need chemical engineers to run their operations.

What are the employment prospects of your graduates?

Chemical Engineering graduates of the Technical University of Kenya are top-rated in Kenya and within the region. Some work in big industries such as Unilever Kenya, East African Breweries, and GSK, to name a few. Some companies book for them before they graduate. Most of our students secure jobs while in their final year of study. Some work in neighbouring countries. One of our graduates recently rejected a job offer from a Company in Dar es Salaam because what she earns in Kenya is more than what she was to get in Tanzania.

Do you have problems in attaching your students?

Most students get the attachment places through the National Industrial Training Authority (NITA). We usually give them letters of introduction to take to NITA. I appreciate NITA for they secure attachment places for our students in the shortest time possible. Some students source the attachment places by themselves.

Do you have any current or pending patents?

We don't have any pending patents. Despite a lack of research funds, staff members carry out research projects at their own cost. We hope after we commence the postgraduate programme, we will be able to secure research funds. Most of the donors give funds to those with graduate students.

Do you have adequate academic staff?

We don't have adequate staff. The University Management is doing everything possible to get us more Academic Staff. In May 2023, the University hired four new Academic members of Staff (One Doctor and three Graduate Assistants); one Graduate Assistant has so far reported to work. The Department has a total of 13 full-time Academic Staff. Those in Session include 1 Senior Lecturer, 4 Lecturers, 1 Assistant Lecturer, 3 Tutorial Fellows and 1 Graduate Assistant. Academic Staff on Study Leave include one Assistant Lecturer and two Tutorial Fellows.

Do you have adequate technical staff?

Currently, the Department has 2 technical staff. The Department needs 3 more technical staff.

What is the status of your relationship with EBK?

The Department of Chemical and Process Engineering through the School of Chemical and Biological Systems Engineering has submitted all the documents required for the Accreditation of BEng. Chemical Engineering. We are waiting for the EBK Feedback.

How can IEK assist you in your mandate?

The Department of Chemical and Process Engineering doesn't own a Chemical Engineering Lab where students can take chemical engineering experiments such as unit operations. The Department takes students to Moi University in Eldoret, where they do such experiments at a fee. TUK covers the cost of conducting Labs at Moi University. The Department has submitted a proposal for Chemical Engineering Lab equipment to the Office of the Vice Chancellor for consideration. To date, no feedback from the VC's office. We request IET to link us to donors who can fund the setting up of this Lab.
Provide financial support to Students and Staff who want to participate in Engineering training and Conferences but are unable due to lack of finances.

Do you have any other issue you want to tell us?

Support the Department in the accreditation of our programme with the EBK and registration of already-graduated students.

REPUBLIC OF KENYA

MINISTRY OF ENVIRONMENT, CLIMATE CHANGE AND FORESTRY
STATE DEPARTMENT FOR ENVIRONMENT & CLIMATE CHANGE
Office of the Principal Secretary

State of Water Resources Management in Kenya

Current state of water resources management in Kenya, highlighting key challenges and opportunities

- *Kenya is a water scarce country with less than 1000m3 per capita of renewable freshwater supplies. The water resources per capita have progressively reduced due to increased population growth with no adjustment to consumption or technology changes.*
- *Kenya has made notable progress on establishing legal and institutional frameworks that enhances the water resource management such as the establishment of the Water Resource Authority whose role is to regulate and manage water resources. The National Environmental Management Authority on the other hand promotes waste management, rehabilitation and protection of rivers among other water resources. In Kenya, Water Resources Management is done at the basin level, with the Country having been divided into five major catchment areas, each corresponding to a certain major body source. The Ministry of Water, Sanitation and Irrigation is mandated by law to undertake water sector investment planning, Sewer & non-sewer sanitation services, water resources management and use, water supply services and water harvesting and storage*
- *The Ministry of Environment has conducted several initiatives that build on water resource management. Notably, the Ministry under the Department for Environment and Climate Change has developed a Wetlands restoration strategy 2023 – 2032 alongside the 15billion national tree-growing restoration program which contributes to water resource and catchment restoration.*
- *On the other hand, the Ministry of Water is developing incentive-based mechanism for Private Sector support to IWRM. Additionally, The Ministry is spearheading the initiative through partnership and stakeholders' collaboration for enhanced conservation and sustainable management of the catchment ecosystem to improve economic and social welfare in the Athi River Catchment Area.*
- *Climate change, pollution activities coupled by population and economic growth are some of the key challenges faced by the water resource sector in Kenya. With the adverse impacts of climate change, Kenya is experiencing high variability in rainfall leading to frequent and prolonged droughts and floods. The uneven distribution of resources and variability will likely worsen with climate change.*
- *Integrated Water Resource Management (IWMI) is one of the key opportunities of resource management that ensures coordinated development and management of water resources by not only maximizing social and economical welfare but also ensuring sustainability of the ecosystem.*
- *Secondly, catchment protection and restoration are enumerated as a shared functions and therefore, clear that, in the context of Kenya, a multilevel approach is the most suitable model of water resource management of the water sector.*
- *Improved water use efficiency directly promotes water resource management in the sense that if we utilise the available water efficiently, less water is abstracted and consequently less abstraction hence sustainability. Reduced Non-revenue water is one of the immediate actions that would result to improved water efficiency.*
- *Technology advancement such as artificial recharge of groundwater is great opportunity that water resource management could explore. The Ministry of Water has set the precedence of aquifer protection under the The Horn of Africa- Groundwater for Resilience Project (HoAGW4R)*
- *Lastly, for Water Resource Management to be successful and sustainable, community engagement is key. The Wetland Restoration strategy aims to promote greater participation of local communities in environmental conservation including wetlands restoration.*

Water scarcity and quality are pressing concerns globally. How is the State Department of Environment & Climate Change addressing these issues in the Kenyan context?

- *Water quality is one of the main challenges that societies are facing and is threatening human health, limiting food production, reducing ecosystem functions, and hindering economic growth. These impacts directly translate into environmental, social and economic problems. This is why we need to work collectively to achieve the SDG goal 6 targets.*
- *Overall, the Ministry of Environment, Climate Change and the Ministry plays a critical role of sustaining life, supporting livelihoods and driving economic growth. Climate change, loss of biodiversity, and degradation, pollution, and depletion of natural resources are some of the environmental issues that are negatively affecting the quantity and quality of water both globally, and in our country.,*
- *The State Department of Environment and Climate Change mandates revolves around management and protection of the environment, sustainable use of natural resources, and mitigation and adaptation to climate change with an overall goal of ensuring healthy and sustainable environment for present and future generations.*
- *Water and climate change are inextricably linked, whereby climate change affects the water in a complex manner by exacerbating both scarcity and quality of water. State Department of Environment and Climate Change has put in place diverse climate change adaptation and mitigation measures that directly and indirectly addresses the water scarcity and quality.*
- *Implementation of climate adaptation and mitigations requires global participation which informed the recently concluded Africa Climate Summit. The Summit provided a resource mobilization platform of climate affected tracks among which was water, sanitation and irrigation. The department therefore, continually plays the role of resource mobilization and forging partnerships for sustainable financing for climate change and water catchment restoration and conservation.*
- *The department has supported and coordinated the implementation on the National Climate Action plan which addresses water scarcity and decline of water quality. One of the key adaptation strategies highlighted in the NCAAP is increased water availability through water harvesting and storage, which is currently being implemented by the Ministry of Water, Sanitation and Irrigation.*
- *MOE has put in place a comprehensive 5-year strategic plan and currently implementing the water catchment protection and conservation programs. Protection of water catchments such as forests will retain rainwater as runoff and promote groundwater recharge and consequently increasing water availability and improving groundwater quality.*
- *Lastly, the State department through National Environmental Management Authority is enforcing river pollution laws. Additionally, NEMA is implementing 'Adopt A River' initiative which is national 'people-driven' wetlands monitoring and restoration project that is being piloted within Nairobi River Basin before up scaling to other parts of the country.*

Strategies and initiatives aimed at sustainable water resource management and conservation

- *Key to note are the water sector policy reforms that the Ministry of Water has put in place. These are the 5-year strategic plans, the Water Act 2016, 2030 master plan*
- *Key actions that the Ministry of Water is undertaking include enhancing coordination and collaboration among water sector agencies for sustainable water resource management (reviewing existing laws & strategies in the view of emerging issues, enhancing collaboration - sectoral and inter-sectoral); Promoting implementation and enforcement of existing laws and regulations for water resources; Adopting an integrated and holistic approach to water sector planning and management (stakeholder participation).*
- *Kenya has subscribed to the Integrated Water Resource Management (IWRM). One of the key principles of IWRM is the recognition of water basins as the main units of governance for WRM. This implies the need for decentralized water resource management. The IWRM principle is recognized in the Water Act (2016) through the transfer of responsibilities for WRM to units at Basin and Sub-Basin Level. These include the Basin Water Resource Committees (BWRCs), County Governments and WRUAs.*

The role of water resources engineering in ensuring sustainable and equitable distribution of water resources across Kenya

- *The Water Resource Engineering have the responsibility of technology advancement. Engineers should innovate and develop systems and processes for government or private entities that can preserve fresh water sources. Some of these new or advanced systems include real-time pipeline leaks and bursts monitoring systems this could consequently lead to reduced NRW and therefore more water available for additional distribution.*
- *Water Resource Engineers should also contribute to the search new water sources to compliment the rapid depletion of current sources. This would entail techniques of wastewater reuse and recycling for irrigation and exploitation of seawater through desalination.*
- *To ensure evidence-based policy development, the engineers should continually conduct assessment of water resources across the country to understand their availability, quality, and sustainability of these resources.*
- *Design and Structural development of water harvesting and supply structures such as dams and pipeline networks is to a great extent the role of water resource engineers.*
- *Support finance assessment and accountability, through value for money designs and project management and implementation.*

In the context of climate change, how is the Ministry working to adapt and mitigate the impact on water resources in the country

- *My Ministry, in consultation with key stakeholders has developed that National Climate Change Action Plan III (2023-2027). One of the objectives that the action plan seeks to achieve is enhanced resilience of the blue economy and water sector by ensuring adequate access to and efficient use of water across the sectors given that access to and quality of water is expected to decline due to the impacts of climate change. Some of the adaptation actions to be undertaken under this objective include:*
    - » Increase annual per capita water availability through the development of water infrastructure (mega dams, small dams, water pans, untapped aquifers)
    - » Improve access to good quality water, increased sewerage coverage and onsite sanitation
    - » Promote water efficiency, among others
- *It's key to note that these actions are aligned with the Ministry of Water mandate and actions and shall be implemented by the Ministry of Water.*

Ongoing or upcoming projects related to water resources engineering and their potential impact on Kenya's water security

- *The Government is implementing water resource engineering projects under different ministries namely Ministry of Environment, Climate Change and Forestry, Ministry of Water, Sanitation and Irrigation and Ministry of East African Community, ASALs and Regional Development. Some of key projects include 15 billion trees initiative by Ministry of Environment.*
- *Construction of 100 dams and Horn of Africa- Groundwater for Resilience Project (HoAGW4R) are some of the notable projects under Ministry of Water. Additionally, the Ministry is implementing Galana Kulalu development project, Bura Irrigation project, Mwanche Multipurpose dam project, Thwake Multipurpose dam project, Mavoko drinking water project.*
- *All these projects have the potential to ensure sustainable water access for the citizens of Kenya. The water supply projects will also increase the acreage of irrigated land hence promoting food security.*

Kenya has a rich diversity of ecosystems, from rivers to wetlands. How does the Ministry balance the need for development with the preservation of these critical ecosystems?

- *The ministry has put Integrated Water Resource Management strategies in place that promotes coordinated development and management of water for social and economic welfare but without compromising sustainability of ecosystems.*

- *The Ministry also ensures proper enforcement of diversity protection for example through controlled logging of forests.*
- *Full participation of stakeholders, including community members in preservation of critical ecosystems. Stakeholder participation also includes both multilateral and multilevel approach to coordinate efforts between local, regional and national institutions.*
- *The Ministry has provided an enabling environment encompassing of national policies, legislation and regulation frameworks that promote ecosystem preservation.*
- *In conclusion, ecosystem preservation is a balance between social needs, economic needs and environmental needs.*

Water-related disasters, such as floods and droughts, have been a recurring issue. What measures are in place to enhance disaster preparedness and response in the water sector?

- Climate change induced hazards such as drought and floods have been experienced alternately in the country over the last several years. The government has been putting in preparedness strategies in place to reduce the impacts of floods and droughts. For example, the Ministry of water has been continually desilting colonial dam structures, small dams and water pans, to enhance fresh water harvesting as flood waters recede.
- As a mitigation strategy the Ministry has plans to reinforcing river embankments in selected flood prone areas ahead of floods, as well as monitoring during floods.
- For preparedness the Ministry, through the Kenya Meteorological Department has been liaising with other stakeholders to create awareness and disaster management plans especially in areas prone to landslides.
- In the long term, the pipeline mega and macro dams will increase storage of rainwater and reduce flooding which consequently will provide water during the drought periods.

In terms of technology and innovation, how is the Ministry leveraging new advancements in water resources engineering to address water-related challenges?

- Ministry is keen on utilization of new technologies and innovation to address water-related challenges such as: Waste water recycling and reuse technologies, desalination technologies, water efficiency eg smart meters and drip irrigation

Collaboration between government, private sector, and civil society is vital for effective water resource management. Could you provide examples of successful partnerships in this regard?

- Effective water governance is necessary to create an enabling environment, which facilitates efficient private and public sector initiatives and stakeholder involvement in articulating needs. The Civil Societies have been vocal on environmental matters and therefore have contributed to the accountability of water management.
- Collaboration with development partners such as World Bank in a number of projects such as the Horn of Africa and other donors such as the KFW and GIZ have successfully implemented programs in the water sector. The success can be attributed to effective governance systems has been a key aspect of development co-operation for many years.
- The PPP bids by the Ministry of Water, Sanitation and Irrigation received overwhelming response which is a proof of favourable enabling environment for the private partners.

How can engineers and the engineering community contribute to the sustainable management of water resources in Kenya, and what support does the Ministry provide for their involvement?

Technological Innovation: Engineers to develop innovative technologies and solutions, such as efficient irrigation systems and water purification techniques, which enhance water management practices, improving water efficiency and security.

Policy Guidance: Through their expertise and analysis, engineers should provide valuable policy recommendations. They identify best practices and suggest policy measures to effectively tackle water-related challenges, contributing to long-term water security.

Climate Change Response: Engineers play a pivotal role in understanding and addressing the influence of climate change on water resources. Their work informs strategies for both mitigating climate change and adapting to its effects, such as altered rainfall patterns and increased water scarcity.

Monitoring, Research and Data: Engineers and the engineering community should conduct research and generate essential data on water resources, climate change impacts, and environmental assessments. This data forms the basis for informed policymaking, enabling evidence-based decisions on water management.

Capacity Building and Public Awareness: The engineering community should engage in capacity-building efforts, empowering local institutions, government agencies, and communities with knowledge and skills for sustainable water resource management. They also educate the public on water conservation and the importance of water security, fostering citizen engagement and support for conservation initiatives.

The relevant ministries have provided an enabling environment for the engineers to contribute to the water resource management. The engineering community has been consulted from time to time in regards to this.

Water governance is crucial for effective water management. Can you share insights into the policies and regulations that guide water resource management in Kenya?

- Good water governance is essential to achieve water security, fair allocation and conflict management. Water governance entails the social, political and economic systems that influence water management.
- Firstly, to achieve effective water governance, it is necessary to create an enabling environment, which facilitates efficient private and public sector initiatives and stakeholder involvement in articulating needs. Water governance also ensures stakeholder collaboration and community participation.
- Some of the key legal frameworks, policies and regulation for water management include: Water Act, 2016, National Water Resources Policy, 2021, Irrigation Act, 2019, Water Resource Regulations,

Are there any upcoming legislative or policy changes related to water resources engineering that engineers and stakeholders should be aware of?

- Following the huge financing water resource financing gap, the government through the Ministries, is exploring the Public Private Partnerships in water management and supply.
- Secondly, the implementation of Bottom Up Transformation Agenda that will drive economic turnaround and inclusive growth agenda will also be adapted in the water resource management.
- The Ministry of Water has developed the Water Resources Regulation 2021, while the Ministry of Environment recently developed the Wetland Ecosystem Management Strategy 2023 – 2032.
- The Land Reclamation Policy is under development that seeks to address matters land degradation, encroachment, water harvesting etc. The draft is available; stakeholder engagement is pending. The plan is to finalize the policy by the end of this financial year.

Lastly, what message or advice would you like to share with our readers, particularly engineers and professionals involved in water resources engineering?

The water resource management presents as many opportunities as there are the challenges. It is therefore, important for engineering professionals to actively participate in the delivery of the solutions to the existing and upcoming climate change induced water resource management challenges.

Revolutionizing Kenya's Agriculture Through Galana Kulalu Irrigation Scheme

By EiK Correspondent

The Galana Kulalu Irrigation Scheme was the ambitious food security project launched by the Government of Kenya, in partnership with various private sector players, in 2013 as a testament of the country's determination to conquer its agricultural challenges. Its scope and ambition aligned closely with Kenya's Vision 2030, a comprehensive roadmap that envisions the country's transformation into a middle-income country with a high quality of life for all citizens by 2030.

Food security, a fundamental pillar of this Vision, remains a pressing concern in Kenya. Despite some improvements, millions of Kenyans still face food and nutrition insecurity each year. The Global Hunger Index consistently ranks Kenya among nations with serious hunger levels.

With the Galana Kulalu scheme, situated in Kilifi County, the government was responding to Kenya's pressing need to boost agricultural productivity, ensure food security, and alleviate poverty in a country where agriculture plays a pivotal role in the economy. Its primary objectives included providing a reliable source of water for agriculture, reducing dependence on rain-fed farming, creating employment opportunities, and stimulating economic growth in the region.

Through implementation by the National Irrigation Authority, the project aimed to transform 200,000 acres of semi-arid land into a flourishing agricultural hub by harnessing the waters of the Galana River. It encompassed the development of crucial physical infrastructure, such as water storage, conveyance, distribution, irrigation, livestock production, aquaculture, road networks, land development, and even eco-tourism. Within its expansive framework, the project also targeted development of various enterprises including maize, sugarcane, horticulture, orchards, dairy and beef ranching, fisheries, tourism, processing industries, and human settlements.

As expected, a project of such magnitude was bound to face various engineering challenges. To transform this expansive arid and semi-arid land into a fertile oasis, an intricate network of canals, pipes, and pumping stations had to be built, while ensuring the efficient utilization of water resources and minimizing wastage. In addition, mitigating environmental impacts and preventing soil erosion demanded innovative solutions, all of which were required to overcome key challenges including water storage and distribution, infrastructure development in a diverse and challenging terrain, and the integration of multiple agricultural enterprises.

To address these challenges, the project designed innovative water management techniques, such as efficient irrigation systems and advanced water storage solutions. Moreover, a sufficient road network was established to facilitate transportation within the vast project area. The projected inclusion of eco-tourism as an enterprise demonstrated the project's commitment to sustainability, emphasizing the importance of preserving the local environment and promoting responsible land use.

However, these were not the challenges that led to the stalling of the project in 2019 after the government terminated the contractor. The project was marred with accusations bordering on misappropriation of funds, among others. This led to delays in the initially set timelines.

However, the new government's promise to revive the project have led to renewed vigour for its completion. For instance, a 500-acre trial crop was of great success, with the government through the President in February this year overseeing new activity in the project site which began with maize production in February in the first 10,000 acres.

The President has also outlined ambitious plans to expand the project to 20,000 acres in the coming year, with further expansion to 200,000 acres over the next four years. This expansion aligns with the project's potential to make a substantial impact on Kenya's food production.

On full capacity, the project is expected to meet 41 per cent of the country's annual maize consumption of about 48 million bags. To cushion farmers against over-supply of maize, the project will plant maize for only one season annually.

Picture Courtesy: Irrigation

How NEMA, Engineering Sector can collaborate to foster sustainable development in Kenya

By EiK Correspondent

Under the National Environmental Management Authority (NEMA) falls the responsibility of preserving and managing Kenya's vast environment riches and natural resources. The country is known for its breathtaking landscapes, diverse ecosystems, and vibrant communities.

Since its establishment in 2002 under the Environmental Management and Coordination Act, NEMA has played a pivotal role in steering Kenya towards sustainable development by safeguarding its ecological integrity. The Authority is mandated to coordinate, regulate, and supervise all matters related to the environment. It operates as the linchpin of Kenya's environmental management framework, overseeing environmental impact assessments, waste management, biodiversity conservation, and pollution control.

To foster a harmonious balance between development and conservation, NEMA collaborates closely and extensively with engineers and the broader engineering sector.

NEMA works with engineers to align development with environmental sustainability. The collaborative efforts begin at the project planning stage, where engineers are required to conduct environmental impact assessments (EIAs) under the scrutiny of the Authority. This ensures that potential ecological ramifications are thoroughly evaluated before any project is kicked off. NEMA's involvement extends to monitoring projects throughout their lifecycle, ensuring compliance with environmental standards and regulations.

In recent years, NEMA has spearheaded several policy changes and initiatives aimed at fortifying the integration of environmental considerations into engineering practices. One noteworthy development is the introduction of stricter regulations governing waste management, particularly in the construction and industrial sectors. This initiative serves to curb the environmental footprint of engineering projects, prompting engineers to adopt innovative waste reduction and recycling measures.

However, engineers often encounter challenges and compliance issues when navigating the regulatory landscape governed by NEMA. Lengthy approval processes, bureaucratic hurdles, and a lack of clarity in environmental regulations are common impediments. Addressing these challenges requires streamlining approval procedures, enhancing communication channels between NEMA and engineers, and providing comprehensive training on evolving environmental standards.

To foster a culture of eco-friendly engineering practices, NEMA and engineers must engage in proactive collaboration. This involves ongoing dialogues, workshops, and training programs to disseminate the latest environmental standards and best practices. By fostering a shared understanding of the importance of sustainable development, NEMA and engineers can work hand in hand to create a future where progress harmonizes seamlessly with environmental stewardship.

Despite the challenges, with concerted efforts to streamline processes and enhance communication, engineers and NEMA can jointly champion eco-friendly engineering practices. The path to a greener future lies in the synergy between environmental regulators and the engineering sector, where innovation and sustainability go hand in hand.

Picture Courtesy: Sondu - Environment Protection

Turkana Water Aquifer with high potential for sustainable development

By EiK Correspondent

The Turkana Water Aquifer is a geological marvel below the surface of the remote reaches of northwestern Kenya - a treasure that could have redefined the region's future. With Turkana County being one of the hottest, driest and poorest parts of Kenya, and prone to biting drought, the vast underground reservoir, concealed beneath the arid landscapes became a focal point of both hope and scrutiny. Engineers and environmentalists explored its geological characteristics, evaluated its potential as a water resource, and grappled with the challenges of responsible management.

The 250 billion cubic metres water aquifer is a subterranean reservoir nestled within the Turkana Basin, a geological wonder that spans across Kenya, Ethiopia, Uganda, and South Sudan. It stretches over 250,000 square kilometers, and is primarily composed of sandstone and volcanic rock formations that have accumulated over millions of years. Its geological characteristics suggested the potential for substantial water reserves, making it a tantalizing prospect for addressing water scarcity in the arid regions of Kenya.

However, unlocking the aquifer's potential came with a set of challenges that demanded careful consideration. Engineers faced the daunting task of tapping into this vast reservoir without causing irreversible environmental damage. The extraction of groundwater from the aquifer required a delicate balance to prevent land subsidence and maintain the ecological equilibrium of the region.

Environmentalists hence stressed the need for sustainable practices to safeguard the delicate ecosystems surrounding the aquifer. Proper well construction and management were crucial to avoid contamination and preserving the water quality. The engineering solutions adopted had to be environmentally conscious, ensuring that the extraction processes did not harm the fragile ecosystems dependent on the aquifer.

If successful, the implications of tapping into the aquifer would have been profound. This is especially in the context of addressing water scarcity and supporting development in a region that has long been burdened by water shortages and lack of economic development.

Hydrologists projected that the 250 billion cubic metres of water on the foot of Mount Mogila in Lotikipi could meet Kenya's water needs for 70 years. At the same time, 5,000 acres of land in Lodwar had been earmarked for irrigation using water from the aquifer which covers a surface area of 4,164 square kilometres.

Unfortunately, the government abandoned exploration of the Turkana Water Aquifer in 2022, terming it economically unviable due to high levels of salinity. The government pointed to high costs involving desalination of the water resource, which would have cost upwards of KES 50 million a month on power bills alone.

In 2019, Turkana County government had revealed a partnership with Saudi-owned Almar Water to put up a desalination facility, to construct the plant at a cost of between KES 5 billion and KES 10 billion. The project did not take off.

However, the government is still keen to undertake further exploration to find ways of utilizing the aquifer's waters in future to address Turkana's water challenges.

Vital Role of the Water Sector Trust Fund in Sustainable Engineering Solutions

By EiK Correspondent

Statistics show that out of Kenya's approximate population of 53 million, about 28 million Kenyans lack access to safe water, while 41 million lack access to proper sanitation. This growing clean water and improved sanitation demand, and water scarcity have turned into key challenges in the country.

Sadly, climate change, population growth, urbanization, water pollution, and poor management of water resources have aggravated the issue of the water crisis, which affects economic activities, food security, education, and health. These challenges are especially evident in rural areas and urban slums where people are often unable to connect to piped water infrastructure.

Kenya's Water Sector Trust Fund (WSTF) was established under the Water Act, 2016 as a State Corporation under the Ministry of Water, Sanitation and Irrigation. It's role is to finance and support the implementation of efficient, equitable, and sustainable water projects in Kenya, especially in the marginalised and underserved areas.

The Fund operates as a mechanism to mobilize financial resources, manage funds, and invest strategically in projects that align with Kenya's broader water sector goals. Its role also includes technical assistance, capacity building, and the promotion of innovative solutions to ensure the longevity and effectiveness of water projects within the country. It plays a pivotal role in catalyzing transformative change within the water sector with the commitment to achieve universal water access in the country, and promote sustainable engineering solutions.

WSTF partners with various stakeholders, including government agencies, NGOs, and local communities, to address the complex challenges that hinder water accessibility and quality.

Flagship initiatives in arid and semi-arid regions involving the implementation of water supply and sanitation projects have not only improved water acess to communities facing water scarcity, but have also mitigated health risks associated with inadequate sanitation. In urban areas, WSTF has played a crucial role in upgrading and expanding water infrastructure to meet the demands of a growing population through Urban Investments programmes. Notable examples include supporting the rehabilitation of water treatment plants and construction of water distribution networks, ensuring that urban centers have a resilient and sustainable water supply.

WSTF engages innovative financing models, recognizing the need for diverse approaches to fund water-related projects. Beyond traditional grants, the Trust Fund has explored mechanisms such as revolving funds and concessional loans to promote financial sustainability. These models not only leverage resources efficiently but also encourage community ownership and responsibility for the maintenance of water projects.

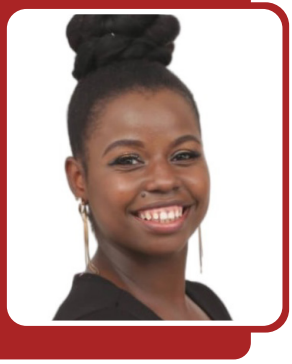
The partnerships with private sector entities foster collaboration that brings in technical expertise and additional funding. Public-private partnerships have proven instrumental in implementing large-scale infrastructure projects that address the complex water challenges faced by the country.

Such collaborations see close partnerships between the Fund and engineers. Through capacity building programs, engineers receive the training needed to design, implement, and maintain water projects effectively. This collaborative approach ensures that projects are not only technically sound but are also culturally and socially sensitive, fostering a sense of ownership and pride within communities.

However, despite the notable significant strides, WSTF still faces a few inherent challenges that echo the complexity of water-related issues in Kenya. Limited funding, especially for large-scale projects, remains a persistent challenge that requires innovative financial models and continued advocacy for increased investment in the water sector. The Trust Fund also grapples with the need to balance rapid urbanization and industrialization with sustainable water management practices. Striking this balance is crucial to avoid over-extraction of water resources and environmental degradation.

Nevertheless, these challenges also present opportunities. WSTF has the chance to leverage emerging technologies, such as smart water management systems and decentralized water treatment solutions, to leapfrog traditional challenges and build a more resilient water sector.

STUDENTS' VOICES



My name is Victoria Musyoki and I am a final year Civil Engineering student at the University of Nairobi. Studying the course has been a wholesome experience. The way the coursework is structured allows the student to have both the vantage point of what Civil Engineering entails and the specificity of whichever aspect of civil engineering they would like to pursue. This is actually what I have loved most about studying here, because it has allowed me to actually explore and appreciate the role of the Civil Engineer to the Society. Ultimately leading me to pursue the Civil Engineering Management docket as a career prospective. I look forward to being a part of the contributing Civil Engineering Community in the country.

Name: Victoria Musyoki
5th Year Student

By studying civil engineering, I view the world from a whole new perspective. What may have earlier seemed like simple structures now have my curiosity with regards to the thinking that must have gone behind the thinking that must have gone behind the designs and how effective they are in solving humanity's day-to-day problems. I've truly come to appreciate the pillar of the community that is civil engineering With all that said, studying civil engineering has been far from a smooth ride. The new concepts we learn come across as extremely complex and so the right amount of focus and discipline is required to take the time to understand them. When the course is tackled with the right mentality, the sensation that comes with understanding and appreciating it is one that is truly rewarding

Name: Kanyi Mwai
2nd Year Student

As I approach the culmination of my journey in civil engineering, I want to take a moment to express my heartfelt appreciation for being a part of this esteemed institution. The university of Nairobi, department of Civil and Construction Engineering.These years have been a transformative experience, shaping me into the engineer I am today, and I am filled with gratitude for the knowledge, skills, and opportunities I've gained here. Looking ahead, I am enthusiastic about my future as a civil engineer. My aspirations go beyond the technical aspects of the profession. I envision a career dedicated to making a positive impact on society.

Name: Gideon Kur
5th Year Student

Civil engineering can be as simple as sketching a daisy and as complex as designing a 500,000-ton structure. The diversity of the course gives so much room for creativity in designing and creating systems and infrastructure that make the world go round. I know I made the right choice selecting the University of Nairobi as learning is customized to make it easy and interactive. It is a great honor to be part of this brigade that plays a major role in shaping a brighter future for the generations to come.

Name: Debby Wangui
4th Year Student

I choose the University of Nairobi, in particular, the Department of Civil Engineering, because of the high-quality education it offers, in that, students are not only provided with the state of the art learning experiences and up-to-date knowledge but also are guaranteed an internationally recognized degree which is highly competitive in today's job market. This fuels my thirst to be part of such a department, it satisfies my longing and makes me crave such a learning experience. Being part of this department has been my vilest of dreams and I am ready to take the opportunity given to me by the University to create a sustainable global impact. I have come to appreciate the various modules that we study and I see the correlation to the country's development, therefore, I take this opportunity to further widen my scope of study at this prime University as I strive to be part of the next big change.

Name: Vincent Nyakomitta
4th Year Student

My name is Jay Parekh. I'm a student & class-rep of the first years, studying civil engineering. I've always loved the idea of being able to use my technical knowledge, as well as my creative side to build fantastic structures in the future. I really like that by becoming a civil engineer I will be able to design structures that are tangible and that I will be able to look back at, with pride.

Name: Jay Parekh
1st Year Student

IEK Membership Report

The IEK membership committee meets every month to consider applications for membership of the various classes received at the secretariat. The IEK council at its 513th,514th and 515th council accepted the following members under various membership categories as shown below;

MEMBERSHIP CLASS	NUMBER ACCEPTED-513TH COUNCIL	NUMBER ACCEPTED-514TH COUNCIL	NUMBER ACCEPTED-515TH COUNCIL
FELLOW	-	-	1
CORPORATE	61	26	28
GRADUATE	42	50	67
GRADUATE ENGINEERING TECHNOLOGIST	1	3	8
GRADUATE ENGINEERING TECHNICIAN	4	3	7
STUDENT	4	9	8
TOTAL	**112**	**91**	**119**

During the period we had 1 member who transferred from the class of Corporate to Fellow member and 115 who transferred from Graduate to Corporate member. In addition we had 159 graduates, 12 graduate engineering technologists, 14 graduate engineering technicians and 21 students were accepted as members.

Gender Data

Class	Male	Female	Percentage (Male)	Percentage (Female)
Fellow	1	-	100%	-
Corporate	95	20	83%	17%
Graduate	138	21	87%	13%
Graduate Engineering Technologist	8	4	67%	33%
Graduate Engineering Technician	12	2	86%	14%
Student	12	9	57%	43%
TOTAL	**266**	**56**	**83%**	**17%**

Summary

Gender	No	Percentage
Male	266	83%
Female	56	17%
	322	100%

513TH APPROVAL

CORPORATE

S/NO.	NAME	MEMBER NO.
1.	Abass Hussein Mohamed	M.7714
2.	Abuya Edward Nyamorambo	M.9449
3.	Alex Kiige Ngamau	M.8512
4.	Ali Mlatso Salim	M.10831
5.	Benson Kamba Matonyi	M.3880
6.	Benson Mutiso Mutuku	M.9832
7.	Billy Omolloh Apudoh	M.10672
8.	Brian Mogaka Masese	M.6767
9.	Brian Nanyendo Otty	M.8762
10.	Brian Obuba Magoma	M.9454
11.	Carolmaxine Wambui Njuguna	M.10519

12.	Chepng'eno Sheila	M.9897
13.	Clarice Jepkemoi Kimwei	M.7290
14.	Cleophas Makokha Maende	M.8948
15.	Clinton Adam Mutonyi	M.7795
16.	Eunice Wanjiku Maina	M.7399
17.	Francis Riziki Buluma	M.7331
18.	Fred Mulyungi Mwanza	M.8967
19.	Fredrick Omondi Ojuaya	M.3524
20.	George Gikuhi Kamuya	M.6342
21.	Gideon Kipkoech Bii	M.9380
22.	Ian Ndambiri Ireri	M.9563
23.	Imagoro Moses Jacka	M.10715
24.	James Kinuthia Kairu	M.8197
25.	Japheth Ombogo	M.5613
26.	Jesse Mutua Maeda	M.8804
27.	Joel Manyara Agwera	M.9652
28.	Joseph Aura	M.10904
29.	Julius Kagwima Kuria	M.8672
30.	Justin Munene Kiriinya	M.8177
31.	Joseck Joab Maloba	M.4089
32.	Mark Kipkemoi Kipsang	M.8640
33.	Michael Mutoro	M.7676
34.	Michael Kamunya Ndungu	M.11718
35.	Michael Kinama Mbithi	M.7836
36.	Michael Kinyanjui Mburu	M.9086
37.	Moses Mbango Gambo	M.6677
38.	Moses Ochieng Aoko	M.8023
39.	Mwasaha Nyemi Mwangudza	M.9548
40.	Kimathi Nelson Mishek	M.3150
41.	Nicholas Noi Omenya	M.11089
42.	Obed Marube Ondimu	M.6692
43.	Patrick Mwenda Muriithi	M.8029
44.	Ronny Cheruiyot Yegon	M.9332
45.	Said Mustapha Ali Jama	M.6531
46.	Saitoti Kiprotich Chemut	M.11081
47.	Samson Kamarkor Akuto	M.2449
48.	Samson Kimweli Orengo	M.7854
49.	Seif Mwanzia Ngui	M.8045
50.	Silas Kiptanui Letting	M.9007
51.	Thomas Wefwafwa Mabelle	M.11336
52.	Vane Kerubo Momanyi	M.9341
53.	Walid Khalid Mbarak	M.7879
54.	William Mandela Kemoli	M.10743
55.	Winfred Mulewa Juma	M.8436
56.	Febous Wambua Njeru	M. 11043
57.	Mohamed Hussein Said	M. 11831
58.	Tom Fred Ishugah	M. 9540
59.	Dennis Leteipa Saidimu	M. 8186
60.	Margaret Wanja Chemweli	M.6911
61.	Eric Odhiambo Ooko	M.7693

514TH APPROVAL

CORPORATE

S/NO.	NAME	MEMBER NO.
1.	Anthony Cheruiyot Rono	M.10883
2.	Anthony Chomba Ndwiga	M.11117
3.	Anthony Kariuki Muchirih	M.7531
4.	Benard Kibet Keitany	M.8757
5.	Bernard Ochieng Olale	M.10364
6.	Bonface Shipwoni Misango	M.7677
7.	Christopher Ngugi	M.7685
8.	Dennis Mbala Ndolo	M.9129
9.	Dennis Odhiambo Onditi	M.10460
10.	Farida Cheptoo Mitei	M.7655
11.	Fredrick Odundo	M.9314
12.	Gilbert Gitonga	M.6735
13.	Gladys Gathoni Waitheru	M.10355
14.	Jacton Mwembe Achieng	M.4014
15.	James Musili Ndungo	M.9069
16.	Jeremy Maina Wainaina	M.10907
17.	Johnson Kamau Njeru	M.12949
18.	Joshua Mokaya Nyangau	M.6118
19.	Juma Mrefu Jacob	M.7642
20.	Kevin Mogesi Ogero	M.7137
21.	Martin Reriani Gachagua	M.7953
22.	Michael Abuyeka Mutogoh	M.4553
23.	Ruto Fredrick Kiprono	M.9551
24.	Samson Kipkirui Keter	M.6955
25.	Silas Wanjala Manyonge	M.8743
26.	Emmanuel Mweni Thoya	M.9112

515TH APPROVAL

FELLOW

S/N	NAME	MEMBER.NO
1.	Shammah Kiteme Munyoki	F.3822

CORPORATE

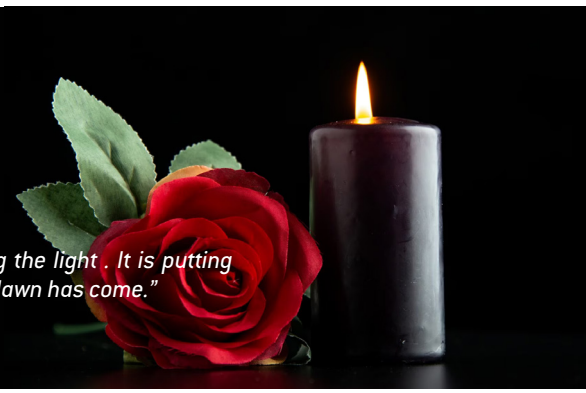
S/NO.	NAME	MEMBER NO.
1.	Amos Ndirangu Karuge	M.8668
2.	Arnold Mwondi Obeli	M.9986

3.	Brenda Kwamboka Nyakundi	M.10463
4.	Corazon Mariam Mecha	M.9211
5.	Daisy Atieno Omondi	M.10458
6.	Dickson Kathenya Marangu	M.9546
7.	Eleanor Tininah Kurash	M.6737
8.	Emanuel Maurice Omuruli	M.12244
9.	Ezekiel Maxwel Oduor Odede	M.6971
10.	Felistus Ayera Misiko	M.9524
11.	Florence Gatwiri Kiburi	M.10888
12.	Cheruiyot Henry Kiptanui	M.4847
13.	Kelvin Mwangi Kamau	M.6354
14.	Raphael Kibet Koske	M.6280
15.	Linet Adhing'a Atieno	M.7482
16.	Liz Wangui Maina	M.9432
17.	Magnus Imorut Otwani	M.7820
18.	Maurice Opar Junior	M.9326
19.	Miriam Nyaboke Sagini	M.10330
20.	Patricia Wangui Karumi	M.10908
21.	Richard Otieno Olare	M.9002
22.	Samuel Charles Ojwang Oloo	M.7119
23.	Shirley Shisiali Muhati	M.10065
24.	Victor Marita Mauti Ogero	M.5478
25.	Vivian Nasike Khayanga	M.10165
26.	William Moseka Kedienye	M.7030
27.	Brian David Nyamweya	M.11338
28.	Edwin Kipkemboi Koech	M.10645

The council invites Engineers and affiliate firms to apply for membership in the various membership classes, kindly follow the link members.iekenya.org to register or scan the QR Code below to apply for membership;

The IEK condoles with family and friends of our members who have passed away in the recent past. May their souls rest in peace.

"Death is not extinguishing the light . It is putting out the lamp because the dawn has come."



30TH IEK INTERNATIONAL CONVENTION
Engineering a New World

In Partnership with

ENGINEERS BOARD OF KENYA
Enhancing Professionalism

WCCE
WORLD COUNCIL OF CIVIL ENGINEERS

30TH IEK INTERNATIONAL CONVENTION

Theme:

Engineering a New World

***DATE:** November 14th - 17th 2023 | **VENUE:** Pride Inn Paradise Beach Resort Convention Centre and Spa in Mombasa*

SPONSORSHIP OPPORTUNITIES

TheIEK @TheIEK | +254 721 729363, +254 020 2729326 | iek@iekenya.org | www.iekenya.org

30TH IEK INTERNATIONAL CONVENTION
Engineering a New World

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WORLD COUNCIL OF CIVIL ENGINEERS

THE 30TH IEK INTERNATIONAL CONVENTION

Theme: Engineering a New World

14th -17th November 2023

Pride Inn Paradise Beach Resort Convention Centre and Spa, Mombasa

Full Convention Package

	IEK Member in Good Standing	IEK Member Not in Good Standing	IEK Non-Member
Physical Attendance			
Early Registration (Before 1st Oct.)	KES 40,000	KES 45,000	KES 45,000
Late Registration (After 1st Oct.)	KES 45,000	KES 50,000	KES 50,000
Virtual Attendance			
Early Registration (Before 1st Oct.)	KES 15,000	KES 20,000	KES 20,000
Late Registration (After 1st Oct.)	KES 20,000	KES 25,000	KES 25,000

**By the Date of Registering for the Convention*

	Foreign Delegate	Undergraduate Student
Physical Attendance	USD 380	
Virtual Attendance	USD 150	KES 3,000

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Engineering a New World

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SPONSORSHIP OPPORTUNITIES

The Institution of Engineers of Kenya (IEK) is the learned society of the engineering profession in Kenya and co-operates with national and other international institutions in developing and applying engineering to the benefit of humanity. The institution is set to hold its annual convention in November 2023.

The 30th IEK Annual International Convention themed ***"Engineering A New World"*** to be held from the 14th to 17th November 2023 at the PrideInn Paradise Beach Resort Convention Centre and Spa in Mombasa County. The 6th Women Engineers Summit themed ***"Beyond Excellence: The Future of Women in Engineering"*** and the 2nd Future Leaders Summit and Expo themed ***"Future Leaders Fostering Positive Impact",*** will be held on the 14th November 2023 during the first day of the convention.

The convention shall be attended by engineers from different parts of the world as well as local and student engineers among other professionals who would benefit from the event.

The organizing committee wishes to invite sponsors, exhibitors and collaborating partners to take up sponsorship opportunities from the categories presented below:

Diamond	Platinum	Gold	Silver	Ruby	Bronze
1 slot	2 slot	2 slots	5 slots	6 slots	12 slots
Ksh. 7,000,000	**Ksh. 5,000,000**	**Ksh. 2,500,000**	**Ksh. 1,500,000**	**Ksh. 1,000,000**	**Ksh. 500,000**

Other Classes

SMEs:

Industry Level (10 slots)	**KSHS. 450,000**
Corporate Level (10 slots)	**KSHS. 300,000**
Support Level (20 slots)	**KSHS. 150,000**

Exhibitors:

Prime Slots	**Based on sponsorship amount**
3 x 3m Booths	**Kshs. 350,000**

In-kind Contributions

- **Convention Bags for 500 Participants**
- **Welcome Cocktail for 500 Participants**
- **Gala Dinner for 800 Participants**
- **Sponsoring Participation of Women Engineers**
- **Sponsoring Graduates & University/ High school Students (100pax)**
- **Videographer (filming all plenary sessions)**
- **Publishing of the convention report**

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EASTERN AFRICA FEDERATION OF ENGINEERING ORGANISATIONS
EAFEO

30TH IEK INTERNATIONAL CONVENTION
Engineering a New World

The Institution of Engineers of Kenya
Founded 1972

In Partnership with

ENGINEERS BOARD OF KENYA
Enhancing Professionalism

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WORLD COUNCIL OF CIVIL ENGINEERS

SPONSORSHIP BENEFITS

PHYSICAL BENEFITS	**Diamond** *(1 slot)* **Ksh 7m**	**Platinum** *(2 slot)* **Ksh 5m**	**Gold** *(2 slots)* **Ksh 2.5m**	**Silver** *(5 slots)* **Ksh 1.5m**	**Ruby** *(6 slots)* **Ksh 1m**	**Bronze** *(12 slots)* **Ksh 0.5m**	**Industry** *(10 slots)* **Ksh 0.45m**	**Corporate** *(10 slots)* **Ksh 0.3m**	**Support** *(20 slots)* **Ksh 0.15m**	**In-Kind**	**Exhibitors** *(50 slots)*
Appropriate acknowledgement during the conference.	●	●	●	●	●	●	●	●	●	●	
Logo in printed Conference Magazine	●	●	●	●	●	●	●			●	
No. of Complimentary tickets for delegates	**5**	**4**	**3**	**2**	**2**	●					
1 conference exhibition booth prime booth	●	●	●	●	●						
Colour advert in Conference Magazine	●	●	●								
Short speech by CEO/MD during opening ceremony (or sponsors at cocktail/dinner)	●	●								●	
1 Corporate banner in conference hall (5x2m)	●	●	●	●							
Company profile distributed to participants.	●	●	●								
2 additional banners in conference hall (5x2m)	●	●	●	●							
Table display and corporate banner in entrance hall	●										
20 minutes to make technical presentation at the opening session	●										
VIRTUAL BENEFITS											
Logo, profile IEK conference website	●	●	●	●	●	●	●	●	●	●	●
Virtual exhibitor booth with company profile	●	●	●	●	●	●	●	●	●	●	●
Social media promotion on LinkedIn, Twitter, Facebook, and Instagram	●	●	●	●	●					●	
Company logo in all our promotional emails to participants	●	●	●	●							
Infomercial Advertisements on the Conference Virtual platform & Women Engineers Summit	●	●	●								
Company logo and profile in all post-event thank you emails to participants	●	●	●								
Showcasing on the Conference Virtual platform during main conference	●	●									
Showcasing on the Conference Virtual platform during the Women Engineers' Summit	●										

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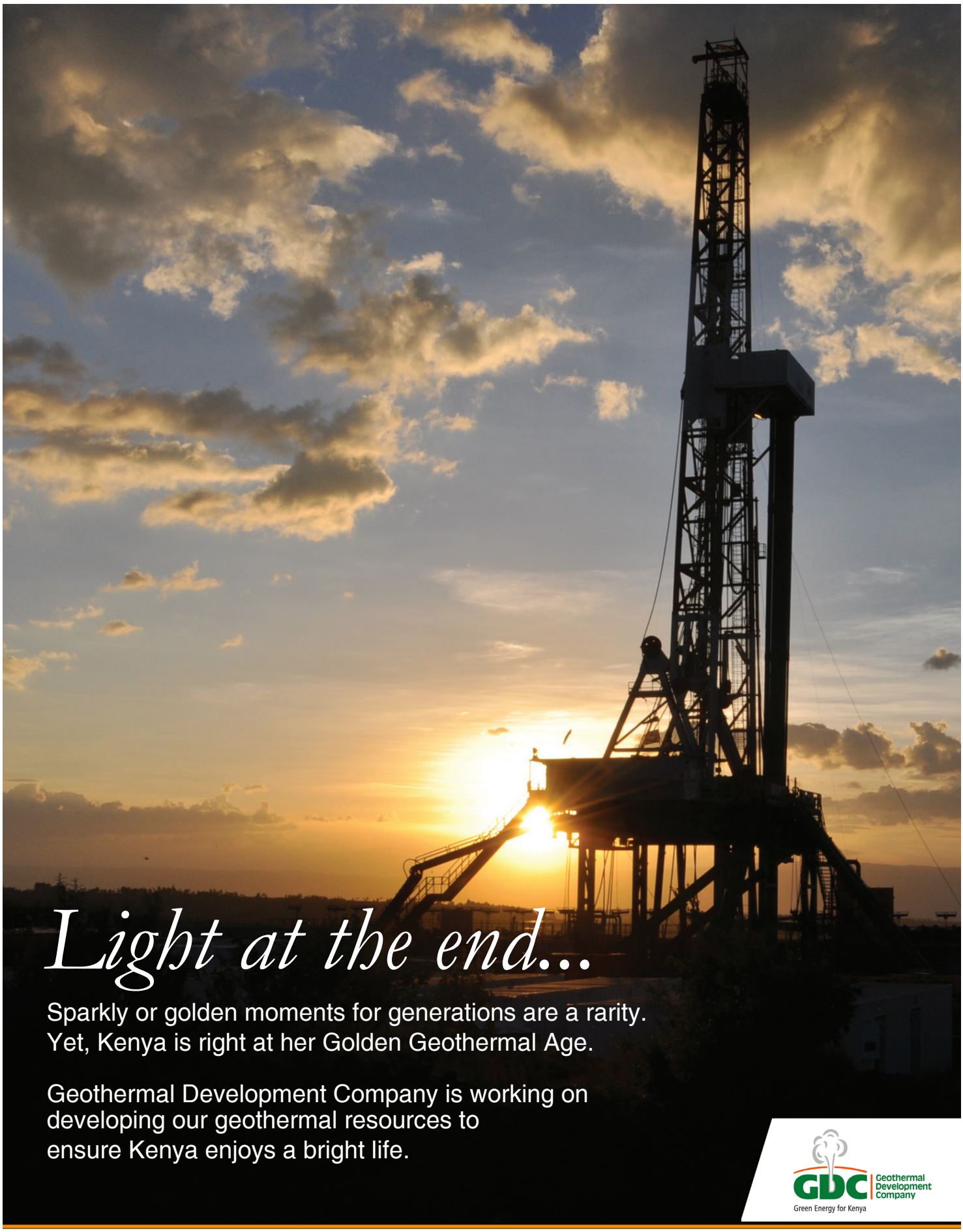
Light at the end...
Sparkly or golden moments for generations are a rarity.
Yet, Kenya is right at her Golden Geothermal Age.
Geothermal Development Company is working on
developing our geothermal resources to
ensure Kenya enjoys a bright life.
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Find out how we can solve water together.